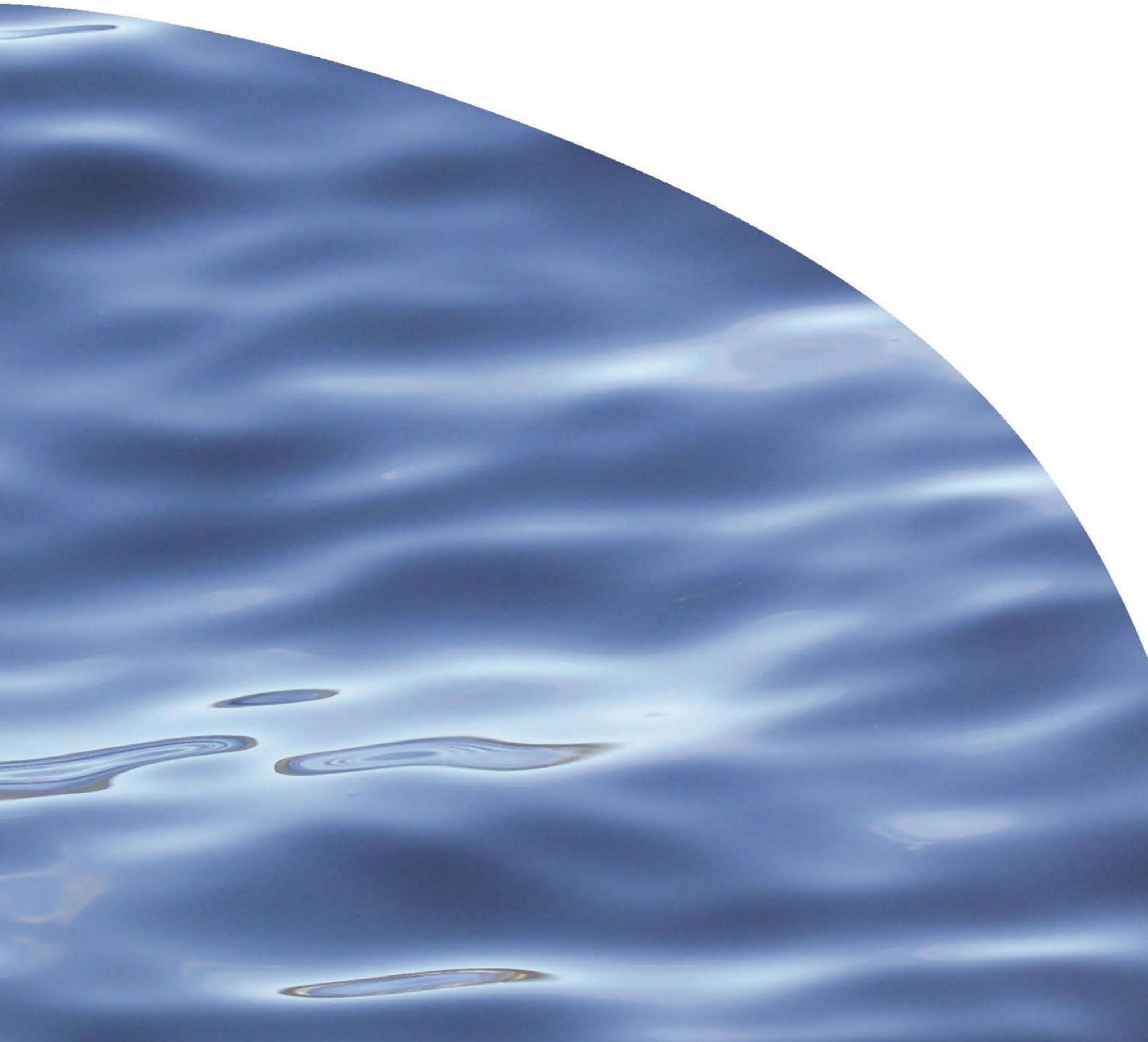
REPORT NO. 2998

ENVIRONMENTAL MONITORING OPPORTUNITIES IN PICTON BAYS



ENVIRONMENTAL MONITORING OPPORTUNITIES IN PICTON BAYS

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Prepared for Marlborough District Council

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EXECUTIVE SUMMARY

Picton Harbour, Waikawa Bay and Shakespeare Bay, known collectively as Picton Bays, are the gateway to the Marlborough Sounds and are used recreationally and commercially by thousands of people. The Picton Bays are important at a local, regional, and national level for cultural, social, recreational, and commercial reasons. Marlborough District Council (MDC) requested that the Cawthron Institute identify opportunities for environmental monitoring that will enable a robust scientific assessment of the state and trends of the environmental health of the Picton Bays.

A small number of interviews were conducted with key parties (representatives from Te Ātiawa o Te Waka-a-Māui, Port Marlborough, and Marlborough Sounds Integrated Management Trust) to discuss their priorities for environmental monitoring. The potential for integration of cultural indicators into a broader monitoring programme was also discussed with the Te Ātiawa representative. However, the iwi will be in a better position to develop cultural indicators in coming years. The currently-used measurements are of use and interest to iwi in the interim.

Key aspects of environmental health for the Bays were identified as follows: the levels of numerous forms of contamination, habitat integrity, and fisheries depletion. Monitoring options were considered with respect to considerations of (i) information availability, (ii) local environmental stressors, (iii) a brief assessment of the importance to the community (iv) ability to attribute environmental change to human activity and (v) to control that activity, (vi) ongoing data collection and (vii) the ability to integrate new monitoring with existing activity. The relevance of different monitoring activity to some key local, national, and international initiatives is also briefly considered.

Monitoring options exist for all the environmental characteristics addressed, as per the table below. However, while the need to attribute environmental health to specific activities was a strong message in some interviews, the ability to make these connections from monitoring data is often not strong. Research or modelling will in some cases be necessary to attribute cause-effect relationships.

Development of a general picture of the state of the environment was considered important by all parties interviewed, and this is also a key motivator behind moves to integrate different kinds of monitoring data. Some monitoring options in Picton Bays provide context for smaller-scale activity, for example, development of a habitat map relevant to smaller-scale impact assessments. Water quality monitoring in Picton Bays, on the other hand, would constitute a 'special interest' component of a Sounds-wide water quality monitoring programme.

Explicit consideration of community values or management aims or priorities will provide the basis for development of detailed survey designs, and may also influence prioritisation of different monitoring options.

Environmental characteristic	Threats and pressures	Monitoring methods	Causal links	Ongoing data collection	Monitoring time-scale
Faecal contamination	Sewage systems Land runoff Marine animals	Faecal indicator bacteria • water samples • shellfish • microbial source tracking	Moderate - strong	Council SoE Occasional consent-associated assessments	Weeks – months – years
Nutrient contamination (enrichment)	Farming Urban/industrial wastes Sediment inputs	Physical samples • water (nutrients or chlorophyll) • sediment Macroalgal cover Instrumentation - chlorophyll Modelling Increased freshwater sampling	Weak	Larger SoE programme in QCS, consent-associated monitoring in QCS Estuarine SoE monitoring	Weeks – months
Chemical contamination	Urban runoff Antifouling componds Waste disposal (e.g. sewage)	Physical samples • water column • seabed • shellfish flesh	Moderate - strong	Occasional consent-associated assessments	Years – decades
Sediment input	Land disturbance	Water column measurements • suspended solids • turbidity • light levels Seabed sediment grain size Modelling Chemical source tracking	Weak - moderate	Estuarine SoE monitoring Occasional consent-associated assessments	*Inputs:* Weeks – months *Seabed characteristics:* Years – decades
Habitat integrity	Reclamation Disturbance Loss of habitat-forming species Sediment deposition	**Historical** Historical images, community knowledge **Current** Seabed imagery Physical sampling (sediments and infauna)	Weak - moderate	Multibeam echosounder seabed mapping Significant site monitoring	Years – decades
Fisheries	Direct removal Habitat loss Loss of reproductive stock	Catch data Targeted catch surveys Diver counts Seabed images	Moderate - strong	MPI data collection	Years – decades

Resultant recommendations for environmental monitoring and establishment of contemporary baselines are as follows:

- Habitat mapping, including fisheries species/kaimoana
- Shellfish suitability for consumption
- Addition of a water quality monitoring station (or two) to the wider Marlborough Sounds water quality monitoring programme
- Higher-frequency monitoring of intertidal estuarine habitats, and addition of cockle surveys designed for their assessment as a fisheries species.

Historical baselines should also be established where possible.

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1. INTRODUCTION

Picton Harbour, Waikawa Bay and Shakespeare Bay, known collectively as Picton Bays (Figure 1), are the gateway to the Marlborough Sounds. The Picton Bays are important at a local, regional, and national level for cultural, social, recreational, and commercial reasons. Picton Harbour is used for commercial vessels including ferries, cruise liners, and log ships. Other current and historic commercial activities include ship yards and marinas, and the release of stormwater and treated sewage into the harbour. The area is used for swimming, diving, sailing, kayaking and other water sports by thousands of locals and visitors. The area is also of significance to iwi. Its ecological health is therefore important for the wider community.

In a previous council-commissioned summary of the state of knowledge regarding the Picton Bays environment, we concluded that:

> There are gaps in our understanding of the pressures or stressors, state, and trends of marine environmental health in the Picton Bays…While a lot of information is available about some aspects of environmental status, this is generally targeted to a particular activity, rather than to making a general assessment of environmental health relevant to values in the area. Accordingly, there is a lack of repeated measurements with consistent sites and methodologies over time. (Newcombe & Johnston 2016: p 44).

Marlborough District Council (MDC) requested that the Cawthron (Cawthron) identify opportunities for environmental monitoring that will enable an ongoing assessment of the state of the Picton Bays. This information would be used to inform MDC's statutory planning and consenting responsibilities, as well as provide a framework for MDC to communicate the state of the environment to iwi and the wider community.

Figure 1. Picton Bays consists of three bays in Queen Charlotte Sound / Totaranui: Shakespeare Bay, Picton Harbour, and Waikawa Bay (image edited from Google Earth).

1.1. Scope

The purpose of this report is to assist MDC in designing monitoring that will fill gaps in Council and community understanding of marine environmental health. Thus, the aims of this report are to:

- outline a series of options for monitoring and for the establishment of contemporary baselines
- explore with iwi the possibility of integrating cultural indicators of environmental health in future
- seek to integrate and build on consent and state of the environment monitoring, such as that done by Port Marlborough.

