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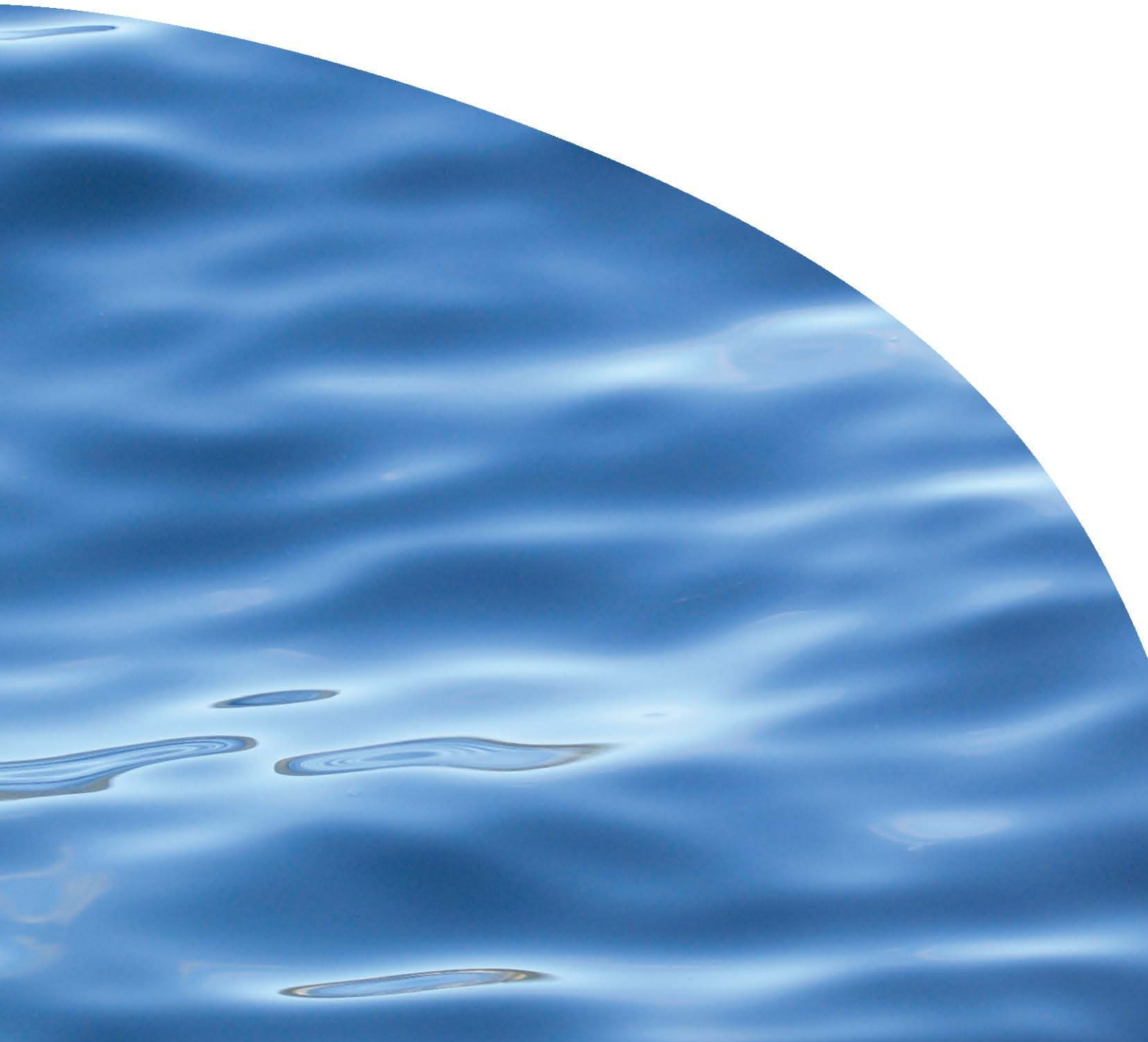
REPORT NO. 2415

MONITORING FRAMEWORK FOR THE WAIKATO COASTAL MARINE AREA: REPORT 1–RATIONALE AND KEY ELEMENTS



MONITORING FRAMEWORK FOR THE WAIKATO COASTAL MARINE AREA: REPORT 1–RATIONALE AND KEY ELEMENTS

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EXECUTIVE SUMMARY

Waikato Regional Council (WRC) has recognised the need to rationalise and improve environmental monitoring for the Waikato coastal marine area (CMA). As part of WRC's steps towards meeting this need, Cawthron Institute (Cawthron) has developed a framework that integrates consent-related and wider state of the environment (SOE) monitoring. With aquaculture as a first case study for the framework, a three-report series has been produced to present the framework and develop ecological monitoring requirements and standards for aquaculture in the CMA. The three reports are as follows:

Report 1: Monitoring framework: Presents the rationale and key elements of a regional monitoring framework that integrates monitoring associated with consented activities and wider SOE monitoring.

Report 2: Regional guidance on priority issues and monitoring: Covers the ecological effects of aquaculture in the Waikato CMA and identifies the priority issues that need to be addressed through industry best practice and reporting, and / or through monitoring of effects (Forrest *et al.* 2014).

Report 3: Monitoring methodologies and standards: Recommends methodologies and standards for monitoring the seabed, water column and the wider environment in relation to the potential effects of aquaculture (Keeley *et al.* 2014).

This document is Report 1 in the series. In developing a framework for monitoring, our initial appraisal for the Waikato region reveals that both consent-related environmental monitoring and SOE monitoring are minimal and not presently integrated with each other. There is a lack of consistency in the approach to monitoring consented activities in terms of the depth and breadth of requirements (*e.g.* parameters measured, monitoring frequency), with the majority of activities (other than aquaculture) requiring no monitoring. State of the environment monitoring is so limited in scope at present that the background state of the environment, the importance of various activities, and the relative importance of diffuse-source effects (*e.g.* from catchment inputs), are poorly understood. Additionally, there is limited recognition of the potential for cumulative effects on the CMA.

To address these shortcomings, a regional framework is presented (Figure 1) that advocates: (1) the definition of clear goals, (2) an understanding of the sources of risk to the CMA so that monitoring priorities can be determined based on actual or potential effects, and (3) identification of linkages between fine-scale consent-related environmental monitoring and broad-scale SOE monitoring. Whereas consent monitoring is clearly targeted toward effects of discrete point source anthropogenic activities, we suggest that SOE monitoring should:

1. Align with, and provide a direct context for, understanding the effects of consented activities.
2. Capture trends in background conditions that may be influenced by diffuse-source pollution (*e.g.* from river discharge), and interact with consent-related sources.

3. Capture trends in background environmental conditions that may have no recognised or direct link with consented activities or other anthropogenic effects.

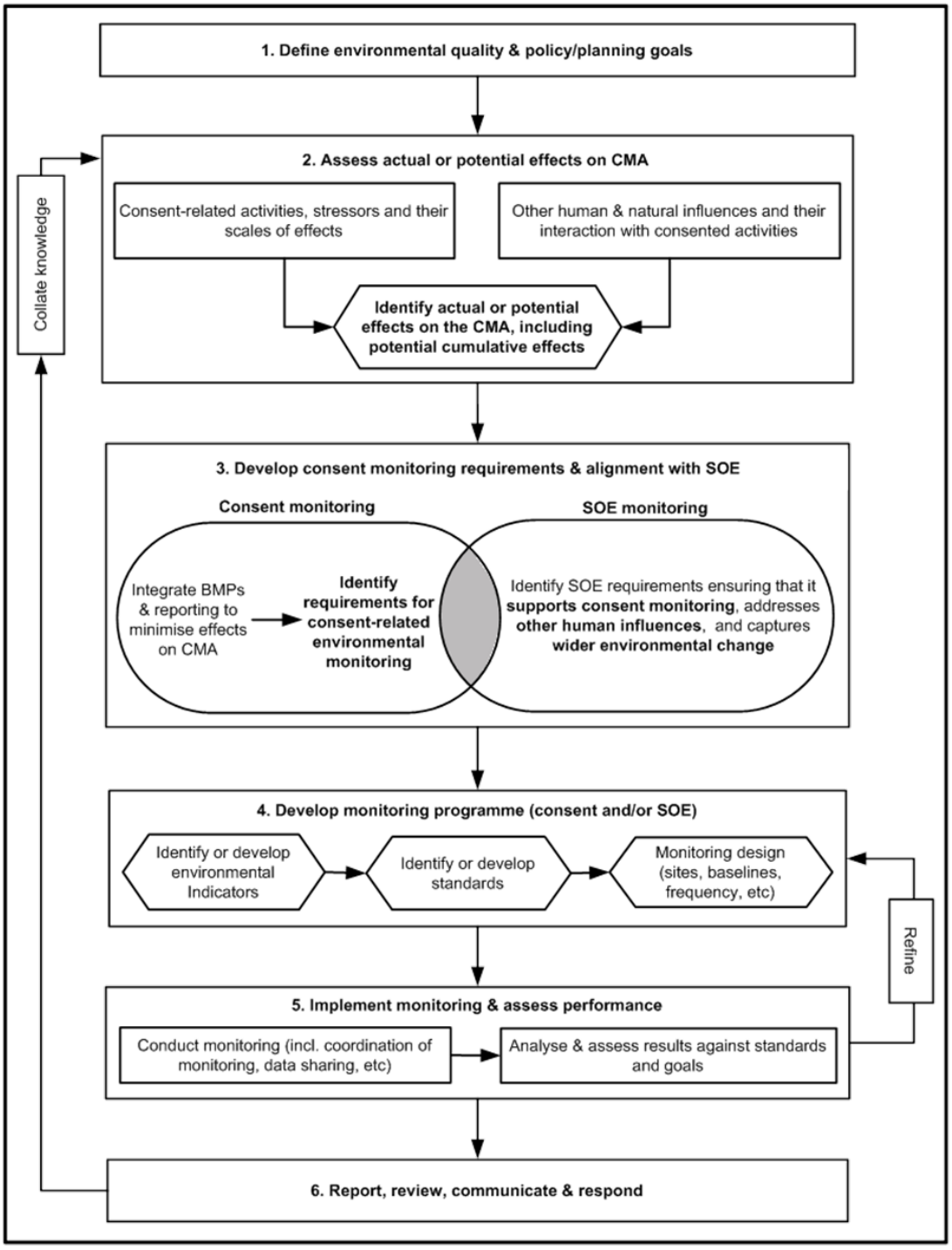

Figure 1. Regional monitoring framework described in this report.