A small number of interviews were conducted with key parties (representatives from Te Ātiawa o Te Waka-a-Māui, Port Marlborough, and Marlborough Sounds Integrated Management Trust) to discuss their priorities for environmental monitoring.

Monitoring options were considered with respect to considerations of (i) information availability, (ii) local environmental stressors, (iii) a brief assessment of the importance to the community (iv) the ability to attribute environmental change to human activity and (v) to control that activity, (vi) ongoing data collection and (vii) the ability to integrate new monitoring with existing activity. The relevance of different monitoring activity to some key local, national, and international initiatives is also briefly considered. Firstly, however, we consider the purpose of monitoring, including the key themes that monitoring could address in Picton Bays.

Box 1: Picton Bays environmental information and health assessment

An assessment of the information availability, and state and trend of the environment in Picton Bays was undertaken for MDC (reported in Newcombe & Johnston 2016).

Most marine communities in Picton Bays are similar to other areas of Queen Charlotte Sound / Totaranui. The ecologically important estuarine areas (Figure B1) are rarer.

Figure B1: Estuaries in Picton Bays support seagrass beds that are important habitat for some species and that mitigate effects of land-based activity on the marine environment. Photo: Shakespeare Bay, 2016. Photographer: Anna Berthelsen

The marine environment in Picton Bays suffered substantially from human activity over the last century, but many pressures have lessened in recent decades. Information about many aspects of environmental health is scarce, however seabed **habitat integrity** has been reduced by historical input of sediment, reclamation and construction. The very high disturbance from ferry wakes that was occurring late last century has been lessened.

Fisheries are much depleted from their historic highly abundant state, and this is reflected in habitat integrity of rocky reefs (Figure B2).

Figure B2: Rocky reefs lack large habitat-forming seaweeds. Seaweeds can be prevented from thriving due to effects of sediments, or overgrazed by herbivores such as kina that have been released from predation pressure as large predators have been fished out.

A range of types of **contamination** are present, mostly at low levels. Chemical contamination from anti-fouling materials is likely to be reducing over time. Past contamination by organic matter was extreme, with raw sewage and freezing works waste causing high levels of enrichment and faecal contamination. These sources of pollution have been largely eliminated (Figure B3).

Figure B3: The freezing works outfall that was responsible for high bacterial and nutrient enrichment in Shakespeare Bay was shut down decades ago, and substantial seabed recovery has subsequently occurred. Photo supplied by PML.

1.2. Environmental health

Environmental health can be considered from many different perspectives; for example, the preservation of taxonomic biodiversity and intrinsic value may have different requirements than the preservation of functional biodiversity and ecosystem functioning. A management aim of protecting provision of ecosystem services to humans may require a different approach again. One definition of high integrity or health of an environment was provided by Lee et al. (2005):

> The full potential of indigenous biotic and abiotic features, and natural processes, functioning in sustainable communities, habitats, and landscapes. Ecosystems have ecological integrity when all the indigenous plants and animals typical of a region are present, together with the key major ecosystem processes that sustain functional relationships between all these components, across all of the ecosystems represented in New Zealand.

Reductions in environmental health may be considered acceptable when other benefits to society are considered more important. A monitoring programme in a relatively small area such as Picton Bays may be most useful when it is designed in response to a statement of community aspirations, or management aims or priorities. We understand MDC is looking to develop a coastal science strategy through the Marlborough Marine Futures forum, and this report should inform development of monitoring as part of that process. Here we outline an approach that considers key aspects of environmental health with input from a small number of parties (iwi and stakeholders).

2. PURPOSE OF MONITORING

2.1. Types of environmental monitoring[1]

Environmental monitoring can be broadly defined as a suite of activities that aim to characterise baseline conditions, track changes and establish trends in parameters used to describe or enable assessment of the status or quality of the environment or associated resources. The two types of environmental monitoring that councils such as MDC generally require or undertake are:

- Consent-related environmental monitoring: for the purpose of gauging the environmental effects of a consented activity. This type is usually limited to monitoring of effects that can be directly linked to specific activities and hence often involves local-scale surveys. Examples are water quality or seabed monitoring that focuses on the immediate environs of a point-source activity.
- SOE monitoring: for the purpose of providing a generalised indication of environmental condition and quality. Councils are required to monitor the state of the environment to the extent that is appropriate to enable them to effectively carry out their functions under the Resource Management Act 1991 (RMA s35(2)(a)).

SOE monitoring tends to (or should) focus on broad-scale changes in select indicators that are representative of environmental conditions. Effective SOE monitoring can provide the baseline conditions and broad-scale trajectories and changes in the receiving environment alongside the pressures potentially impacting the system.

In addition to monitoring conducted by councils, other stakeholders may undertake monitoring for their own purposes to fulfil needs unrelated to immediate council requirements and obligations. Examples relevant to Marlborough include the following:

- monitoring of water quality and harmful algae species to understand production risks to aquaculture
- marine reserve monitoring undertaken by the Department of Conservation (DOC)
- monitoring of fish stocks undertaken by the Ministry for Primary Industries (MPI)
- surveillance for marine pests undertaken by NIWA for MPI.

2.2. Monitoring of Picton Bays vs the wider marine environment

All of the environmental issues facing the Picton Bays are also present to some extent in areas of the wider Coastal Marine Area (CMA), and the rationale for environmental monitoring in Picton Bays can generally be applied to the larger CMA. The purpose of

[1] Material adapted from Forrest et al. (2016)

establishing additional environmental monitoring in the specific area of Picton Bays therefore warrants consideration.

As the ‘Gateway to the Marlborough Sounds’, Picton Bays are visited by more people, and used more intensively, than most (or all) other areas of the Marlborough Coastal Marine Area (CMA). Commercial, cultural, and recreational values are all important in Picton Bays. Waikawa Bay is of particular importance to manawhenua iwi, Te Ātiawa.

Associated with the higher residential, visitor, and commercial activity in the area is a greater number and degree of environmental stresses, including reclamation for commercial purposes and waste discharges.

Monitoring has a part to play in community engagement with marine issues, and as Picton Bays are familiar to a wider range of people than other parts of the CMA, they may have a greater relevance that less-visited areas lack.

Another benefit to monitoring on a small scale is a scope for community involvement (citizen science initiatives) in a manner that may be logistically difficult or prohibitively expensive on a larger scale. Monitoring programmes that incorporate direct community involvement may be more feasible in Picton Bays than more distant monitoring sites. It is, however, beyond the scope of this report to robustly consider the potential for citizen science initiatives.

2.3. Drivers of environmental health in Picton Bays

Determinants of environmental health, or environmental stressors, that are most relevant to Picton Bays can be considered under four topics:

- Contamination (*water and sediment quality*)
    - faecal (pathogen/bacterial)
    - nutrient
    - chemical
    - sediment
    - litter
- Habitat alteration (*habitat integrity*, which has a strong relationship with *biodiversity*)
- Biosecurity—marine pests and diseases (aspects of *biodiversity*)
- Fisheries depletion (*fishery productivity, biodiversity*).

Activities relevant to these topics above are presented in Figure 2. Apart from two exceptions (see Section 2.3.1), these topics are considered in Section 4.2 and Appendix 1.

Figure 2. Activities potentially related to particular drivers of aspects of environmental health in Picton Bays.

2.3.1. Topics not considered

Note that two topics are not considered in detail in this report: biosecurity (marine pests and diseases) and litter.

Monitoring and management of biosecurity threats are overseen by the Top of the South Marine Biosecurity Partnership, and MDC, along with the Ministry for Primary Industries (MPI), are actively involved in monitoring of this threat. We consider that an assessment of biosecurity monitoring of Picton Bays here would be redundant given the activity already underway, and the specific needs associated with monitoring for biosecurity purposes. With regard to scale and integration, Picton and Waikawa are key areas of risk in terms of biosecurity due to the number of vessel movements, and relatively large amounts of artificial structures. Accordingly, the area acts as a sentinel site for biosecurity within Marlborough.

Litter is not a key environmental stressor and monitoring of litter is not expected to be of high priority in a scientific monitoring programme. It was also not mentioned as an issue by any of the interviewees for this project. Accordingly we do not develop monitoring strategies for this issue here. Community initiatives have occurred to clean up litter in the bays, and these provide a qualitative indication of the extent of litter in the region (Newcombe & Johnston 2016).

3. INTERVIEWS

Monitoring priorities for Picton Bays were discussed in informal interviews in early December 2016 with representatives from Te Ātiawa o Te Waka-a-Māui, Port Marlborough, and the Marlborough Sounds Integrated Management Trust. Invariably, consideration of monitoring requirements also touches on management issues, some of which are also reported below.

3.1. Te Ātiawa o Te Waka-a-Māui

Te Ātiawa priorities with respect to marine environmental monitoring in Picton Bays (as expressed by Rohe Management Officer, Bruno Brosnan) are to capture a broad picture of environmental status, and trajectories of change. Recent reports commissioned by MDC (Newcombe & Johnston 2016; Handley 2016) have presented a picture of environmental health that was of great concern to many people.

Bruno expressed the view that monitoring is of interest principally if it is related to expected change, but is not a wise use of resources if no management response is anticipated. For example, while suitability of kaimoana for consumption is important, Te Ātiawa see limited value in ongoing monitoring if council intend that that the current sewage disposal methods and other discharges are to be retained for the foreseeable future. Te Ātiawa are, however, supportive of drastic protective measures in the marine environment, as this is apparently required to reverse current decline. The protection of the ecologically significant marine sites [2] is desired, along with protective buffer zones around those areas. Such protective measures would be accompanied by targeted monitoring.

In general, the ideal outcome would be that monitoring would provide an overall picture of environmental health, rather than focus on excessive detail. However a potentially contradictory requirement is the assignation of environmental change to particular causes. Bruno highlighted the importance of understanding what inferences can be made from given environmental measurement, and what the ability to manage the relevant stressors is. As a result the sub-sections ‘Causal links‘ and ‘Pathways to management’ were included in considerations for environmental monitoring (Appendix 1).

3.1.1. Integration of cultural indicators, utility of existing data

One aim of this report was to explore with iwi the possibility of integrating cultural indicators of environmental health, and this was therefore discussed with Bruno. Development of cultural indicators is an aspiration for the future, but is not an

[2] http://www.marlborough.govt.nz/Environment/Coastal/Coastal-Ecosystems/Significant-Marine-Sites.aspx

immediately high priority for Te Ātiawa, who have many immediate challenges to address subsequent to the recent finalisation of the treaty settlement process. Cultural indicators will be developed in the future when more immediate priorities have been dealt with. This is because potential for integration rests in large part on the timeframes and purposes of monitoring activity, and these may or may not align, depending on how cultural indicators are identified and measured. A further consideration is that attempts to develop cultural indicators at a national level will encounter important differences in approach between iwi. Bruno noted the importance, at least initially, of indicator development or identification at a rohe level. Accordingly, work undertaken by other iwi is not necessarily relevant to the consideration of cultural monitoring of Picton Bays. We consider that, before cultural indicators are identified, it is not possible to assess the nature and extent of possible integration with other monitoring programmes.