The process of identifying the actual requirements of a monitoring programme needs to consider many technical and non-technical (*e.g.* cost and cost allocation, stakeholder uptake, public expectations regarding monitoring) aspects. To delve into all of these was beyond our present scope; however, some key technical considerations include:

- identifying the suite of environmental indicators that reflect changes in priority activities and stressors, and adopting or developing standards for them in order to assess and evaluate the significance of monitoring results
- deciding where monitoring sites should be located and how many to monitor. Can representative activities or habitats/sites be monitored to improve efficiency and reduce cost? Are suitable reference sites available? What type of baseline data on environmental conditions and natural variation are needed? How often should monitoring be undertaken?
- deciding on appropriate methods and spatial scales of sampling, and identifying where existing or emerging technologies could be used to enhance efficacy or reduce monitoring costs (*e.g.* use of real-time water quality monitoring buoys in SOE monitoring to characterise background environmental conditions).

In terms of implementation, it is suggested that a programme with well-integrated consent-related and SOE monitoring would be conducted more efficiently, and has the potential to be more useful, if it was managed and undertaken (or at least coordinated) by WRC. This would enable scientific consistency (*e.g.* in terms of methods and timing of monitoring) and quality control, a central repository for the data, and would cater for a standardised approach to evaluation of results and assessment of environmental quality from a regional perspective; these are all desirable features that are currently absent.

Progressing a regional monitoring approach in its entirety (*e.g.* considering all activities in the region's CMA) would be a significant undertaking, and there will be issues to resolve in relation to activities whose effects cross regional boundaries, and for which regional councils have no control (*e.g.* fishing). In the meantime, the regional aquaculture monitoring case study described in the next two reports in this series will build on and operationalise many of the ideas described here.

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1. INTRODUCTION

1.1. Background

Waikato Regional Council (WRC) has recognised the need to improve environmental monitoring within their coastal marine area (CMA; Figure 2), as presently there is a lack of cohesion between resource consent-related monitoring undertaken for coastal developments and regional state of the environment (SOE) reporting. Through the development of an overarching framework, WRC aims to make monitoring more integrated and efficient, and increase the value and utility of the data that are acquired. Improvements in this regard will assist WRC in meeting its policy and planning goals regarding sustainable integrated management of the region's CMA.

As part of WRC's steps towards meeting these needs, the Cawthron Institute (Cawthron) has produced a three-report series aimed at developing monitoring requirements and standards for aquaculture in the CMA. The three reports are as follows:

- **Report 1: Monitoring framework:** Presents the rationale and key elements of a regional monitoring framework that integrates monitoring associated with consented activities and wider SOE monitoring.
- **Report 2: Regional guidance on priority issues and monitoring:** Covers the ecological effects of aquaculture in the Waikato CMA and identifies the priority issues that need to be addressed through industry best practice and reporting, and/or through monitoring of effects (Forrest *et al.* 2014).
- **Report 3: Monitoring methodologies and standards:** Recommends methodologies and standards for monitoring the seabed, water column and the wider environment in relation to the potential effects of aquaculture (Keeley *et al.* 2014).

This document is Report 1 in the series, and considers how monitoring can be placed within a framework that integrates consent-based and wider SOE approaches. The focus on aquaculture in Reports 2 and 3 serves as a tractable means of illustrating the issues that arise when developing a regional monitoring approach. Simultaneously, this focus assists WRC in its need to develop improved guidance for the aquaculture industry on consent-related environmental monitoring and reporting requirements.

All three reports have been undertaken by Cawthron in collaboration with WRC, with support from the Ministry for Primary Industries (MPI) Aquaculture Planning Fund. It is expected that the ideas and approaches presented in the reports will be a starting point for consultation with the aquaculture industry and other stakeholders.

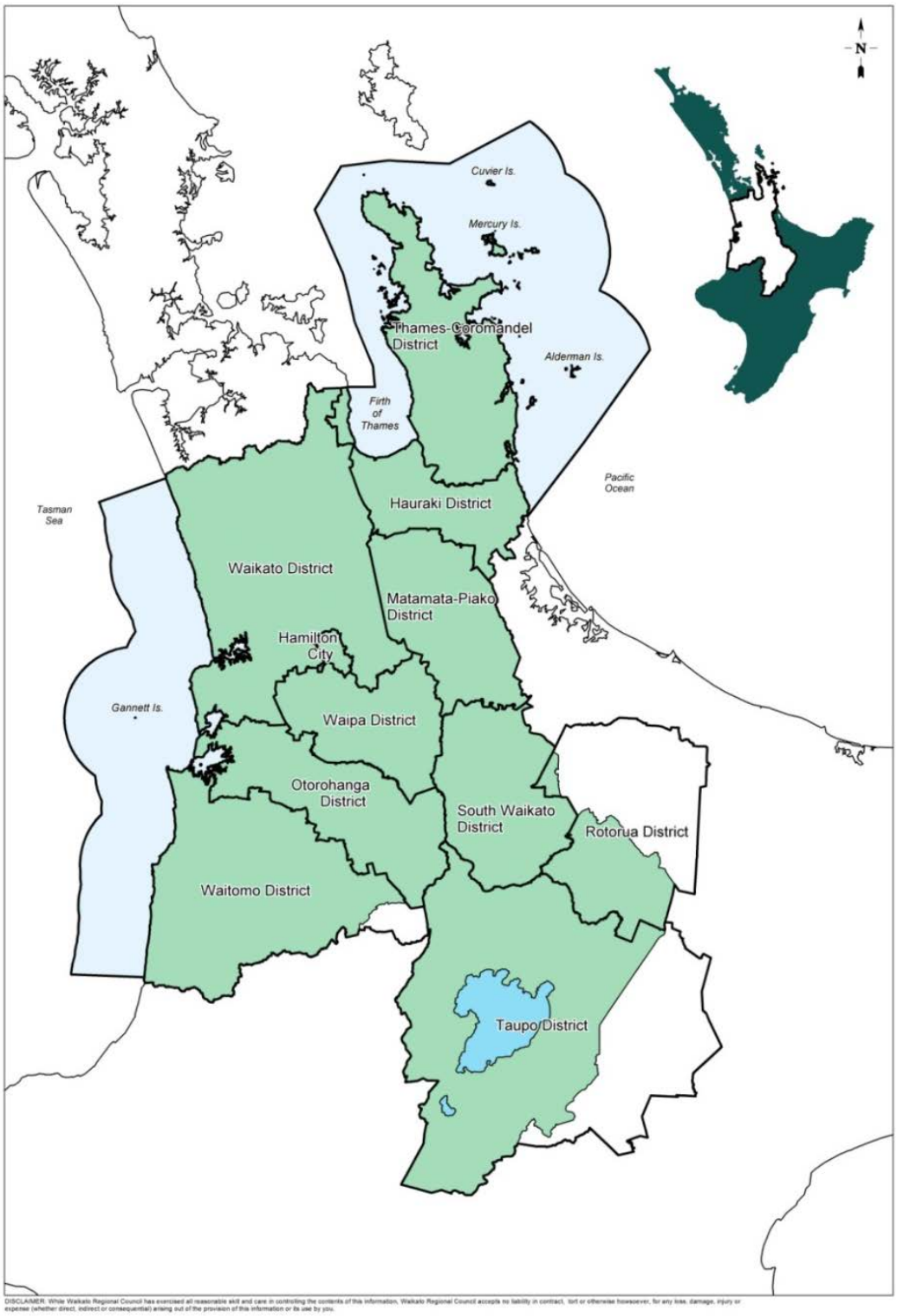


Figure 2. The Waikato coastal marine area (blue shading) includes west coast harbours, the Firth of Thames and south-eastern Hauraki Gulf, as well as the coastline and many estuaries along the eastern side of Coromandel Peninsula. Source: Waikato Regional Council.

1.2. Report scope and objectives

This first report is intended primarily for WRC, and sets the background and rationale that leads to Reports 2 and 3. These last two reports are of more direct relevance to the aquaculture industry. This report highlights some of the issues, information needs and benefits that arise through development and implementation of a more integrated monitoring approach.

This report undertakes the following:

- To describe the multiple activities and associated stressors that impact on the CMA, and recognise the complex ways in which cumulative effects may arise. We use a recent aquaculture example to illustrate the importance of having an appropriate level of environmental monitoring and regional environmental knowledge, in order to understand effects and identify monitoring needs for consent-related activities.
- To describe the nature and purpose of monitoring, and provide a stocktake of coastal activities and monitoring underway in the Waikato CMA, noting the limitations of existing approaches.
- To present the rationale and key elements of a regional monitoring framework that would improve on the existing situation, by integrating monitoring associated with consented activities impacting on the CMA and a wider SOE monitoring programme.

Although the scope of the report is generic, a number of aquaculture examples are used to illustrate some of the key points.

2. STRESSORS IMPACTING ON THE CMA

2.1. Overview

Effective environmental monitoring requires a good understanding of how various activities lead to environmental changes in the CMA. Anthropogenic activities on adjacent land and in the CMA lead to a range of stressors that contribute to key threats to marine ecosystems, including pollution, resource use (*e.g.* overfishing), habitat modification and loss, and climate change (Figure 3). Stressors are factors or processes that lead to negative effects on ecosystem components, including lethal and sublethal effects on organisms, their populations and the communities and habitats they form. Some stressors occur naturally in the marine environment, such as sedimentation associated with flood events or weather-induced shifts in water temperature or wave climate. Natural stressors can be exacerbated by anthropogenic activities, as in the case of land use and related enhanced rates of sedimentation and nutrient delivery to coastal waters.

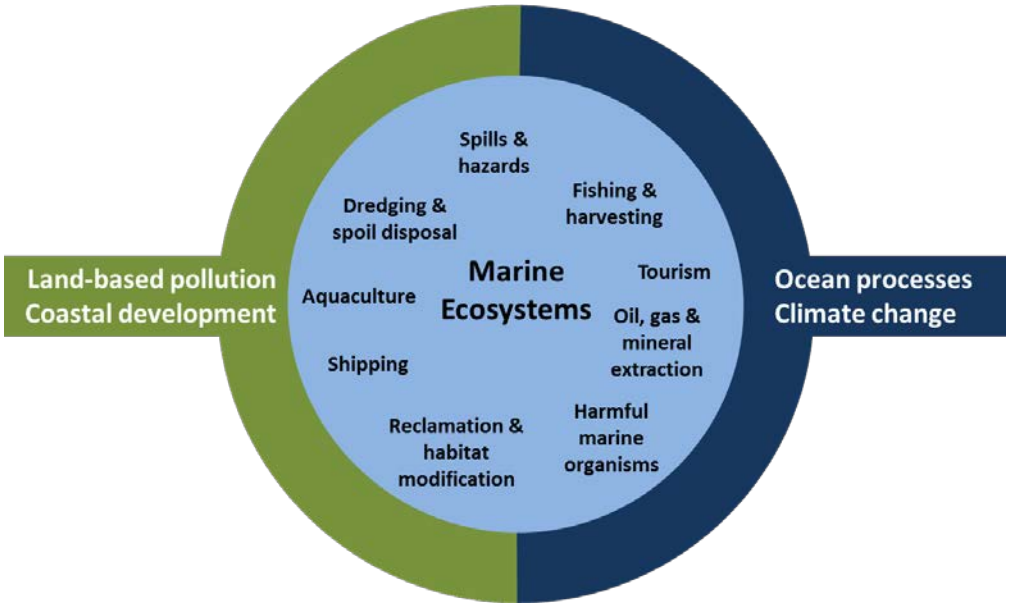


Figure 3. Sources of anthropogenic and natural stressors in the coastal marine area (CMA). Human influences arise from direct activities in the CMA, and land-based sources in adjacent catchments and coastal margins. Marine ecosystems and human influences are also modified by larger-scale processes.

Key stressors in the CMA include: sedimentation and reduced water clarity associated with sediment loading; increased nutrient concentrations and subsequent increases in primary production with potential for generating harmful algal blooms; the influx of a range of contaminants including metals and faecal microorganisms that affect coastal recreational resources; and the introduction of potentially harmful marine organisms.

The CMA is also affected by activities that disturb or modify natural habitats, and by the provision of artificial habitats. Many of the human activities that give rise to this range of stressors or effects are managed through the resource consent process. However, in addition to consented activities, there are a range of additional anthropogenic activities and stressors that could affect the Waikato CMA, such as:

- patterns of land use (past, present, future) that input a range of contaminants to the CMA, especially via rivers and streams
- fisheries resource depletion by harvesting, and disturbance by commercial and recreational fishing or harvesting methods
- episodic or unpredictable events such as oil spills
- a range of recreational and tourism activities also have potential to impact on the CMA, as in the case of increased boat traffic and interactions with marine mammals, or increased foot traffic in intertidal areas.

Many of the above activities and stressors lie outside the control of councils and some may lead to issues that are poorly understood, such as underwater sound or light pollution. Furthermore, activities affecting the Waikato CMA may occur outside the region in shared water bodies (*e.g.*, Auckland and Bay of Plenty regions).

2.2. The issue of cumulative effects

An important consideration with regard to environmental monitoring and managing the CMA is that multiple stressors can interact in complex, synergistic ways and cumulatively degrade marine ecosystems. An example is the process of eutrophication, which is driven by nutrient loading from multiple sources and exacerbated by other stressors such as overfishing, and the loss of habitats (*e.g.* seagrasses, wetlands) that play an important role in nutrient retention.

Cumulative effects can operate on different spatial and temporal scales, and can arise as a result of both additive and synergistic effects (MPI 2013). Most people broadly understand the concept of cumulative effects, but widely accepted or standardised approaches to measuring and managing such effects have not yet emerged in practice (Duinker & Greig 2006). Addressing cumulative effects is inherently complex, as it requires not only taking a broad regional approach, but also assessing effects associated with the full complement of past, ongoing or forecasted activities that affect the marine environment.

Addressing cumulative effects in the CMA requires, among other things, a two-tiered approach that not only considers the contribution of effects from individual developments, but also includes regional assessment and monitoring of wider environmental change. This approach may also consider the effect of activities in neighbouring regions. Dubé (2003) referred to these two tiers as ‘project-based’ and

'regional-based' cumulative effects assessment. To some extent these two tiers are analogous to consent-related environmental monitoring and SOE monitoring. In both cases, integration of these tiers is essential for effective monitoring of consents, and for regional monitoring and management. However, note that while we recognise the issue of cumulative effects in this report, as well as the two other reports in the series, we do not provide a formal basis for cumulative effects assessment. Addressing cumulative effects in a comprehensive manner is a significant management challenge globally, which we cannot hope to address at this stage. However, the development and eventual implementation of an integrated regional approach to monitoring is clearly a useful starting point that will better enable cumulative effects to be addressed in the future.

A recent example that illustrates the need for a well-integrated approach arises in the lessons learned from the outcomes of an Environmental Protection Authority (EPA) Board of Inquiry (BOI) into the expansion of salmon farming in the Marlborough Sounds (Box 1). Issues relating to seabed and water quality effects from salmon farms came under particular scrutiny during the EPA process.

Water quality effects, especially the potential for nutrient enrichment and harmful algal blooms, were perhaps the most contentious issue. It was evident that the response to nutrient enrichment from the salmon farms would occur beyond their immediate environs (*e.g.* across scales of kilometres or greater), thus the influence of the farms needed to be considered in light of the cumulative effects of other nutrient sources and sinks. A key gap was a lack of SOE monitoring data for the Marlborough Sounds that could be used to establish baseline conditions and validate models, and there were insufficient data to determine the trophic status of the Marlborough Sounds, and the system's ecological carrying capacity (Gibbs 2007). The high level of uncertainty that arose was reflected in the BOI's decision to grant consent for four new farms, but decline five.

The New Zealand King Salmon Company Ltd (NZ King Salmon) example illustrates the importance of an appropriate level of regional environmental knowledge, and monitoring datasets of sufficient duration, to provide greater certainty regarding the effects of consented activities in the context of other natural and human activities that affect the CMA. Efforts by WRC to develop a monitoring framework that more clearly integrates consent-related and SOE monitoring will provide an essential step towards addressing such issues.

Box 1. Salmon farm expansion case study

Approximately 70% of New Zealand's farmed salmon (king salmon, *Oncorhynchus tschawytscha*) is produced at five farms in the Marlborough Sounds by the New Zealand King Salmon Company Limited (NZ King Salmon). In 2011, NZ King Salmon applied to the Environmental Protection Authority (EPA) to change the Marlborough Sounds Resource Management Plan to enable development of nine new salmon farms in the region. During the EPA Board of Inquiry (BOI) process, scientists provided technical evidence on environmental issues. The debate that arose serves as a lesson on the importance of an appropriate level of regional environmental knowledge, and accessible datasets of sufficient duration, to provide greater certainty regarding the effects of any particular consented activity in the context of other natural and human activities that affect the environment.

Two issues that came under intense scrutiny during the EPA process related to salmon farming effects on the seabed and on water quality (especially the potential for nutrient enrichment and harmful algal blooms). Considerable monitoring of the seabed beneath and near individual farms has been previously commissioned by NZ King Salmon. However, in assessing the relationship between industry expansion and effects, there was a poor understanding of broad-scale seabed effects beyond the immediate depositional 'footprint' of individual farms. In relation to water quality the situation was particularly complex as modelling had indicated that the response to nutrient enrichment from the farms would occur beyond their immediate environs (*e.g.* across scales of kilometres or greater). Thus, the influence of NZ King Salmon farms needed to be considered in light of the cumulative effects of other nutrient sources (*e.g.* other discharges, land-run off) and nutrient sinks (*e.g.* mussel farms). Furthermore, it was recognised that adverse effects such as harmful algal blooms are often regional phenomena driven by natural environmental processes, and may occur in the absence of anthropogenic nutrient enrichment. A key gap was a lack of state of the environment monitoring data (and inaccessibility to datasets from research) for the Marlborough Sounds which could be used to establish baseline conditions and validate models. There were also insufficient data to determine the trophic status of the Marlborough Sounds, and the system's ecological carrying capacity; *i.e.* the level of culture that can be supported without leading to significant changes to ecological processes, species, population or communities in the growing environment (Gibbs 2007). This situation meant that the level of uncertainty with regard to the effects of the proposal was greater than would have been the case if more extensive data had been available. According to Eccles (2013), this is reflected in the final decision of the BOI:

> The uncertainty about the capacity of the Marlborough Sounds marine environment to assimilate the modelled nitrogen discharges from the farms sought was a troubling factor for the Board, which bemoaned the lack of available research and monitoring data…The need to monitor and understand the capacity of the receiving environment should be heeded in other areas of the country where aquaculture expansion or intensification is sought.