Given that cultural indicators are not likely to be developed in the short term, we discussed the utility of existing data. Bruno stated that at this stage some of the currently-used monitoring methods and indicators can function as useful proxies for cultural indicators. He confirmed that the approach to environmental issues taken here (and in Newcombe & Johnston 2016) is of use. All themes (habitat integrity, contamination, etc.,) are seen as relevant. The data collected under current protocols[3] are informative to iwi. Regarding some primary data sources, however, availability and accessibility is an issue. Te Ātiawa have aspirations to become the guardians or managers of environmental data, which would facilitate access. However, at the moment there is a pragmatic acceptance of council currently holding data. In the shorter term, use of the marae as a forum for dissemination of information would facilitate transmission of environmental information to iwi, and assist in moving towards the establishment of iwi as managers of environmental data.

3.2. Port Marlborough

A meeting was held with Port Marlborough Limited (PML) representatives Rose Prendeville (Manager Projects and Support) and Gavin Beattie (Manager Infrastructure).

Rose and Gavin recognise that the port and marina are key sources of potential environmental impact in the Picton Bays, but consider these operations to be very well-managed. They cited examples such as the best-practice management of storm water discharges, and containment of potential contaminants from hard-stand areas. They suggested that public emphasis is sometimes placed disproportionately on potential environmental effects of PML activities (such as the marina) with less

[3] For example, data presented in Newcombe & Johnston (2016) and Handley (2016), also that collected in estuarine areas under the Estuarine Monitoring Protocol (Berthelsen et al. 2016; Robertson & Stevens 2016; Stevens & Robertson 2016)

emphasis placed on other uses (such as council-managed moorings, and historical sources of contamination). They expressed a need for greater recognition of the multiple causes of environmental degradation (ongoing and historical) in the area, as well as improvements in environmental quality. PML representatives expressed a desire to see contextual environmental information in Picton Bays, both for identifying trends over time, and for spatial comparison with PML data. This information would also be expected to streamline the application process for new consents, as the effects of proposed activity would be more readily assessed. For example, habitat characterisation has been required prior to dredging or construction works. Such relatively small-scale studies may not be necessary if a broad assessment of the nature and extent of different habitats were available. Thus, a priority need for PML is for monitoring that provides useful habitat information, which would limit the need for repeated benthic surveys associated with consent applications.

PML staff also highlighted the importance of correct communication of environmental information. They were comfortable in principle for the results of environmental surveys to be publically available[4], but had some concerns that attempts to oversimplify information can result in incorrect messages being conveyed. To prevent this, review by specialists (such as the science provider responsible for the original data), for accuracy of council communications of scientific data may be appropriate.

3.3. Marlborough Sounds Integrated Management Trust

Eric Jorgensen acts as trustee of the Marlborough Sounds Integrated Management Trust ([5]. The trust and the broader Marlborough Marine Futures initiative represent a range of stakeholders, and Eric also expressed his belief that no single perspective on marine management and monitoring will be subscribed to by all parties.

Eric highlighted the need for better understanding of environmental dynamics generally, and for the acknowledgement of shifted baselines. He identified the monitoring of water quality as of primary importance, on the basis that this reflects the most important stressors, including land-sea interactions. He saw sediment input and resuspension as a critical issue for environmental health. Eric stated the importance of a monitoring programme as a means of establishing cause and effect relationships between activities and environmental health. This would in turn provide opportunities for mitigation of effects, and for restoration.

Eric also flagged the need to establish the extent to which any monitoring would be used as a tool for environmental management vs. for community engagement. Within pragmatic limits, he felt that monitoring activity should be ongoing even in the absence of substantial environmental degradation or planned management changes.

[4] Much PML environmental data are made publically available through materials supporting consent applications.
[5] www.marlmarinefutures.co.nz

4. MONITORING CONTEXT AND OPTIONS

Here we outline the approach taken to assessing the value of, and options for, environmental monitoring and address the environmental themes of contamination (faecal, nutrient, chemical, sediment), habitat alteration, and fisheries depletion.

4.1. Considerations for identifying appropriate monitoring activity

From past reports, discussions with Council, and formal and informal conversations with some iwi and community representatives, we identify a number of factors that influence decisions regarding environmental monitoring in Picton Bays:

- existing knowledge on state and trend of the environmental characteristic of interest
- threats to and pressures on the characteristic (past, present, and future)
- importance to the community[6]
- ability to measure the environmental characteristic, and to detect change
- extent to which health status of the characteristic can be linked to a particular activity/stressor
- pathways to management (control of a given agency or part of the community over the environmental characteristic).

4.1.1. Scale and integration

Recent discussion regarding the greater Marlborough Sounds (e.g., in Forrest et al. 2016) has identified a monitoring framework, where consent associated monitoring and other small-scale activities fit within a broader SoE network (Figure 3). The result of this framework would be that synergies would occur across different kinds of environmental monitoring. The aim is to move away from a situation where a disproportionate amount of environmental monitoring is undertaken in association with a small number of consented activities. Rather, monitoring would capture a broader picture of environmental health status. Consent-associated monitoring (and other kinds of project-based monitoring) would sit within the broader framework. Increased efficiency would occur with the use of sentinel or representative sites, integrated survey design, and an improved understanding of reference conditions.

[6] While some discussion of community values follow in Appendix 1, it is beyond the scope of this report to robustly assess the importance to the community of each environmental characteristic considered.

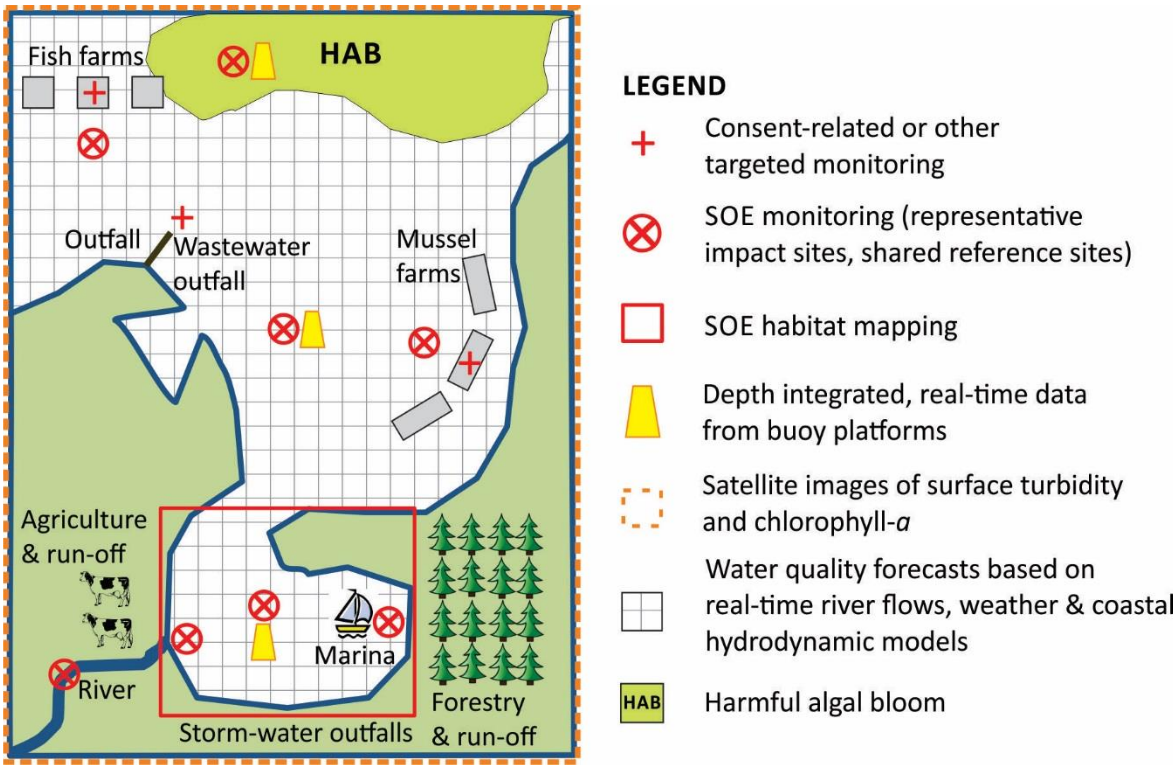

Figure 3. An integrated monitoring programme (in a representative coastal area), where consent or other targeted monitoring sits within a broader SoE monitoring programme. Adapted from Forrest et al. (2016).

Components of an ideal integrated monitoring programme are likely to include:

- context/large scale/SoE measurements
- targeted/small scale/impact-related measurement
- identification of sentinel/representative sites
- use of modelling where it is more informative or cost effective than field measurements
- supplementary research to assist in understanding causes of environmental change.

Given that Picton Bays is a small area of the larger Marlborough Sounds, it is useful to consider the extent to which environmental monitoring might relate to other components of an integrated monitoring programme. Therefore, for suggested monitoring options we also consider the ways that monitoring activity may relate to monitoring at larger or smaller scales.

4.1.2. Limitations of monitoring

It is important to acknowledge that monitoring is one component of a larger toolbox for managing the environment, and there are limitations to what monitoring can realistically achieve. For example, for some activities, suitable monitoring indicators (or associated environmental standards) may be unavailable or impractical to implement (e.g. due to high cost). There may be a spatial or temporal ‘disconnect’ between a stressor and the expression of its effects. Also, monitoring alone may be limited in its ability to attribute measured effects to a particular activity; in some cases further research is needed to better understand effects.

4.2. Monitoring options

4.2.1. Overview

Monitoring options are broadly outlined in Table 1. More detailed consideration of the context and utility of the various options is presented in Appendix 1, and general conclusions regarding the opportunities for monitoring of each environmental theme are given below.

Table 1. Monitoring options and context for key drivers of environmental health (topics) in Picton Bays.