The BOI eventually granted consent for four new farms, but declined consent for five other sites. Due to the paucity of baseline data, the BOI imposed conditions that require NZ King Salmon to monitor the local seabed environment and conduct regional-scale water quality monitoring for up to a year before they can proceed with stocking the new farms with fish. In the case of the water quality monitoring, NZ King Salmon is undertaking studies that will inevitably detect the cumulative effects of activities in addition to the salmon farms; however, in most instances those other activities are not contributing to the monitoring programme. The NZ King Salmon situation clearly highlights the need for coordinated regional scale monitoring programmes to establish baseline conditions in New Zealand's coastal marine areas.

3. PURPOSE OF ENVIRONMENTAL MONITORING AND REPORTING

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 environmental quality. In order to be useful, monitoring requires a clear purpose and objectives that it will satisfy. A common purpose of monitoring is to describe changes over time in relation to specific activities or the wider environment, taking account of the severity and spatial extent of any anthropogenic effects. **Consent-related environmental monitoring** (for the purpose of gauging the environmental effects of a consented activity) and **SOE monitoring** (for the purpose of providing a generalised indication of environmental condition and quality) represent the two types of environmental monitoring that regional councils generally require or undertake.

The type and scope of consent-related environmental monitoring relates to the potential environmental effects and the scale of the activity. Environmental monitoring in the CMA often involves measurement of specific parameters that describe the quality of water, sediments or biota. Such monitoring is usually prescribed as part of consent conditions, especially where there is concern about specific adverse effects and/or uncertainty about the magnitude of effects. In these situations a range of (potentially complementary) approaches can be used, including specifying standards (*e.g.* for effluent or environmental quality), and specifying related requirements for mitigation when standards are breached. Consent-related environmental monitoring is usually limited to monitoring of effects that can be directly linked to specific activities and hence often involves local scale surveys. An example is seabed monitoring that focuses on the immediate environs of a point source activity.

In relation to SOE monitoring, regional 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)). In order to gauge trends in environmental conditions, which can assist in placing results from finer-scale consent monitoring within a broader context, 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.

Monitoring is one component of a wider toolbox for managing the environment. For some activities suitable indicators and associated standards may be unavailable (or impractical to implement), or cause-effect links between an activity and its effects may be confounded by multiple sources or a spatio-temporal disconnect between a stressor and the expression of its effects, or effects may simply be poorly understood. In essence, monitoring may not always be feasible or helpful, and situations may arise

where further research is needed to better understand effects. It is therefore important that a broader framework should include management practices (often termed 'best management practices' or 'BMPs') that aim to minimise actual or potential environmental effects to the extent feasible and practical, irrespective of known actual or potential risks or uncertainties.

In relation to consents, it is not uncommon for conditions to require the development (and approval by the consenting authority) of environmental management plans that specify the range of BMPs to be implemented by a consent holder. BMPs are often contained within Environmental Codes of Practice (ECOP) for a particular industry. For example, each aquaculture sector in New Zealand (mussels, oysters, salmon) has its own ECOP. Aquaculture New Zealand, through their A+ programme[1], has also developed a framework to formalise a cycle of continuous reporting, review and improvement that provides a platform for the community and industry to engage on their sustainability aspirations. A+ objectives align with those of world leading accredited certification programmes—such as Aquaculture Stewardship Council (ASC) and Best Aquaculture Practice (BAP). Although BMPs may be based primarily on descriptive measures, rather than quantifiable indicators that are monitored, it is nonetheless possible for reporting and audit procedures to be put in place to ensure that BMPs are being adopted or met. Generally, these types of broader tools should be considered as part of a regional monitoring approach. There is a grey area in terms of the difference between environmental monitoring and reporting, but the distinction we make for the purpose of this report is described in Box 2.

[1] http://www.aplusaquaculture.nz/

Box 2. Distinction between environmental monitoring and reporting

Resource consents can include conditions that require consent holders to conduct environmental monitoring and reporting (RMA s108), but these terms are not clearly defined in the RMA.

Where technically feasible and useful, **monitoring** can be undertaken to track changes over time in relation to a given environmental issue. Monitoring will typically be based on an assessment of indicators that relate to key stressors or their effects. Such monitoring may also be linked to **environmental standards** (in some cases these may be referred to as trigger levels), and also to **adaptive management** approaches where appropriate. We consider monitoring as an activity that can be conducted in a systematic way and planned in advance. It may include self-monitoring by an industry or consent holder, but will often need independent technical expertise. It is important to recognise that, irrespective of the environmental significance of an issue, monitoring *per se* may not be feasible or useful. Whereas some effects may be well known and amenable to quantitative measurement, others may be less measureable, or may be uncertain.

Where feasible and useful, councils may require (*e.g.* as part of consent conditions) ongoing **record keeping and reporting** in relation to the potential effects of an activity, possibly with an independent **audit** to determine compliance (*e.g.* compliance with the requirements of an environmental management plan). To distinguish such activities from monitoring *per se*, we consider reporting to involve collection and recording of *ad hoc* data, which may be periodically collated by the consent holder and reported to a regional council. For example, a marine fish farm operator may be required to keep records of interactions with marine mammals (*e.g.* entanglement); this is an effect that is important to understand, but cannot be easily 'monitored' in terms of the definition above.

4. PRESENT MONITORING IN THE WAIKATO COASTAL MARINE AREA

4.1. Introduction

This section focuses on existing coastal activities and monitoring undertaken as part of consented or SOE monitoring activities in the Waikato CMA. It is beyond the scope of our report to detail the range of other targeted monitoring efforts or studies involving data collection (*e.g.* water quality monitoring buoy deployments, field surveys) that have been undertaken in the Waikato Region both by WRC and other organisations such as NIWA, the University of Waikato and Cawthron. However, we note that these wider sources of information are likely to be of considerable relevance to WRC in developing a regional monitoring approach. For example, time-series data collected as part of other studies may provide a picture of long-term variation in environmental quality. Additionally, where ongoing monitoring is conducted by other organisations, it may be possible for WRC to align regional monitoring with such programmes. For example, various water quality and shellfish quality-related monitoring programmes are already in place in the Waikato region, including microbial water quality monitoring, and industry-funded harmful algae and shellfish biotoxin monitoring.

In addition to ongoing monitoring programmes, there are also national initiatives underway that are relevant to the Waikato CMA, especially for aquaculture, and should be considered as part of any development of a regional monitoring approach. Key examples are described in Appendix 1 and include:

- *Sea Change–Tai Timu Tai Pari*, involving development of the Hauraki Gulf Marine Spatial Plan (a collaborative effort among various stakeholders, including WRC).
- development of estuarine data GIS layers (Department of Conservation; DOC)
- revision of Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)
- review of the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment; MfE)
- development of a broad environmental reporting framework (MfE)
- catalogue of Marine Environmental Monitoring in New Zealand (MPI)
- development of ecological guidance for aquaculture (MPI)
- national biosecurity projects and regional marine biosecurity partnership initiatives (led by MPI)
- A+ New Zealand Sustainable Aquaculture programme (Aquaculture New Zealand)
- Aquaculture on-farm biosecurity (MPI and Aquaculture New Zealand).

4.2. Consented activities and associated monitoring in the coastal marine area

In 2013, WRC compiled a database of key information relating to coastal resource consents and permitted activities, including maps showing the spatial distribution of consented activities in the Waikato region. All consented activities within the CMA as well as a 3 km zone inland of the CMA were included in the database. The 3 km distance was somewhat arbitrary, but was intended to reflect point-source activities most likely to have direct effects within the CMA (pers. comm. Hilke Giles, Coastal Scientist WRC). The database indicates 440 different consents in the combined CMA and 3 km zone. This total consists of 334 consents for activities directly within the CMA, 91 for discharges to freshwater (*e.g.* streams) within the 3 km zone, and 15 for discharges to land (of dairy-farm effluent) within the 3 km zone. Maps compiled by WRC for the western and eastern Waikato (Figures 4 and 5, respectively) reflect the many and wide ranging types of anthropogenic activities in the region.

Within the CMA, the majority of the consents are for marine farming (primarily mussel farms; Table 1). While many of the marine farm consents require monitoring of receiving environment effects, this is not the case for all marine farming (*e.g.* oyster farming consents have no associated monitoring). Greater detail on marine farm monitoring is given in Report 2. In terms of the other activities, the requirement for monitoring differs within and among the types of activity. Furthermore, while some discharge types (*e.g.* stormwater, domestic wastewater) require monitoring of effluent quality, few consents other than those for marine farming specify monitoring of receiving environment effects within the CMA. Even where monitoring of effluent quality is required, the range of parameters being monitored can differ markedly, even for the same types of discharge. Overall, if marine farms are excluded, only 14 of the remaining 178 consents require monitoring of receiving environment effects, and 159 require no monitoring at all.

4.3. State of the environment monitoring in the coastal marine area

WRC currently conducts a limited amount of SOE monitoring in the CMA. State of the environment monitoring is confined primarily to estuaries and is limited in its spatial and temporal extent (Figure 6). An overview of current monitoring, based on information provided by WRC (pers. comm. Hilke Giles, WRC), includes:

- Regional Estuary Monitoring Programme (Raglan Harbour, southern Firth of Thames, Tairua Harbour): monitoring of sediment-dwelling organisms and sediment properties
- estuary vegetation mapping (18 estuaries): monitoring of the spatial extent of estuarine vegetated habitats.

- sediment pollutants (Port Waikato, Raglan Harbour, Aotea Harbour, Kawhia Harbour, southern Firth of Thames, Tairua Harbour): monitoring of trace elements and organic compounds in estuarine sediments.
- estuarine water quality (seven estuaries, each monitored for only one year): water and shellfish quality monitoring to assess ecological health, and suitability of water quality for contact recreation and shellfish-gathering.