Topic	Threats and pressures	Methods	Causal links	Ongoing data collection	Survey cost estimates	Monitoring time-scale
Faecal contamination	Sewage systems Land runoff Marine animals	Faecal indicator bacteria • water samples • shellfish • microbial source tracking	Moderate - strong	Council SoE[7] Occasional consent-associated assessments	\$1000s – low \$10,000s	Weeks – months – years
Nutrient contamination (enrichment)	Farming Urban/industrial wastes Sediment inputs	Physical samples • water (nutrients or chlorophyll) • sediment Macroalgal cover Instrumentation (moored or occasional) to measure chlorophyll Modelling Increased freshwater sampling	Weak	Larger SoE programme in QCS, consent-associated monitoring in QCS Estuarine SoE monitoring	Water sampling \$1000s + High-tech moored buoys \$10,000s to \$100,000+	Weeks – months
Chemical contamination	Urban runoff Antifouling componds Waste disposal (e.g. sewage)	Physical samples • water column • seabed • shellfish flesh	Moderate - strong	Occasional consent-associated assessments	\$10,000s	Years – decades

[7] https://www.marlborough.govt.nz/recreation/swimming-and-boating/recreational-water-quality-

Table1, continued

Topic	Threats and pressures	Methods	Causal links	Ongoing data collection	Survey cost estimates	Monitoring time-scale
Sediment input	Land disturbance	Water column measurements • suspended solids • turbidity • light levels Seabed sediment grain size Modelling Chemical source tracking	Weak - moderate	Estuarine SoE monitoring Occasional consent-associated assessments	Physical sampling: $1000s – $10,000s	*Inputs:* Weeks – months *Seabed characteristics:* Years – decades
Habitat integrity	Reclamation Disturbance Loss of habitat-forming species Sediment deposition	**Historical** Historical images, community knowledge **Current** Seabed imagery Physical sampling (sediments and infauna)	Weak - moderate	Multibeam echosounder seabed mapping[8] Significant site monitoring, particularly Bob's Bay	Collect community knowledge $40,000 Drone mapping intertidal/shallows: low $10,000s Seabed photo/video survey and corresponding mapping: $10,000s	Years – decades
Fisheries	Direct removal Habitat loss Loss of reproductive stock	Catch data Targeted catch surveys Diver counts Seabed images	Moderate - strong	MPI data collection	Shellfish surveys as component of habitat mapping $10,000+	Years – decades

[8] http://www.marlborough.govt.nz/Environment/Coastal/Seabed-Habitat-Mapping.aspx

4.2.2. Contamination

Contamination is a broad term for inputs of a number of substances that can have detrimental effects[9]. Unnatural levels of particular substances have a range of undesirable environmental effects.

Faecal contamination

The key source of pathogens (including viruses and bacteria) in New Zealand waterways is faecal contamination, which is generally indicated by bacterial concentrations. Pathogens largely cause human health issues, rather than environmental disruption. However, some ecological issues are possible from contamination by pathogens, such as the protozoan parasite *Toxoplasma gondii*, which is present in cat faeces, and is thought to increase mortality in Hector's dolphins (Roe et al. 2013).

The Council's recreational water quality monitoring programme provides reasonably good context for assessment of faecal contamination in the Bays, and a similar programme related to shellfish flesh contamination levels would be informative to those interested in harvesting kaimoana. If specific sources of contamination were to be targeted, microbial source tracking would be a useful tool.

Nutrient contamination (enrichment)

Nutrient contamination can cause blooms of algae in the water column or on the seabed. These may cause physical nuisance (discolouration, smothering, masses of seaweeds, odour from rotting material), may include blooms of toxic microalgae, and can cause depletion of oxygen by bacteria that decompose the algal material.

Terrestrial sources of nutrients to Picton Bays are moderately well-monitored, in that either freshwater inputs or estuarine monitoring, are undertaken in each of the three bays. However, the opportunity to align freshwater and estuarine monitoring by extending freshwater monitoring to the catchments associated with each estuary (Waikawa Bay and Shakespeare Bay) could be considered. We note that, particularly in Shakespeare Bay, stream volumes can be very low, and that this may have fed into the Council decision not to monitor.

Any additional water quality monitoring in Picton Bays should be integrated with the larger MDC SoE water quality monitoring programme. Therefore, if targeted water column monitoring in Picton Bays is undertaken, this would most appropriately be with the addition of sites in Picton Bays to the wider programme.

[99] The RMA (1991) defines a contaminant (with respect to water) as: any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that…when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water.

As particularly sensitive sites, the estuarine areas are prime candidates for increased monitoring effort. While nutrients are perhaps not the most important stressor, nutrient levels and indicators of nutrient stress in estuarine communities are captured in standard estuarine SoE monitoring protocols. Increased frequency of monitoring would assist in understanding variability, and therefore in setting meaningful management targets for these environments.

Chemical contamination (toxicity)

Chemical contamination can have a range of lethal and sub-lethal effects. Often species differ in their response to particular chemicals. There are also implications for human heath when kaimoana species are contaminated with high levels of toxins.

Key sources of chemical contamination are readily identified (such as stormwater, antifouling materials, sewage outfall), and hotspots of contamination that have been previously identified are from activities that no longer occur (i.e., the sites of high input of antifouling compounds from vessel cleaning, and untreated sewage). Reductions in other sources of chemical contamination (such as urban runoff and leaching from antifouling compounds on vessel hulls) are unlikely, therefore the environmental benefit from investment in monitoring would be minor. An intensive survey across the Bays could measure the degree and extent of contamination. This would be very costly, and there is likely to be limited benefit in doing so. Occasional state of the environment seabed monitoring may serve to document a slow improvement from a historical low-point.

Any monitoring of chemical contamination levels would most usefully reflect specific community concerns (if these are present in the community). The best approach would therefore be that a monitoring programme were designed once those concerns were clearly defined.

Sediment input

Increased sediment inputs into the marine environment can cause a range of problems, including smothering of plants, animals, and settlement surfaces, and shading of the water column and seabed (reducing primary productivity). Sediments are also associated with transport of other contaminants, both chemical and biological.

As for other characteristics of the water column, sediment monitoring which takes a very different approach to the large-scale Marlborough Sounds SoE water quality monitoring seems unwise. Many characteristics relevant to sediment contamination are included in the Sounds monitoring programme, and the addition of one or two sampling stations within Picton Bays may be appropriate. The most relevant parameters in that programme for Picton Bays may be the measurements of clarity and suspended sediments, as these are most likely to be affected by local activities of particular concern to some members of the community.

However, water quality measurement would not reliably distinguish between new inputs and resuspension of historical sediments. High frequency measurement of sediment levels in freshwaters and quantification of coastal erosion[10] would provide a more accurate picture of new inputs. Estuarine monitoring may elucidate some changes in sediment inputs over time, particularly if the frequency was increased, and if surveys were undertaken in response to expected high-stress events, such as increased sediment inputs. Extensive monitoring of marine sediments is probably not an efficient means of describing sediment dynamics due to the high levels of disturbance experienced, although some general sediment characteristics may be appropriately assessed as part of habitat mapping (see next section).

Techniques to identify which land-uses were the source of sediments found in the marine environment (Gibbs 2008) would most efficiently be used to address a particular question, and would not be recommended as a component of an SoE monitoring programme. A recent study has addressed the nature of sediment deposition in Pelorus Sound over the last 1000 years (Handley et al. 2017). This research described a profound increase in sediment deposition rates since European settlement, and successfully identified a range of terrestrial sources of seabed sediments.

4.2.3. Habitat integrity

Habitat integrity refers to the extent to which the physical structure of the habitat is suitable for its naturally-occurring biological community. This can refer to either inorganic or biogenic (created by organisms) structures. Unmodified habitat would have greater structural integrity. Alterations to habitat, such as changes in sediment grain size or loss of plants and animals that created structure, will invariably have implications for biodiversity.

Small areas of the Bays have been quite intensively studied, but an integrated assessment of the status of habitat integrity could be considered. Habitat mapping in Picton Bays would be of interest to Port Marlborough and Te Ātiawa. For Port Marlborough, this could reduce costs of repeated habitat characterisations required during resource consenting processes. For Te Ātiawa, habitat mapping would indicate large-scale environmental health, and would serve as a baseline for measurement of ecosystem recovery from a relatively degraded state.

A mapping programme could also include sites within Picton Bays for which areas protected as ecologically significant marine sites might provide useful comparative systems. These could assist in establishment of historical baselines, and potentially describe trajectories of recovery under protective management.

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[10] Some existing data are available associated with ship wake monitoring, and site-specific studies (e.g. Ward & Edwards, 2015 a, 2015b)

4.2.4. Fisheries decline

Fisheries of shellfish (such as scallops) and vertebrates (from small fish such as the Picton bloater, to large grouper) were historically much more abundant in or near Picton Bays than they currently are. A reduction in fisheries species[11] has social and economic impacts, but it also affects habitat integrity and ecosystem functioning.

There is limited value in measuring many fishery species in a relatively small area such as Picton Bays due to the high mobility of many species, and the limitations of many monitoring methods. A number of factors suggest that there is more value in measuring relatively sedentary species such as shellfish, than highly mobile fish species. These include:

- the relatively small scale of Picton Bays vs. the high potential mobility of fish
- the low numbers of fish relative to shellfish
- the ease of measuring sedentary species.

Assessment of juvenile fish species seems more suited to a research project than a component of monitoring, due to the relative complexity of assessment. For SoE monitoring in the face of budgetary contraints, the presence of *habitat* for juvenile fish (as incorporated in estuarine monitoring and other habitat mapping) seems a more appropriate focus for monitoring.

Cockles are counted as part of the estuarine monitoring protocol (Robertson et al. 2002), however methods are not designed to permit an assessment from a fisheries perspective. It may be useful and low-cost to add a specific survey of cockles from a fisheries perspective. For example, estuarine surveys could include the counting and measurement of cockles in quadrats.

Shellfish such as scallops, paua and mussels are important kaimoana species, and as such may be identified as indicators within cultural health monitoring frameworks. They also play important role in community structure and functioning. It would be both relevant and straightforward to capture these species in habitat surveys.

Interviews with iwi and older members of the community may provide valuable information regarding resource abundance in living or historical memory. Coring studies are likely to provide an indication of historical species dominance, which would assist in establishing appropriate baselines.

[11] We note that fisheries activity is managed by the Ministry for Primary Industries, and is in large part beyond the control of councils.

5. REGIONAL, NATIONAL AND INTERNATIONAL PRIORITIES

Here we briefly consider some other projects and programmes that have relevance to the prioritisation and design of monitoring in Picton Bays.

5.1. MDC coastal monitoring strategy

The Marlborough Coastal Monitoring Strategy was published in 2012, and a number of changes in monitoring activity have subsequently occurred. This includes the establishment of the Marlborough Sounds water quality monitoring programme, hydrodynamic modelling, and estuarine surveys.

The principal objectives of the proposed coastal monitoring programme were:

1. To assess the state and trends of the coastal environment in order to comply with the requirements of the RMA, New Zealand Coastal Policy Statement (NZCPS) and Regional Plans.
2. To provide water quality data for the Marlborough Sounds to (i) build and develop hydrodynamic and ecological models (ii) to assess the impacts of land use and aquaculture on water quality in the Sounds (iii) to provide baseline data from which future trends in water quality can be assessed.
3. To assess and monitor the state of ecologically significant marine sites identified by Davidson et al. (2011) with the help of a coordinated multi-agency approach.
4. Identify and describe new significant sites through field surveys where additional or anecdotal reports indicate significant habitats may be present.
5. Develop a web-based database for the collation of knowledge on marine biodiversity.
6. To ensure the ecological integrity, recreational and cultural values of the marine environment are not compromised through mismanagement and/or intensification of the marine environment.
7. Explore opportunities to involve iwi in the implementation of the strategy.
8. To investigate and collect information to help inform the community on the pressures and issues related to the coastal environment.

The considerations and monitoring options presented here are particularly relevant to points 6-8. We note that there is no consideration of the establishment of historical baselines in the principal objectives, however these are key for effective management decision-making.

5.2. Opportunities for integrated environmental monitoring

Representatives from 11 iwi and stakeholder groups were interviewed in 2016 regarding the potential for establishing integrated monitoring in the Marlborough Sounds (Forrest et al. 2016). Advantages of an integrated approach were identified:

- more efficient and 'fit-for-purpose' monitoring, with the potential for cost-savings to stakeholders. For example, SOE monitoring could provide regional reference sites against which the effects of point-source activities were assessed
- improved scientific consistency and quality control of monitoring design, methods, data analyses and evaluation, contributing to a consistent management response and an improved understanding of cumulative effects
- centralised storage for monitoring data, enhancing the potential for data sharing and increasing stakeholder collaboration and trust.

Monitoring activity undertaken in Picton Bays should, as much as possible, employ the same methodology as other programmes underway in Marlborough. Alignment in time is also best practice where relevant and possible. Data from a Picton Bays monitoring programme would also be incorporated into any larger-scale assessments and into any centralised data-management systems.

5.3. MfE/Statistics NZ report 'Our marine environment 2016'

This work, undertaken under the Environment Reporting Act 2015, identified three top issues in the New Zealand marine environment:

- global greenhouse emissions are causing ocean acidification and warming
- native birds and mammals are threatened with extinction
- coastal marine habitats and ecosystems are degraded.

When considering 'Our coastal waters, harbours, and estuaries' (p. 38 in 'Our marine environment') the most important pressures identified from expert opinion and scientific literature (and recognising data scarcity in many areas) were:

- ocean acidification and impacts of climate change
- excess sedimentation, which accumulates over decades and can directly affect shellfish and finfish species and destroy important habitats including fish nurseries
- seabed trawling and dredging for fish and shellfish
- marine pests, which can alter ecosystem processes and modify natural habitats, potentially causing biodiversity loss and threatening marine-based industries
- excess nutrients carried down waterways, mostly from urban development and agriculture, which can reduce oxygen in seawater and contribute to algal blooms, harming marine ecosystems.

Sediment input and habitat integrity therefore rank highly in this assessment, with nutrient enrichment being an important concern, but not quite as high a priority.

5.4. Coastal SIG

Coastal Special Interest Group (C-SIG) is made up of coastal scientists and planners from New Zealand's regional councils and unitary authorities. C-SIG research needs were identified and prioritised as reported in Berkett et al. (2015). The five highest scoring research needs were:

1. Develop nationally consistent frameworks (including determining core parameters and quality assurance) for both regional and spatially-targeted monitoring (e.g. estuaries) that incorporates cost-effective technologies.
2. Characterise the existing CMA by collecting appropriate data for establishing baselines.
3. Identify relevant and meaningful indicators to describe the state and condition and assess change over time of the CMA.
4. Research environmental thresholds and establishing appropriate and relevant limits and standards for stressors impacting on the CMA, including those derived from land-based activities.
5. Identify the effects of stressors within both a spatial and temporal context. Understand the synergistic and cumulative effects of multiple stressors and develop tools to manage these effects.

The key initial point relevant to this report is that of characterising the CMA, however when the specific design of monitoring surveys occurs, the consideration of consistent frameworks and indicators would be critical. In many cases, these are under development in research projects, and monitoring programmes should be designed according to best practice at the time.

5.5. Assessment of anthropogenic threats to New Zealand marine habitats

In a study that employed expert knowledge to identify the most important anthropogenic threats to New Zealand's marine habitat (McDiarmid et al. 2012), threats associated with climate change were very important. However, threats deriving from activity on land (in catchments that discharge into the sea) were also very important; of these, sedimentation was the most important. This was 'the highest ranked threat for five coastal habitats including harbour intertidal mud and sand, subtidal mud, seagrass meadows, and kelp forest.'

Other highly-ranked threats included fishing (dredging, bottom-trawling, line and longline fishing, trapping, and shellfish gathering—all individually identified as high impact), invasive species, algal blooms, increased turbidity, coastal engineering (including reclamation), pollution from sewage discharge, increased nitrogen and phosphorus loading, oil and heavy metal pollution, and aquaculture (benthic deposition).

The causes of climate change, and the associated threats to the marine environment, are important to the marine environment in Picton Bays, and should be considered in state of the environment monitoring. Nonetheless, they occur on a global scale, and are therefore not of specific relevance to Picton Bays. Sedimentation is, however, of particular relevance due to the sheltered environment, high sediment inputs, and presence of vulnerable habitat in Picton Bays. All the habitats for which sedimentation was the highest ranked threat are, or were, present in Picton Bays.

5.6. United Nations sustainable development, Goal 14

The United Nations sustainable development Goal 14 is to: Conserve and sustainably use the oceans, seas and marine resources. This is focused on management rather than monitoring.

Targets with particular relevance to the Picton Bays include:

- 14.1 by 2025, 'prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution'
- 14.2 refers in general terms to sustainable management and resilience
- 14.4 includes 'to … end … destructive fishing practices'
- 14.5 identifies a target of 10% protection of coastal and marine areas by 2020

If the Picton Bays are considered an area of specific interest, consideration of protection on the scale proposed by the UN (10% protection) could be considered. This would provide the opportunity to address the potential for environmental recovery in a relatively high-use environment. This protection would be relevant to a monitoring programme, as it would (along with other means of assessing environmental health) allow for current measurements to be placed in a broader context—i.e., to be compared to a less-impacted environment.

6. CONCLUSIONS

There is widespread interest in an improved and integrated understanding of the environment of Picton Bays and the wider Marlborough Sounds. While Te Ātiawa o Te Waka-a-Māui are not currently in a position to prioritise development of cultural indicators of environmental health, commonly-collected data is of use in the interim.

The importance of broad-scale assessment of environmental health was expressed by interested parties, and state of the environment monitoring was the intended subject of this report. SoE monitoring by definition does not address specific activities, but there is also a desire among interested parties to be able to make clearer links between environmental quality, and the stressors of interest. The differing purposes for monitoring are each valid, but do become subject to cost-benefit analyses, such that priorities must be established. Moreover, research projects may be a more appropriate means of addressing some cause-effect relationships than reliance on monitoring data alone.

All monitoring, including the control sites in consent-associated monitoring, contribute to the establishment of contemporary baselines. The utility of a given data set in defining the contemporary baseline is dependent on the intensity of monitoring relative to the variability in the environment. When these data are used to assess effects, the utility of the data will depend on the precise requirements of the assessment of effects. Accordingly, it is not possible to identify survey requirements that will in all cases fulfill requirements for baseline data quality. Moreover, data collection will always be subject to a cost-benefit tradeoff. Identification of specific survey aims will provide the basis for development of detailed survey designs, e.g., survey intensity, frequency, and parameter selection.

An assessment of the historical baseline is necessary to understand the state of the contemporary environment. This can take a number of forms, including use of physical environmental samples, comparison to relevant reference conditions, collection of historical knowledge, and use of scientific literature to establish likely pre-impact environmental characteristics. Establishment of a historical baseline does not, however, necessarily imply an aspiration to return an environment to that state.

There is not currently a great deal of direct environmental monitoring occurring in Picton Bays. Key opportunities for integration include the habitat information collected for Port Marlborough consenting processes. Established monitoring activity includes the estuarine monitoring programme, which addresses the areas that are ecologically, the most important environments in the Picton Bays. These habitats are rare in the Sounds, have very high values in terms of biodiversity, and can mitigate land-to-sea effects such as sediment input.

It is beyond the scope of this project to attempt to articulate community aspirations or management aims or priorities for the Bays. Some members of the community accept substantial environmental degradation as a tradeoff for the other uses of the Bays. Others have aspirations for environmental recovery. It is our understanding that the state of the Picton Bays environment is of great concern to many iwi, and no doubt to other members of the community. Improved environmental monitoring and research data will facilitate well-informed discussion regarding management aims for the Picton Bays. We understand Council is looking to develop a coastal science strategy through the Marlborough Marine Futures forum, and this report should inform development of monitoring priorities as part of that process.

6.1. Recommended programme

The following recommendations have been prioritised according to our impression of the value of each option on the basis of all factors considered in this report (see Section 4). However, further consultation or focus on specific council priorities may, quite reasonably, result in differing priorities.

In order to prioritise monitoring, the recommended programme below assumes that there is interest in targeting Picton Bays over and above that of the Marlborough Sounds generally. The programme is intended to collect the best data to:

- use as an engagement tool
- reflect broad measures of environmental health and establish the context for activity in the Bays
- address some interests of iwi
- rationalise investment in project-driven data collection[12] .

The recommended monitoring programmes are:

1. Establishment of a **habitat mapping** programme. Factors influencing the placement and scale of monitoring will include:
    - management changes such as protection from disturbance and fishing pressure
    - integration with Port Marlborough monitoring
    - integration of **fisheries species/kaimoana**
    - integration with Ecologically Significant Marine Site network
    - availability/quality of multibeam echosounder data.

[12] At this time, this principally refers to investment made by Port Marlborough in gathering data from the marine environment. It is beyond the scope of this report to propose financial arrangements for funding monitoring programmes. We simply reflect the finding from conversation, and from Forrest et al. (2016), that integrated and efficient monitoring programmes are supported in principle by a number of relevant parties.