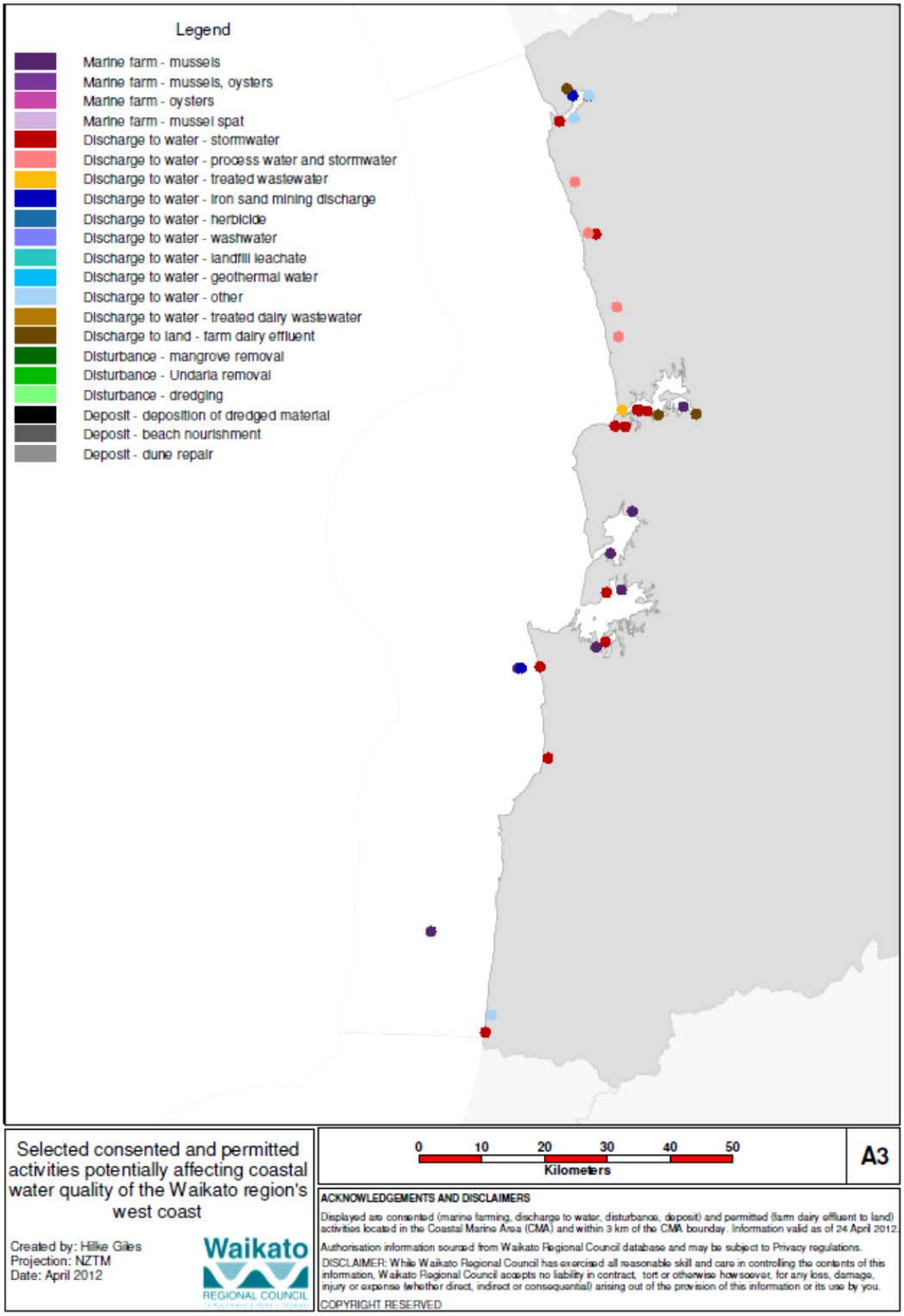


Figure 4. Consented point source discharges, marine farms and other activities within the western Waikato coastal marine area (CMA) and within an inland 3 km zone, as of April 2013 (provided by Waikato Regional Council).

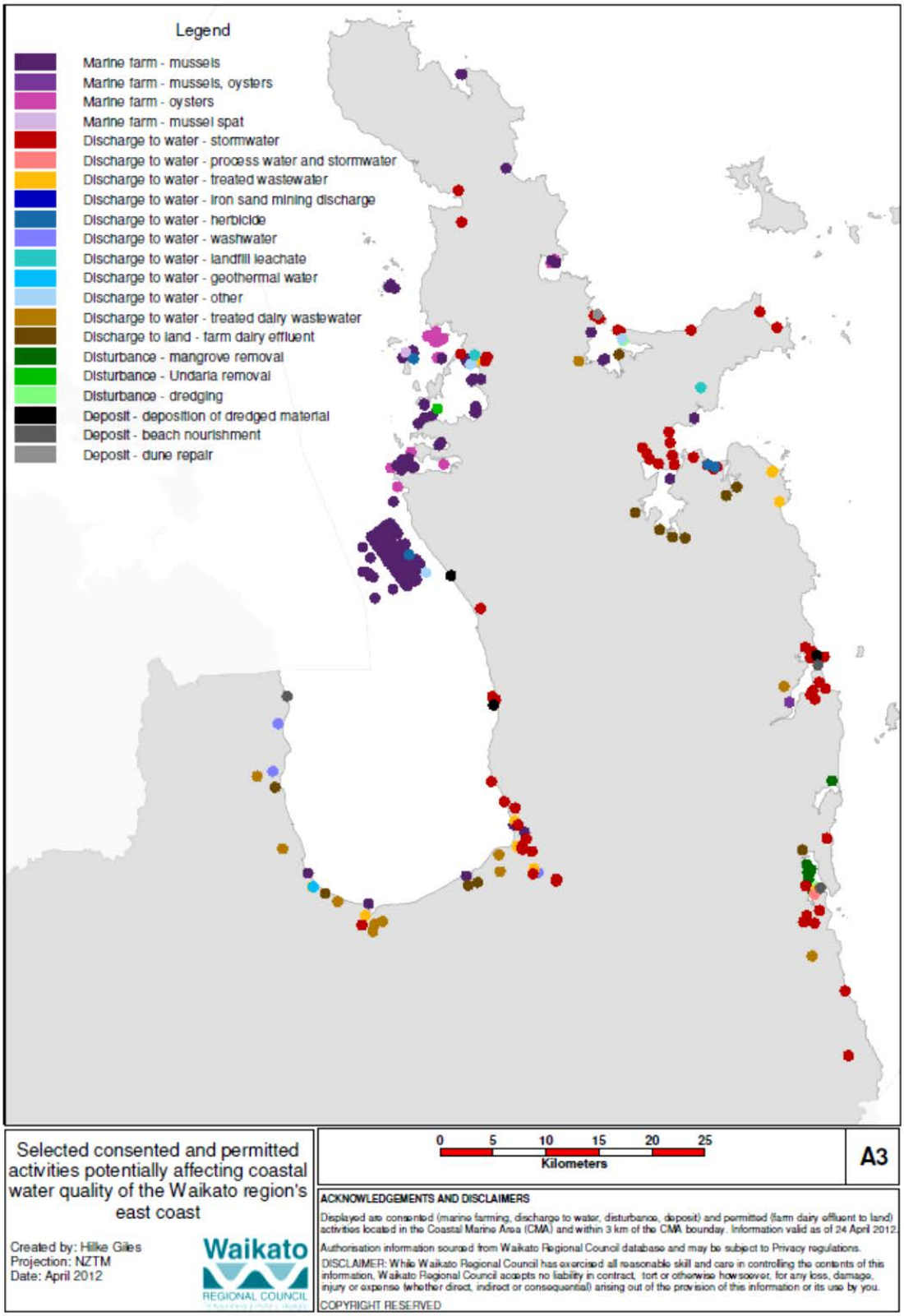


Figure 5. Consented point source discharges, marine farms and other activities within the eastern Waikato coastal marine area (CMA) and within an inland 3 km buffer zone, as of April 2013 (provided by Waikato Regional Council).

Table 1. Consented activities and associated monitoring requirements in the Waikato coastal marine area (CMA) and a buffer zone 3 km inland. The summary data were extracted from a database provided by Waikato Regional Council, which was current as of April 2013.

Activity type	Number of consents	Percentage requiring receiving environment monitoring
Marine farm–mussels	244	80
Marine farm–mussel spat	1	100
Marine farm–oysters	16	0
Marine farm–mussels, oysters	1	100
Discharge to water–stormwater	76	0*
Discharge to water–process and stormwater	7	14
Discharge to water–treated wastewater	13	0*
Discharge to water–iron sand mining	2	0*
Discharge to water–herbicide	18	0
Discharge to water–washwater	3	33
Discharge to water–landfill leachate	2	100
Discharge to water–geothermal water	2	50
Discharge to water–other	9	0*
Discharge to water–treated dairy wastewater	11	82
Discharge to land–farm dairy effluent	15	0*
Disturbance–mangrove removal	7	86
Disturbance–*Undaria* removal	1	0
Disturbance–dredging	5	60
Deposit–deposition of dredged material	3	100
Deposit–beach nourishment	3	33
Deposit–dune repair	1	100

* Although no receiving environment monitoring is required, some of these consents require effluent monitoring

Beyond estuaries, WRC monitors shoreline change (erosion and accretion) at sandy beaches on the Coromandel Peninsula's east coast to assess risk to houses and infrastructure and to provide key data for managing coastal hazards (Figure 5). In addition to routine monitoring, WRC initiates one-off surveys, for example estuarine shellfish surveys and habitat mapping. Additionally, WRC is part of'*Sea Change–Tai Timu Tai Pari*, a collaborative effort with Auckland Council, the Department of Conservation and other stakeholders, to develop a marine spatial plan for the Hauraki Gulf (Appendix 1). The project involves a collation of available datasets and stakeholder input to develop priorities for resource planning and management of the Hauraki Gulf.