An assessment of the integrity of the contemporary baseline could be made by comparison to data from coring studies, and historical habitat information from documented sources, and from community members.

2. Establishment of a **shellfish suitability for consumption** programme. Over the first year this would be moderately intensive, (e.g., monthly sampling of two or three sites per bay, dependent on the distribution of shellfish suitable for harvest). Following the initial period, survey design would be adaptive, dependent on the previous results.

3. **Addition of a water quality monitoring station** (or two) in Picton Bays to the wider Marlborough Sounds water quality monitoring programme. Integrate this location into any future water water quality monitoring programme.

4. **Higher-frequency monitoring of intertidal estuarine habitats**, and targeting monitoring to times when sediment input is expected to be at a peak. For example, opportunistic sampling after storm events, and during the window of expected highest impact after forestry harvest. Consider also addition of cockle surveys designed for their assessment as a **fisheries species**.

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8. APPENDIX

Appendix 1. Considerations for environmental monitoring

A1. Contamination

A1.1. Faecal contamination

A1.1.1. Threats and pressures

Some level of bacterial contamination is frequently present, particularly from diffuse sources that enter the marine environment during heavy rainfall. Shellfish are sometimes not fit for human consumption. Concern has also been expressed by council staff regarding sewage systems that overflow into neighbouring Wharetukura Bay (email from Steve Urlich, MDC, 12 October 2016). However, there is much less contamination in Picton Bays waters than in 1970s, when untreated sewage and freezing work waste were discharged into the sea. An on-going gradual improvement is apparent on the Picton foreshore.

Faecal material comes from a range of sources, including;

- overflows and leaks from sewage systems
- runoff from land containing faeces from farm animals, domestic animals, and potentially humans
- seabirds and potentially from marine mammals.

These pressures are all present to some extent in Picton Bays.

A1.1.2. Knowledge on state and trend

The state and trend of bacterial contamination in water in Picton Bays is one of the best-understood aspects of the marine environment; some substantial historical studies have been undertaken and council recreational water quality surveys are undertaken at two sites throughout summer. Contamination of shellfish by faecal material is less well-understood. The data that are available indicate that faecal contamination is often too high for safe consumption of harvested shellfish (Newcombe & Johnston 2016).

A1.1.3. Importance to the community

Faecal contamination of waterways, in particular contamination by human faecal material, is in general of particular concern for Māori. Considerable concern regarding faecal contamination of shellfish in Picton Bays was expressed by the iwi representative (Raymond Smith) on the MDC Environment Committee[13].

Faecal contamination is also important to the general community, as it has implications for health relating to contact recreation and to the consumption of contaminated shellfish.

A1.1.4. Available methods and ability to measure and detect change

It is relatively simple and low-cost to measure faecal contamination in the water column, or in shellfish, by collecting physical samples, and sending them for laboratory analysis of the concentration of particular indicator bacteria (ideally three classes are measured; *Escherichia coli*, faecal coliforms, and enterococci). However, the relationship between water column and shellfish bacterial concentrations, and between bacterial concentrations and pathogenicity can be weak. Both water samples and shellfish flesh samples have very variable concentrations of faecal indicator bacteria, in order to reliably assess concentrations, and to detect change, it may be necessary to collect a large number of samples. Molecular methods (microbial source tracking) can be used to identify sources of faecal contamination (e.g., Cornelisen et al. 2011).

A1.1.5. Causal links

Causes of elevated faecal indicator bacteria can be identified by sampling at source, but can otherwise be difficult to clearly attribute to a particular source. Microbial source tracking can identify a source species (such as birds or cattle) for which a direct pathway to management (or reassessment of risk) may be apparent, but identification of diffuse contamination by human sources may be difficult.

A1.1.6. Pathways to management

When sources of faecal bacterial have been traced, it is theoretically straightforward to limit future contamination in some cases, however political and logistical factors quickly come in to play. For example:

- it is expensive to upgrade sewer and stormwater systems
- there is an on-going debate in New Zealand regarding the appropriateness of stock access to waterways
- while by-laws require that dog owners remove dog faeces from public places, this frequently doesn't occur. Moreover, no similar requirement exists for cats generally, or for disposal of faeces of domestic animals on private property.

[13] On the occasion of the presentation of the report 'Picton Bays environmental information and health assessment.' (Newcombe & Johnston 2016) 24 March 2016.

Some sources of faecal contamination (seabirds and marine mammals) are natural, and would be impossible to eliminate.

A1.1.7. Ongoing environmental monitoring

Annual monitoring of discharge (rather than sampling in the receiving environment) occurs for a number of discharges, including the Picton Sewage Treatment Plant (CH2M Beca 2016). Council recreational water quality monitoring involves sampling of marine waters, and occurs at the Picton foreshore and in Waikawa Bay every summer. PML on occasion measure faecal contamination as part of consent-associated activity.

A1.1.8. Scale and integration

Due to the lack of other similar-sized urban environments in the Marlborough Sounds, findings from monitoring of pathogens in Picton Bays is unlikely to be relevant to other areas of the Marlborough Sounds. Faecal contamination tends to be patchy and localised. Hotspots of contamination in the Sounds that have been identified by council tend to be related to particular infrastructure issues. Opportunities for particular places to function as sentinel or representative sites are therefore limited.

A1.2. Nutrient contamination (enrichment)

A1.2.1. Threats and pressures

Nutrient contamination could occur as a result of:

- over-development of feed-added aquaculture
- run-off of fertiliser or animal waste from farmland
- disposal of nutrient-rich waste products (including sewage)
- sediments that carry nutrients being washed into the sea, or resuspended.

Neither aquaculture nor large areas of land-based farming are present in the immediate Picton Bays region. Picton Sewage Treatment Plant discharges effluent into Picton Harbour, and it is possible that diffuse sources including leaking septic tank systems provide some nutrient input. Forestry and other activities that cause land disturbance are also present.

A1.2.2. Knowledge on state and trend

Current knowledge about local levels of enrichment is available in the estuarine state of the environment monitoring programme, such as the recent surveys undertaken at Shakespeare Bay (Berthelsen et al. 2016) and Waikawa (Robertson & Stevens 2016). Patchy information exists on nutrient levels in the water column and the seabed from a range of consent-associated and council-commissioned surveys. Larger-scale water column surveys undertaken throughout the Pelorus and Queen Charlotte Sounds measure nutrient levels monthly[14].

As with bacterial contamination, available data has been sufficient to document a reduction from extreme nutrient enrichment in the vicinity of untreated sewage and freezing work outfalls. It is difficult to address the current trajectory of change due to lack of consistent data collection methods and sampling stations over time.

A1.2.3. Importance to the community

There is some concern within the community regarding the effects of feed-added aquaculture in the Marlborough Sounds—however this is most effectively addressed in Sounds-wide monitoring than in the smaller Picton Bays area. While there is general concern about nutrient enrichment in the area, it is not known to what extent this is the case for Picton Bays specifically.

A1.2.4. Available methods and ability to measure and detect change

Water column

Water column nutrient levels are easy to measure in water samples. However, nutrient concentrations can be highly variable, therefore high frequency measurements are required to detect any long-term change[15]. The use of moored instrumentation improves the ability of in-situ monitoring to provide meaningful data, however direct measurement of nutrients is not yet possible, and therefore indirect measurement of nutrient concentrations is required (chlorophyll-*a*, see below).

Measurement of one of the key results of nutrient contamination—algal growth—may be a more effective approach, and is increasingly being considered in national guidelines (such as the National Objectives Framework, which considers upstream nutrient levels). This could be measured either in the water column—where chlorophyll-*a* is a widely-used proxy for phytoplankton density—or on the seabed, as macroalgal cover[16]. Measurement of phytoplankton can be undertaken with a moored fluorometer, or in water samples. Macroalgal cover is affected by a range of factors other than nutrient levels (such as grazing, habitat availability), making it a less reliable indicator. Accordingly, macrophyte cover is unlikely to be a useful indicator of nutrient levels in Picton Bays.

[14] A number of forms of nitrogen and phosphorous are measured, see Broekuizen (2015)
[15] the limitations of monthly (as opposed to higher-frequency) measurement are discussed in Forrest et al. (2016)
[16] Although macroalgae (seaweeds) grow on the seabed, they are still an indicator of water-column nutrient levels.

Seabed

Seabed sediments can serve as a less variable indicator of water column enrichment, as nutrient levels in the water column over a period of time are reflected in sediments. The nutrients themselves can be measured, but other environmental parameters are often also measured to provide a more detailed picture of environmental status. These parameters include indicators of oxygenation and infaunal community structure (Robertson et al. 2002).

A1.2.5. Causal links

The ability to attribute nutrient levels to a particular cause is problematic, largely due to mixing of water bodies. Causal links between minor or moderate sources of nutrient input are, therefore, difficult to attribute to particular sources on the basis of environmental monitoring. However, freshwater inputs may be measured to indicate the level of terrestrially-derived nutrient inputs. Measurements at source and modelling approaches may be a the most effective approach in establishing relative importance of different inputs.

A1.2.6. Pathways to management

Some nutrient inputs are highly manageable (such as control of inputs from feed-added aquaculture), while others suffer the same limitations as those associated with bacterial contamination; namely, high costs of infrastructure improvement and limited control over farming practices.

A1.2.7. Ongoing environmental monitoring

The key ongoing environmental monitoring relevant to nutrient enrichment is the MDC water quality monitoring programme in the Marlborough Sounds. This includes measurement of a number of forms of nitrogen and phosphorus, and other parameters relevant to nutrient enrichment and primary production (including chlorophyll-*a*). A number of limitations (sampling frequency and sample size) restrict the ability of this programme to robustly measure variation in water quality in the Sounds (Forrest et al. 2016). Nonetheless, it seems logical that if any nutrient monitoring of marine water quality is undertaken in Picton Bays, that it be aligned directly with MDC's approach in the wider Sounds. Given this consideration, the addition of a site (or sites) in Picton Bays might be considered. As it stands, sites to the east and west of the Picton Bays are included in the surveys (Figure A1).