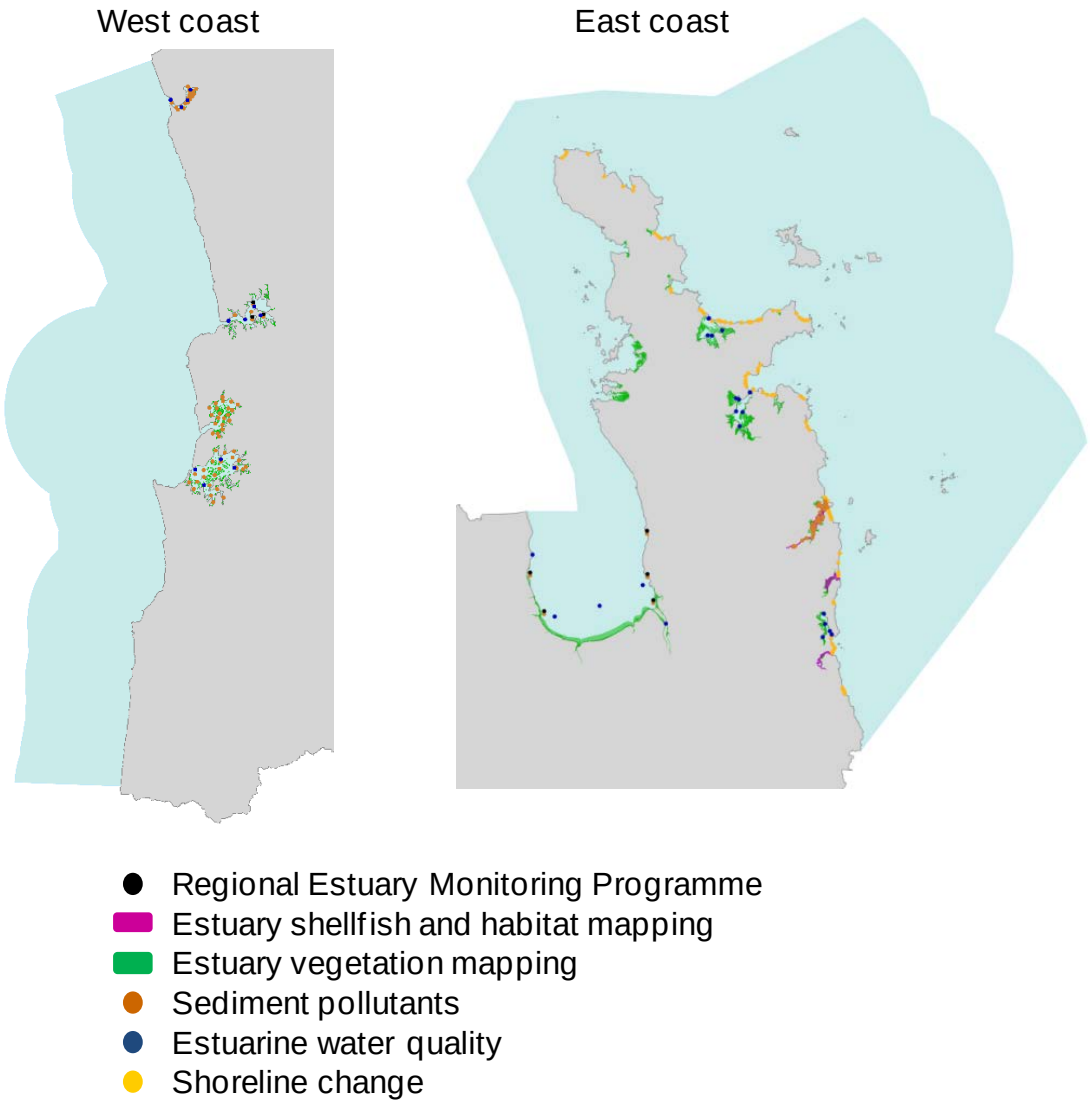


Figure 6. Waikato Regional Council (WRC) coastal monitoring and assessment programmes (in 2013).

4.4. Limitations of existing coastal monitoring efforts

The above overview reveals that monitoring within the CMA has a limited scope, and there is a lack of an overarching framework to ensure consent-related and SOE monitoring are well-integrated. Monitoring of consented activities currently lacks consistency in terms of the breadth of requirements (*e.g.* parameters measured and monitoring frequency). The fact that the majority of consented activities (other than marine farming) require no monitoring, and very few require receiving environment monitoring, limits understanding of actual and potential effects on the CMA.

In the case of marine farming, existing monitoring focuses on seabed and water quality issues, and does not capture a number of other ecological effects that may be important (MPI 2013) and which we describe in Report 2. We have not considered monitoring requirements for non-aquaculture consents in enough depth to know the extent to which the same is true for other activities. However, given the limited receiving environment monitoring in the Waikato CMA, it is reasonable to assume that the existing monitoring will provide a very narrow perspective on environmental effects. Waikato Regional Council also recognises that the frequency of consent-based monitoring and methodologies used are often not sufficient to discriminate effects from natural variability (pers. comm. Hilke Giles, WRC).

State of the environment monitoring is so limited in scope at present that the baseline state of the environment, the importance of various activities, and the relative importance of diffuse-source effects, is poorly understood. Greater emphasis and effort goes into consent monitoring, despite the fact that point sources may not be the most important cause of coastal degradation. Waikato Regional Council has recognised the poor integration of monitoring in terms of linking land-use/river water quality and the coastal environment, and has initiated steps to improve its SOE programme (Appendix 2).

Finally, it is evident that the cumulative effects on the CMA from multiple activities and stressors (both consented and otherwise) are not considered in present monitoring programmes. This is an important issue not only in relation to the presence of regionally widespread activities such as aquaculture, for which interactions with other activities or stressors can be expected (MPI 2013), but also in recognition that there are many activities whose individual effects may be small, but of far greater importance when considered collectively.

5. REGIONAL MONITORING FRAMEWORK

5.1. Introduction

There is considerable scope and opportunity to improve existing monitoring in the Waikato CMA. A more consistent and transparent approach that better integrates consent-related and SOE monitoring, and accounts for cumulative effects, is required. A regional monitoring framework has the potential to facilitate these types of improvements, and provide a broader context for understanding the effects of existing and future anthropogenic activities, against the background of natural variability.

Below we provide a conceptual framework based on key steps that contribute to developing and implementing monitoring programmes and which are able to be integrated within a regional context (Figure 7). Steps range from broad tasks such as identifying threats to the CMA, prioritising monitoring needs based on risk, and integrating monitoring conducted for different purposes and across varying scales (*e.g.* consent *vs* SOE), to more specific tasks such as identifying indicators and standards for monitoring and assessing change. Carrying out these steps will ensure that consent-related and SOE monitoring programmes contribute toward meeting environmental quality goals and regulatory requirements.

As part of the description below of the key elements of the framework (and also in Section 5.3) we provide some general commentary around the benefits of better integrating consent and SOE monitoring. A clear understanding of these matters is imperative to realising the merits of a regional framework, and to improve on the existing situation. The process of identifying the actual requirements of a monitoring programme and implementing them will need to consider many technical and non-technical aspects (*e.g.* cost and cost allocation, stakeholder uptake, public expectations regarding monitoring). To delve into all of these is beyond our present scope; however, some of the key technical considerations are addressed at a high level in this report, and in more detail for aquaculture in the next two reports in the series. Additional information on developing integrated approaches to regional monitoring can be found elsewhere (*e.g.* Hedge *et al.* 2013; Newcombe & Cornelisen 2014).

Note that the framework in Figure 7 has been conceived so that it can be used by WRC staff to consider monitoring requirements for specific consents. It highlights the importance of keeping in mind the links between consent-related environmental monitoring and the ‘bigger picture’; for example, considering where consent-related monitoring could be made more efficient and more valuable by overlapping with SOE monitoring. For staff considering SOE monitoring requirements, the framework and related discussion highlights the important role for SOE monitoring in measuring and contextualising consent-related effects.

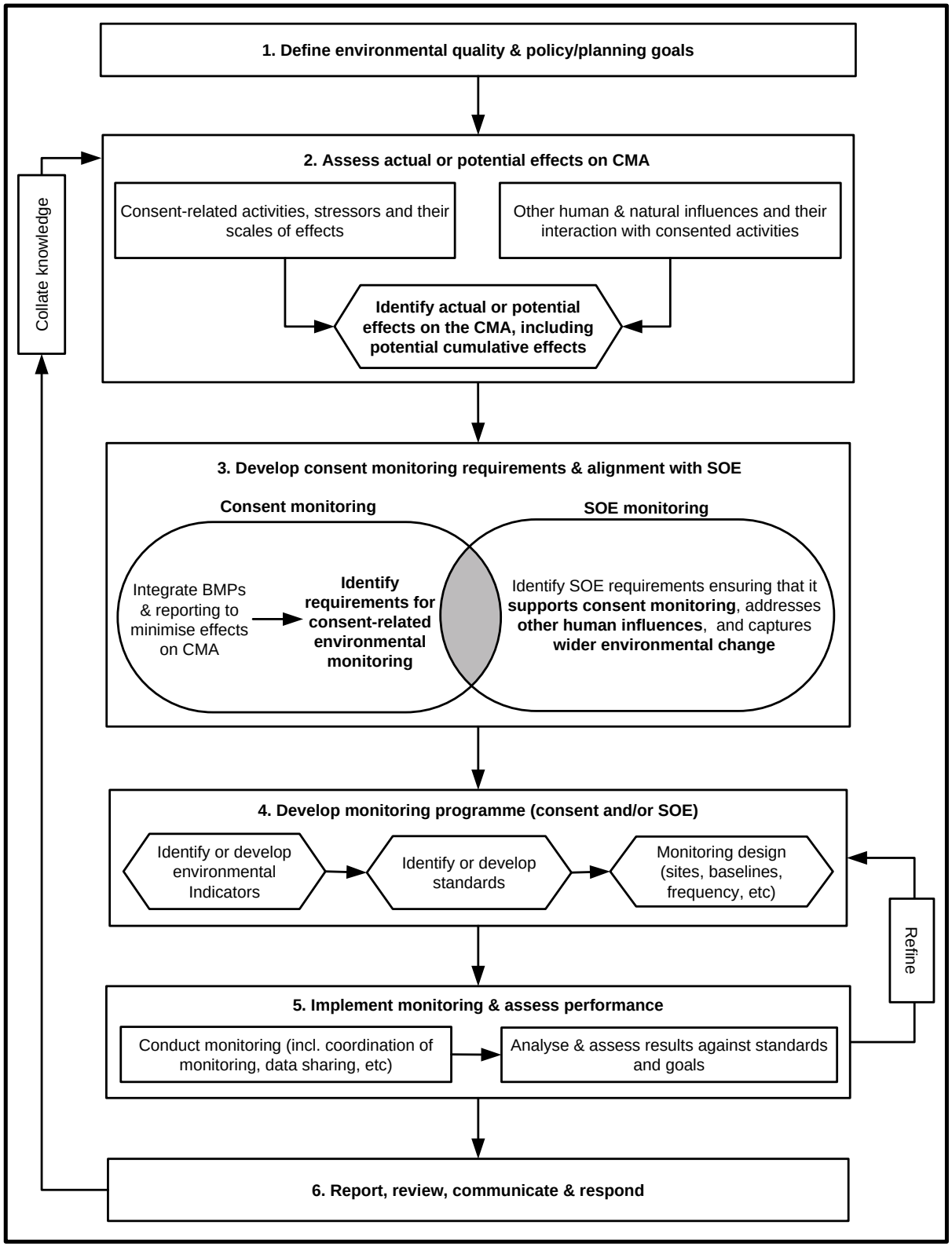


Figure 7. Regional monitoring framework outlining key steps in the development of a programme that integrates consent-related and state of the environment monitoring.

5.2. Elements of a regional monitoring framework

5.2.1. Part 1: Define environmental quality and policy/planning goals

Key elements

- Define purpose of monitoring and expected environmental outcomes
- Account for the goals and requirements of national and regional policy and coastal plans
- Consider the need to tailor goals and desired outcomes according to location-specific differences in pressures on the environment and community aspirations

An important initial requirement in developing a regional approach is to have clear goals around the purpose of the monitoring and expected environmental outcomes, especially in relation to national and regional policy and coastal plans, so that it is not a case of 'monitoring for the sake of it'. These policies and related requirements form the basis for the high level goals and priorities for a regional monitoring framework. However, it should be recognised that goals and priorities may differ within the region, depending on pressures on the environment, as well as community values and aspirations.

As described in Box 3, the proposed Waikato Regional Policy Statement (RPS) sets out objectives for the CMA in Part A and specific policies in Part B, most relevant of which are Policy 7.2 (Marine water quality) and Policy 11.4 (Safeguard coastal/marine ecosystems). Part C then describes monitoring and evaluation requirements, including a framework for policy implementation, monitoring and review. Among the environmental results anticipated in Section 15.4 and described in Box 3, success measures include 'No unanticipated adverse effects on the marine environment caused by land use activities and vice versa' (15.4.1.d), 'Marine water quality is maintained or enhanced' (15.4.4e) and 'Marine water quality standards are developed and water meets these standards' (15.4.4f).

Despite WRC's policy and plan requirements, it is important to recognise that the regulatory framework has limitations. For example, Waikato's RPS and Regional Coastal Plan (RCP) recognise the issue of cumulative environmental effects, but neither document clearly recognises the linkages between cumulative environmental effects and monitoring needs, or the importance of integrating consent and SOE monitoring. Additionally, although recognised in the RCP, effective coastal management will require issues to be considered that relate to anthropogenic activities which regional councils have no control over, such as fishing. Waikato Regional Council will also need to address regional boundary issues, in particular with Auckland Council and Bay of Plenty Regional Council.

Box 3. Proposed Waikato Regional Policy Statement: key requirements relating to the coastal marine area

PART A contains RPS objectives, of which key ones for the marine environment are:

Objective 3.6, Coastal environment: The coastal environment is managed in an integrated way which: protects the unique features and values of the coastal environment; avoids conflicts between uses and values; and recognises the need to link marine-based and land-based activities.

Objective 3.12, Mauri and health of marine waters: The mauri and health of marine waters is maintained and where necessary enhanced to provide for human uses and values, and the health of marine ecosystems. In particular, the adverse cumulative effects of different land use activities on water in the coastal marine area are reduced.

PART B contains RPS policies, of which key ones for the marine environment are:

Policy 7.2, Marine water quality: 'Discharges to marine waters shall be managed to maintain or enhance the mauri and health of marine water and to protect ecosystem, amenity, and tangata whenua values.' Implementation methods include initiatives to improve water quality (*e.g.* development and implementation of best practice guidelines and industry standards), and information gathering to be conducted by WRC, namely setting baselines for marine water quality, determining the causes of marine water quality degradation, and assessing the limits of marine waters for assimilating discharges.

Policy 11.4, Safeguard coastal/marine ecosystems: WRC must have particular regard to maintaining or enhancing indigenous species or habitats, for example that are: '…unique to the coastal environment and vulnerable to modification and the impacts of climate change, including estuaries, lagoons, coastal wetlands, dunelands, rocky reef systems, seagrass and saltmarsh.'

PART C describes monitoring and evaluation requirements, including a framework for policy implementation, monitoring and review.

Section 15.2 refers to a regional monitoring programme that 'will be reviewed to ensure that monitoring activities (for example, state-of-environment reporting and monitoring and reporting of Community Outcomes) are collecting relevant information that will: allow an understanding of progress towards the stated objectives in Part A (long-term focus); and environmental results anticipated…'. It is stated that: '…the monitoring programme review will have particular regard to the benefits gained through alignment of monitoring and data collection effort and ensuring that as much of the existing baseline information can be used and built upon. It will recognise the value of long-term monitoring to the recognition and understanding of trends.'

Section 15.4 describes environmental results anticipated, with specific success measures relating to integrated management (15.4.1) and the CMA (15.4.4) which include:

15.4.1d: 'No unanticipated adverse effects on the marine environment caused by land use activities and vice versa'.
15.4.4c: 'Significant marine habitats and ecosystems are protected from adverse effects'.
15.4.4d. 'Coastal water is safe for contact recreation, shellfish gathering and recreational fishing, and aquaculture'.
15.4.4e. 'Marine water quality is maintained or enhanced'.
15.4.4f. 'Marine water quality standards are developed and water meets these standards'.

5.2.2. Part 2: Assess actual or potential effects on the coastal marine area

Key elements

- Collate information on consent-related activities, stressors and their scales of effects
- Consider other human and natural influences and their interaction with effects from consented activities
- Identify actual or potential effects on the CMA, including potential cumulative effects

Knowledge of anthropogenic activities (both consented and other) in the WRC region and their actual or potential effects in the CMA, including their potential cumulative effects in combination with wider pressures (see Section 2), provides the basis for understanding risks to the CMA and developing priorities for monitoring, both from a consenting and SOE perspective. It is important to be mindful that background environmental change may modify anthropogenic influences in complex ways. For example, medium and long-term changes in climate that alter rainfall patterns within a catchment may influence the delivery (*e.g.* mass load, distribution) of land-derived stressors to the coast.

Collation and assessment of existing information from monitoring or research would assist in the assessment of actual and potential effects, and also identify any key information gaps or uncertainties. Development of priorities for monitoring should take into consideration the habitats or values at risk and their importance. This is because the attributes of the environment that people most care about and consider most important to protect, and which are also at greatest risk, should arguably receive the greatest priority.

Ideally, key threats and related monitoring priorities would be determined in a systematic and transparent way. For example, a simple approach to ranking the ecological effects of aquaculture was conducted in a recent workshop convened by MPI on aquaculture risk assessment (Stoklosa *et al.* 2012). In that workshop a hierarchical assessment was undertaken in which experts ranked different aquaculture effects against each other in a pairwise manner. Other approaches for aquaculture have identified stressors posing the greatest threat according to the magnitude (*e.g.* likelihood x severity) of their effects, as well as their spatial extent (local to regional) and duration (*i.e.* the extent to which effects are reversible if the activity ceases) (Forrest *et al.* 2009).

These types of assessment, when applied in a generic way (*e.g.* from a national perspective), are a useful screening tool for identifying the greatest perceived threats and can provide reasonable guidance. However, outcomes from such approaches may not appropriately prioritise issues that may be specific to a given region or sub-region. For instance, some aquaculture effects on highly-valued species such as marine mammals may be severe (*e.g.* death by entanglement), but the actual

significance of effects will likely depend on species (*i.e.* conservation status) and location.

Furthermore, the application of simple screening approaches would probably be unwieldy when multiple sources, stressors and values are considered. For these more complex situations, understanding of effects and development of monitoring priorities may benefit from the application of more sophisticated methods. One such method is the Relative Risk Model (RRM) of Landis (2005), which has previously been applied to the Firth of Thames in relation to aquaculture development (Elmetri *et al.* 2005), and to investigate multiple risks to the Miranda Ramsar wetland site in the southern Firth (Elmetri & Felsing 2007).

Although far from perfect and limited by the quality of information, these types of approaches provide a reasonably fast means of gauging relative risk at sub-region or regional scales, and methods like the RRM incorporate tools for capturing uncertainty. Where uncertainty reflects absence of information, this type of systematic method facilitates the identification of knowledge gaps and information needs.

5.2.3. Part 3: Develop consent monitoring requirements and alignment with state of the environment

Key elements

- Integrate BMPs and reporting to minimise effects on CMA
- Identify requirements for consent-related environmental monitoring
- Identify SOE requirements, ensuring that SOE supports consent monitoring, addresses other human influences, and captures wider environmental change

As noted in Section 3, an important consideration for consenting is to ensure the implementation of environmental management plans and associated best management practices (BMPs) that aim to minimise effects to the extent feasible and practical. As part of development and implementation of BMPs, it is important to identify the record keeping and reporting requirements that will be required of a consent applicant. In relation to aquaculture, BMPs are explored in Report 2.