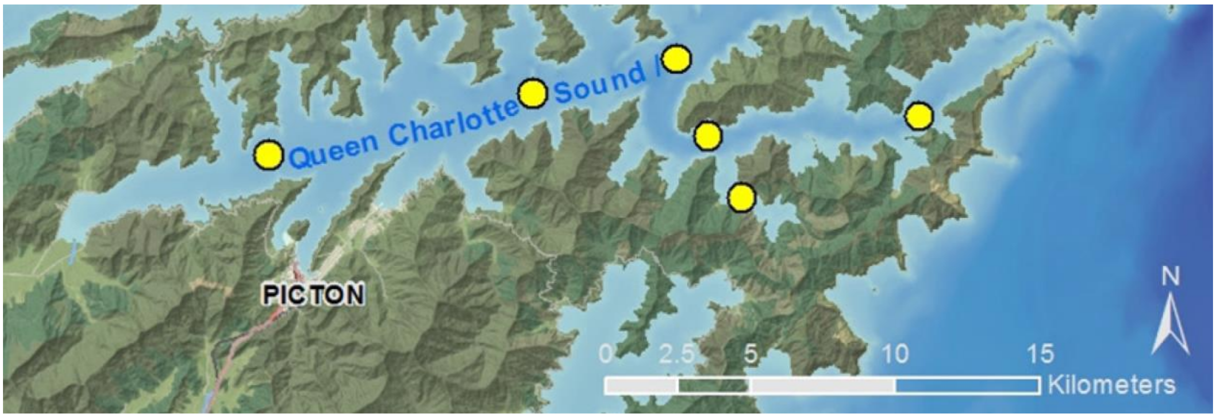

Figure A1. The MDC Coastal Water Quality Monitoring programme includes sampling stations (yellow circles) to the west and east of Picton Bays. Image from MDC 2016, Coastal Water Quality - Monitoring 2015/2016.[17]

Data on freshwater inputs are collected by MDC, including from the Waitohi Stream[18], which flows into Picton Harbour. Streams running into Waikawa Bay and Shakespeare Bay are not monitored; however, monitoring of the intertidal estuarine environments in Waikawa Bay and Shakespeare Bay is expected to occur on a regular (although not frequent) basis[19]. Occasional habitat characterisations that occur associated with consent processes, such as dredging, include analysis of sediment nutrient levels.

A1.2.8. Scale and integration

Due to the mixing of water bodies, water column nutrient levels are most meaningfully measured on a large scale. Context for nutrient levels is provided by the Marlborough Sounds water quality monitoring programme. Addition of water quality sites within Picton Bays would serve to monitor this as an area of special interest, in relation to the wider Sounds.

Seabed nutrient levels from estuarine surveys are currently being compared in analyses of all estuarine data available nationally as part of the MBIE-funded programme: Oranga Taiao, Oranga Tangata (OTOT) – Knowledge and toolsets to support co-management of estuaries. While no formal programme exists for comparative work in sub-tidal areas, there are numerous datasets that collect this information, including at a number of reference sites around the Marlborough Sounds. A prime example of this is the New Zealand King Salmon monitoring data. This could

[17] http://www.marlborough.govt.nz/Environment/Coastal/~/media/Files/MDC/Home/Environment/Coastal/Report_Card-Coastal_Water_Quality-2016.pdf

[18] https://www.lawa.org.nz/explore-data/marlborough-region/river-quality/waitohi-stream/waitohi-river-at-state-highway-one/

[19] Monitoring of Shakespeare Bay is expected to occur 5-yearly, however no schedule was indicated for Waikawa in the 'Coastal Monitoring Strategy, Marlborough' (Tiernan 2012)

provide context for any assessment in enrichment levels in Picton Bays, as well as an indication of broad-scale changes over time.

A1.3. Chemical contamination (toxicity)

A1.3.1. Threats and pressures

Likely sources of contamination in coastal marine areas include:

- Urban and industrial runoff—point-source and diffuse
- Antifouling compounds—historical deposits and ongoing leaching and particulate matter
- Disposal of contaminated waste (e.g., sewage, industrial waste)—historical and current

These stressors are present to some extent in Picton Bays, however present-day sources of contamination (stormwater and outfalls) are addressed through consent monitoring.

A1.3.2. Knowledge on state and trend

Moderate localised impacts of historical activity persist, and have been documented in targeted surveys (e.g., Stewart 2004, Conwell & Sneddon 2009). Some chemical contamination is detectable near point-sources such as stormwater outfalls (various consent-associated reports), and low concentrations of chemical contaminants are also detected more widely (i.e., not associated with a point-source). Often these are detected at control sites of monitoring targeting consented activity. The ongoing status and any trends of these diffuse contaminants are not well-understood.

A1.3.3. Importance to the community

We have little information regarding the extent to which chemical contamination of Picton Bays is of concern to the community. Recent measurement of heavy metals in cockles from Waikawa Bay showed that concentrations were not at levels that would cause concern for human health[20]. Bruno Brosnan (Te Ātiawa Rohe Manager) referred to this finding when discussing the belief that monitoring of chemical contamination was not of primary importance to Te Ātiawa.

A1.3.4. Available methods and ability to measure and detect change

Chemical concentrations can be readily measured with physical samples of water, sediments, or shellfish flesh, which are sent for laboratory analysis.

[20] Email Brian Roughan (Ministry for Primary Industries) to Steve Urlich (MDC) 10 October 2016.

Effects to affecting marine communities can be assessed by comparing contamination levels and the community structure of animals that live in sediments (infauna), although the effects of chemical contamination vs. other stressors is sometimes not readily distinguished.

A1.3.5. Causal links

Broadly, causes of contaminants are easy to assign, for example, certain compounds are known to be present in antifouling compounds, while others result from the combustion of fossil fuels, or other identifiable activities. However, many such compounds also occur naturally in the environment, although generally at low levels. The specific source of contamination may, however, not be readily identified. For example, consent-associated stormwater and sewage treatment plant outfall monitoring has shown that contaminants were detected, but that they were not associated with the consented activity (Peacock et al. 2015). Either historical or diffuse sources of contamination can be more important than current consented activities. Habitat factors can also complicate the identification of sources of contamination. For example, finer sediments retain higher levels of contaminants than coarser sediments, due to the increased surface area of the fine sediments. Nonetheless, causal links between contaminant sources and environmental contamination could be identified in many cases with sufficiently high resolution sampling.

A1.3.6. Pathways to management

In recent decades, a number of chemicals that have historically caused high levels of contamination have been controlled by changes in legal restrictions to use or in management practices. For example, changes to hull-cleaning protocols and in permitted antifouling compounds have been made to reduce negative effects from toxicity. Often diffuse sources are responsible for new contamination, and these are difficult to manage. Further restrictions on use of some toxins would be subject to trade-offs between toxicity issues on one hand, and biosecurity and efficiency concerns on the other. It is unlikely that current sources of chemical contamination would be easily reduced.

With respect to persistent contamination from historical sources, it is possible to mitigate effects of contaminated sediments, by dredging and disposal elsewhere, or by sealing of contaminated sediments. Disturbance may, however, worsen the effects of otherwise localised and stable contaminated sediments.
Effects of ongoing consented point-source discharges are addressed and managed within the consenting framework.

A1.3.7. Ongoing environmental monitoring

Five-yearly benthic surveys associated with Picton Sewage Treatment Plant (Peacock et al. 2015) include analysis of sediment chromium, copper, mercury, lead and zinc. Contaminants are often measured in environmental assessments associated with Port Marlborough consenting processes, but this does not occur on a regular basis.

A1.3.8. Scale and integration

There is no obvious hierarchy of representativeness apparent for chemical contamination within Picton Bays, or with respect to the Sounds more broadly. Commonly monitored chemical contaminants are generally related to localised activities (large numbers of moored boats, historical hotspots of contamination, monitored outfalls). As such, data regarding such sources of contamination are unlikely to be informative of near-by or far-field contaminant levels.

A1.4. Sediment inputs

A1.4.1. Threats and pressures

Increases in sediment inputs can result from:

- reduction in forest cover
- land disturbance during farming, construction, etc.
- natural and human-exacerbated land instability, both coastal and inland.

All these stressors are present in Picton Bays.

A1.4.2. Knowledge on state and trend

While there is little empirical data available regarding sediment loadings, sediment input can be calculated from land use[21]. Sediment structure is measured as part of estuarine monitoring, which have been undertaken recently at both Shakespeare Bay and Waikawa (Berthelsen et al. 2016; Robertson & Stevens 2016). Subtidal seabed sediments have also been studied for a range of purposes, including consent-associated surveys (e.g., for dredging effects). However, due to high levels of disturbance, including dredging, it is difficult to distinguish between new inputs from land and mobility of marine sediments in the Bays.

Historical inputs were likely very high when land was cleared for a range of purposes. Sediment input from land has probably decreased but is on-going. Hydrodynamic data have shown that sediments deposited into the sheltered Picton Bays are not exported again due to the low water movement experienced in the area (Urlich 2015), therefore effects of inputs are expected to persist.

[21] Sediment yield can be calculated with the tool at www.niwa.co.nz/freshwater/management-tools/sediment-tools/suspended-sediment-yield-estimator

A1.4.3. Importance to the community

Te Ātiawa have expressed concern about sediment input associated with earthworks (Ian Shapcott, pers. comm.), and some interviewees recognised sedimentation as an important issue. However, the extent to which the causes and implications of sediment inputs and resuspension are understood by the community generally is unclear.

A1.4.4. Available methods and ability to measure and detect change

Sediments can be measured in water column, but also the composition of the seabed can indicate the historical, and potentially recent, sediment input regime. Composition is established by laboratory processing of samples. Techniques also exist for identifying the source of sediments. Chemical biomarkers from different plants are retained in sediments, and the proportional contribution of different land-uses in a catchment to sediment contamination can therefore be calculated (Gibbs 2008).

A1.4.5. Causal links

Pulses in sediment may be identifiable in freshwater sources and coastal waters, particularly during storms. However, in shallow areas, sediment input can be difficult to separate from resuspension. Source tracking with chemical methods can identify the land-use type, but not the specific location. Accordingly, clear causal links can be difficult to establish.

A1.4.6. Pathways to management

Controls on land use and mitigation of effects of disturbance can limit sediment input, however some input is natural, and diffuse inputs from a range of exiting activities and land uses are inevitable.

Erosion of the shoreline is very apparent in many places in the Marlborough Sounds generally, and this is expected to increase as sea levels rise in association with global climate change. This can be mitigated in a number of ways, including land-use changes, however an assessment of the extent to which this is feasible with respect to many factors, including cost, would require expert assessment.

A1.4.7. Ongoing environmental monitoring

The key ongoing environmental monitoring relevant to sediment levels in the water column is the MDC water quality monitoring programme in the Marlborough Sounds. This programme includes measurement of light levels from a sensor lowered through the water column. It also includes measurement of secchi depth, as well as the collection of samples to measure turbidity and total suspended solids (Broekhuizen 2015).

Occasional habitat characterisations that occur associated with consent processes, such as dredging, include analysis of sediment structure. Monitoring of the intertidal estuarine environments in Waikawa Bay and Shakespeare Bay is expected to occur on a regular (although not frequent) basis[22], and includes measurement of sediment grain size. These data may be more informative of sediment contamination than subtidal seabed data, as it suffers less direct disturbance. Estuarine data may not, however, reflect the effects of coastal erosion.

A1.4.8. Scale and integration

Because of their propensity to settle out of the water column, suspended sediments are likely to vary on a smaller scale than nutrients (although sediments can also carry nutrients).

The estuarine sandflats could act to some extent as sentinel areas for the Picton Bays, or even further afield. The extent to which they serve as sentinel areas may require further investigation, as it is dependent on the relative amount of sediment loadings coming in through permanent freshwater sources (the streams) as opposed to direct runoff from land and shoreline erosion.

[22] Monitoring of Shakespeare Bay is expected to occur 5-yearly, however no schedule was indicated for Waikawa in the 'Coastal Monitoring Strategy, Marlborough' (Tiernan 2012)

A2. Habitat integrity

A2.1. Threats and pressures

Habitat integrity can be degraded by:

- reclamation and dredging—replacement of natural structures with artificial structures or spaces
- incidental disturbance (direct disturbance from fishing / mooring equipment, hydrodynamic disturbance from wakes / prop wash)
- loss of biogenic structure due to removal or other mortality of habitat-forming species (seaweeds, bivalves)
- sediment deposition.

All of these factors are strongly present in Picton Bays.

A2.2 Knowledge on state and trend

The extent of reclamation in Picton Bays is quite extensive, and this can be readily quantified, for example, from standard maps and satellite imagery, alongside some other historical information (e.g., see Newcombe & Johnston 2016). Less information is available on the changes that have occurred to other habitats, as this has been a more gradual and subtle environmental change, and much change pre-dates any formal recording of habitat characteristics.

The state of mudflat estuarine areas at the top of Shakespeare Bay and Waikawa (remnant) has been recently measured. These are recognised as important habitat due to the presence of seagrass beds and other biogenic habitat, and for other aspects of their biodiversity and functioning (such as sediment trapping). These environments are rare in the Sounds. The extent to which many aspects of these estuarine habitats are changed from their original state is not known, but general assessments of health are possible (Berthelsen et al. 2016, Stevens & Robertson 2016, Robertson & Stevens 2016).

The characteristics of extensive habitats in Picton Bays—predominately rocky shores and soft-sediment seabed, and their associated biogenic habitats—are moderately well known in places. Our knowledge comes principally from work undertaken to assess environmental impacts of development projects or dredging for Port Marlborough. Monitoring of the effects of fast ferry operations also provided data on intertidal and shallow sub-tidal habitats. Again, the extent to which these habitats are changed from their original state is not well understood, although our expectation is that these have been substantially impacted by sediment input, disturbance, and both direct and indirect effects of fishing.

A2.3 Importance to the community

Habitat integrity was identified as important during the conversation with the Te Ātiawa representative, because it is central to larger ecosystem function. For Port Marlborough, habitat mapping would reduce the need for repeated surveys associated with consenting applications. It is not clear what importance habitat integrity has to the wider community, however we suspect that the importance of biogenic structure to ecosystem functioning is not well-understood by the general public. Also, a 'shifted baseline' is likely to be perceived as a healthy ecosystem. This is where current generations believe the environment as they experienced it in their youth was 'healthy', without considering that substantial degradation had already occurred.

A2.4 Available methods and ability to measure and detect change

Some aspects of habitat are easily measured and relatively stable: in particular the structure of the seabed (see Ongoing environmental monitoring, below). Seabed photography is an effective means of capturing finer-scale habitat characteristics and species distribution, and could feasibly be used in the Picton Bays. Resultant data would be comparable with a number of existing surveys and observations. Mapping studies can be undertaken at a range of scales, and costs vary accordingly. Costs would be very dependent on the resolution required, particularly in subtidal areas. Intertidal areas could be mapped using drone imagery. Physical measurements such as grain-size and infaunal[23] community structure could further characterise community structure, depending on the level of detail required in the habitat mapping.

Consideration would need to be given to the relative value of mapping the whole of the bays, or of selecting representative areas.

The integrity of the current habitat could be assessed in comparison to similar habitats in protected areas, such as those in or adjacent to ecologically significant marine sites (Davidson et al. 2011). This may provide insight into the historical baseline or recovery trajectory possible at Picton Bays sites. Coring studies can also assist in identifying historical conditions. Sites would need to be carefully selected to incorporate areas that are informative of the Picton Bays environment, but that have not experienced severe disturbance (such as dredging and construction activities).

A2.5 Causal links

Causal links between habitat and particular stressors are difficult to establish, except in the obvious case of reclamation. Even in that case, the implications for biodiversity may not be obvious. For example, some artificial habitats may support healthy natural communities.

[23] Infauna are the animals that live in (rather than on) seafloor sediments

Biogenic habitats, and communities in general, are a result of complex environmental and food web interactions. For example, the absence of seaweed forests could be a result of unsuitable substrate, insufficient light or nutrients, a population explosion of grazing species, a disruption to the reproductive cycle, or a combination of these factors. Similarly, the predominance of fine mobile sediments is likely to be the result of the removal of stabilising species (such as shellfish), terrestrial sediment inputs, and ongoing disturbance of the seabed. Moreover, historical habitat distribution and community structure can be difficult to fully quantify, making the assessment of the current state of health difficult. Nonetheless, substantial information exists to indicate likely causes of change.

A2.6 Pathways to management

Changes in fishing intensity and methodology could lead to recovery of biogenic habitat. Removal of disturbance from swing moorings could limit disturbance to nearby sediments and allow more stable communities to develop. It is not known to what extent other factors (such as suspended sediment loading) may disrupt pathways to recovery of communities.

A2.7 Ongoing environmental monitoring

Estuarine surveys include habitat mapping (Berthelsen et al. 2016, Stevens & Robertson 2016), and extent of important habitat (such as seagrass beds) can be considered to be an indicator of environmental health. No environmental monitoring is currently underway for habitat distribution outside of estuarine areas, however a very relevant piece of work is the multibeam echosounder mapping of the Marlborough Sounds[24]. This large-scale survey is underway to map the physical structure of the seabed in Queen Charlotte Sound. The resultant habitat data are described as follows: 'Multibeam data will … be used to assess the type of substrate or sediments (e.g. hard gravel or soft mud), and what else is on and above the seafloor such as cables, kelp beds and biological aggregations (schooling fish) and geological fault lines'[25]. Accordingly, broad habitat characteristics will be mapped.

The identification of ecologically significant marine sites (Davidson et al. 2011) may provide opportunities for study of protected areas. Should the Marlborough Sounds become subject to substantial changes in fishing pressure (as suggested by Government in early 2016[26]), this would also presumably include targeted monitoring to assess any resultant habitat changes.

[24] http://www.marlborough.govt.nz/Environment/Coastal/Seabed-Habitat-Mapping/Totaranui-Queen-Charlotte-Sound-Seabed-Mapping.aspx
[25] http://www.marlborough.govt.nz/sitecore/shell/Controls/Rich%20Text%20Editor/~/media/Files/MDC/Home/Environment/Coastal/Whats_underneath_the_water.pdf
[26] https://www.beehive.govt.nz/release/recreational-fishing-parks-proposed-hauraki-gulf-and-marlborough-sounds-part-marine-protecte

A2.8 Scale and integration

Picton Bays could function as a representative area for large-scale habitat mapping, and could also include sub-zones specific to particular impacts (future reclamation, mooring disturbance, protection from fisheries impacts). Habitat mapping would also integrate with the multibeam echosounder data.

Some of the already identified significant natural areas could provide useful comparisons for study of the effects of seabed protection on the inner sounds environment. These would likely include Bottle Bay and Umungata Bay subtidal and intertidal areas, Wedge Point, and the areas of and surrounding the Bob’s Bay tubeworm mounds (Davidson et al. 2011).

A3. Fisheries decline

A3.1 Threats and pressures

Extraction of fished species is the primary stressor causing fisheries decline, but secondary effects can also occur, such as the destruction of juvenile habitat, and removal of reproductive stock. Both commercial and recreational harvest can contribute substantially to over-fishing.

A3.2 Knowledge on state and trend

In recent years fisheries have been monitored by MPI on a large scale, although information is not available on a small scale. Accordingly, there is little data available specific to the Picton Bays. Historical reports provide an indication of the abundance of fished species (e.g., those cited in Handley 2016).

A3.3 Importance to the community

Fisheries are undoubtedly of high importance to the community, but the extent to which fisheries within Picton Bays are of interest is not known. The ribbed mussel kopakopa occurs along the coast, and is of particular importance to Māori.

A3.4 Available methods and ability to measure and detect change

A variety of methods are used nationally to assess the status of mobile fisheries, and include;

- catch data (such as abundance, biomass, size structure and catch per unit effort)
- surveys to physically sample target species
- large scale imaging (e.g., Multibeam echosounder, sidescan sonar)

However, an assessment of all potential means is beyond the scope of this report.

Less mobile species (such as shellfish) can be studied on smaller scales with non-destructive techniques such as;

- counts by observers (on SCUBA in sub-tidal areas)
- seabed photography

A3.5 Causal links

A range of factors can affect fisheries, but widespread recovery of valued species is generally seen in the absence of fishing pressure. This indicates that for most commonly fished species, fishing pressure is a key driver of population decline. Other factors, including habitat loss, are likely to also contribute to species decline, or prevent recovery of depleted populations.

A3.6 Pathways to management

The extent to which Council can control fishing pressure is a matter of some debate. A legal opinion asserting that councils can control fishing activity for purposes such as the protection of biodiversity, is currently being challenged in court.

A3.7 Ongoing monitoring

As discussed above, fisheries data are not collected on the scale of the Picton Bays. Some site-specific assessment of kaimoana species has been undertaken in Waikawa by Port Marlborough (unpubl. data). Should the Marlborough Sounds become subject to substantial changes in fishing pressure, this would also call for targeted monitoring to assess any resultant changes in fish stocks and, ideally, to habitat integrity.

A3.8 Scale and integration

The extent to which fisheries in Picton Bays relate to fisheries on a larger scale is difficult to assess, and is beyond the scope of this report. Moreover, fishing pressure in the Picton Bays is probably quite different to other areas of the Sounds.