The requirements for consent-related environmental monitoring will depend on a number of factors including: the level of knowledge regarding actual or potential effects; the real or perceived importance of the effects, especially in relation to the wider context of cumulative effects; the scope to mitigate stressors or effects; the probable spatial scale of measureable effects after appropriate mitigation; and the probable reversibility of adverse effects. As noted in Section 3, monitoring may not always be feasible or helpful, and situations may arise where further research is needed to better understand effects.

The framework recognises that SOE monitoring has three main roles, as follows:

1. to provide a direct context for understanding the effects of consented activities as described above
2. capture trends in background environmental conditions that may be influenced by diffuse-source pollution (*e.g.* from river discharge), and interact with consent-related sources
3. capture trends in background environmental conditions that may or may not have recognised links with consented activities or other anthropogenic effects.

Ensuring consent-related environmental monitoring is aligned with SOE monitoring to the extent feasible, is critical to the development of an integrated approach. Consent-related environmental monitoring may be more efficient and cost-effective, and results may be more meaningful, when fully integrated with SOE. For example, monitoring often involves comparison of local-scale effects (*e.g.* seabed effects of aquaculture) against reference sites that are not directly influenced by the consented activity. An aligned SOE programme could make consent-related monitoring more efficient, cost-effective and robust, by providing shared reference sites. Some further benefits of integrating SOE and consent-related environmental monitoring are outlined in Section 5.3.

The broader context reflected by the second role for SOE monitoring (*i.e.* point 2 above) becomes increasingly important when consent-related effects are non-local and have the potential to result in cumulative effects through interaction with other anthropogenic activities (the NZ King Salmon case study in Box 1 is a relevant aquaculture example). With an increasing spatial scale of influence, there will typically be an increased need for consent monitoring to be integrated within a regional SOE programme.

Although SOE monitoring depicted by point 3 may appear less relevant from a consent perspective, its potential importance should not be overlooked. The natural environment is inherently variable and influenced by medium to large-scale processes, some of which could lead to directional changes in the marine environment,or fundamental shifts in species assemblages. For example, the introduction of a marine pest (*e.g.* as a result of regional or international shipping) could ultimately be followed by regional-scale spread and establishment, and irreversible ecological changes to the regional coastal environment. While such events may be unrelated to consented activities, they clearly have the potential to influence background or reference conditions against which the effects of consented activities may be assessed.

5.2.4. Part 4: Develop monitoring programme

Key elements

- Identify or develop environmental Indicators
- Identify or develop environmental standards
- Design monitoring programme (*e.g.* in terms of sites, baselines, monitoring frequency)

This component refers to the 'nuts and bolts' that need to be considered when developing a monitoring programme, irrespective of whether it is for consent-related environmental monitoring, SOE, or both.

Indicators and standards

One component of developing a monitoring programme is to consider the suite of environmental indicators that can be used to reflect the effects of key activities and stressors. A potential advantage of considering consent-related and SOE monitoring simultaneously is that efficiencies may be realised; for example, by identifying the indicators that consent and SOE monitoring can use in common.

Ideally, standards would be available, or have the potential to be developed, for each indicator. Standards provide a benchmark for evaluation of environmental quality, and may be qualitative or quantitative. It will be important to consider whether national or international standards can be directly applied to the WRC situation, or whether further research is required to determine their applicability. Additionally, there should be consideration regarding the need for trigger levels for certain indicators; for example, to enable mitigation or adaptive management to be implemented if a deteriorating environmental condition is detected.

Monitoring design elements and baseline data

Given a suite of indicators and standards, there will remain the need to ensure appropriate monitoring design elements are in place. Relating to monitoring sites are questions regarding the availability of suitable reference sites, what sites to monitor, and how many.

A critical consideration is identification of the nature and extent of baseline data needed on environmental conditions and natural variation. With increasing spatial scale of influence, cause-effect linkages between an activity and its effects are likely to become more difficult to ascertain, and there is likely to be increased reliance on complex sampling designs and baseline information against which monitoring results are benchmarked; in particular, baseline data that establish temporal variability in environmental quality status. Types of baseline data that may be important are outlined in Box 4.

Box 4. Baseline information to support monitoring

Baseline information is often a necessary component of environmental monitoring, for a number of reasons. The nature and extent of baseline information that is required will differ across the range of issues and activities that affect the coastal environment. Generally there are two main scenarios that are likely to arise, as follows:

1. **Time series baselines:** The most complex scenario is where time series monitoring is needed in order to establish temporal variability (*e.g.* to understand seasonal variability) in environmental quality before a development proceeds. Such information provides the benchmark against which the effects of a subsequent development can be assessed, considering sites that are potentially affected by the development as well as reference (also known as 'control') sites. These types of designs, sometimes referred to as Before-After-Control-Impact (BACI) designs, are considered the most scientifically robust (Underwood 1994; Stewart-Oaten & Bence 2001). In relation to anthropogenic point sources, BACI approaches are probably most needed where cumulative effects arise, as in such situations cause-effect linkages between stressors and their effect are difficult to ascertain from spatial surveys alone. An example is harmful algal bloom monitoring, for which broad-scale environmental drivers are often the trigger for a bloom, but for which anthropogenic sources (*e.g.* nutrient enrichment) may be significant contributors (Heisler *et al.* 2008). A second example would be monitoring the effects of marine pests, for which spatial surveys based on control-impact designs have major flaws (Forrest & Taylor 2002). Situations may also arise where control-impact designs alone make it difficult to detect subtle effects, such as the outer spatial boundary of the seafloor effects footprint of a marine farm.

2. **Baselines established by synoptic spatial surveys:** Although less scientifically rigorous than BACI designs, control-impact spatial designs can adequately assess effects in situations where cause-effect is clear. An example is the seabed impact of aquaculture, for which measureable effects are always highly localised, and can be described by well-recognised ecological responses to known stressors (Keeley *et al.* 2009). In that case, the most important role for baseline assessment is to establish spatial variability in environmental quality status and habitat conditions, which can be accounted for in designing monitoring programmes. For example, ensuring that reference and impact sites are chosen with similar baseline conditions (*e.g.* in terms of physico-chemical conditions or faunal assemblages) means that post-development changes at impact sites that do not also occur at reference sites can reasonably be attributed to the development. To minimise the risk of erroneous interpretation, it is advisable to design such surveys to include multiple reference sites, and ideally multiple impact sites where possible. In these instances, baseline information may be gathered by deliberate systematic surveys, or it may be possible to use existing datasets, habitat maps, *etc*.

Monitoring frequency is also a key consideration. For example, should monitoring attempt to capture seasonal trends as well as longer term patterns? In the case of consent monitoring, is it sufficient that worst-case effects are reflected? Where staged developed is envisaged, the frequency of monitoring may need to reflect the temporal

scale over which effects develop and are expressed. A related issue is the extent and frequency at which monitoring should continue once an activity is at full development, and monitoring results show a stable situation from one monitoring survey to the next. In this instance a reduction in monitoring intensity may be appropriate.

Also important is to identify the methods to use, and the existing or emerging technologies available that could enhance efficacy or reduce the cost of monitoring. These are particularly important questions for regional-scale SOE monitoring, for which there are a number of emerging approaches (*e.g.* real-time water quality monitoring buoys) for characterising background environmental conditions. It may be the case that multiple methods are used, depending on needs regarding the spatial and temporal scale of sampling and level of quantification needed. For example, monitoring of coastal sedimentation or water clarity may use broad resolution tools (*e.g.* satellite imagery of coastal water turbidity) to define areas for finer scale sampling (*e.g.* of water clarity or suspended solids). Modelling approaches (*e.g.* hydrodynamic models) may also have value for selecting monitoring sites in some circumstances.

5.2.5. Part 5: Implement monitoring and assess performance

Key elements

- Conduct monitoring, considering scope for coordination of monitoring, data sharing, *etc*
- Analyse and assess results against standards and goals

Maximising the benefits of better integrating consent-related and SOE monitoring requires some thought regarding responsibility for monitoring, coordination of monitoring efforts and sharing of data. A well-integrated consent and SOE monitoring programme could involve WRC undertaking the non-local components relevant to multiple consents, with consent-holders focusing on the direct local-scale effects of their activity. For example, in a programme to monitor the seabed effects of aquaculture, local-scale effects could be monitored by the consent holder, with an SOE programme providing reference sites against which local-scale effects were assessed. However, in such instances there would need to be close coordination of local-scale and SOE efforts. As a minimum, it would be important to ensure that the surveys were conducted at a similar time using comparable methods and sampling designs.

Ideally, a well-integrated programme would be undertaken or coordinated by WRC. Consent holders could contribute to such monitoring in a way that was fair and appropriate. To delve into possible approaches is beyond our present scope, but they could include a material contribution (*e.g.* sample collection) or cost-sharing. Waikato Regional Council coordination, coupled with centralised data storage, and a standardised approach to data analysis and assessment, would add considerable

value to a monitoring programme and contribute to better understanding of cumulative effects. The requirements for assessing and managing cumulative effects are difficult for any single consent applicant or industry to address and are best dealt with through a central entity such as a regional council (Dubé 2003; Duinker & Greig 2006). Hence, from a scientific perspective we suggest that: (i) without the regional context, such an assessment is not realistic for a consent applicant; and (ii) even if the regional context is available, such as assessment would be most efficiently undertaken, and also be most reliable, if co-ordinated by a single agency like WRC.

Evaluating the significance of monitoring results and informing management responses (see next section) can be straightforward if environmental standards are available (*e.g.* comparison of contaminant levels against ANZECC 2000 guidelines). Where standards are unavailable, they would ideally be developed at a national level, with regional modification as required. Quantitative statistically-based approaches may also be appropriate, for example to distinguish anthropogenic effects from background variability. However, acknowledging that statistical significance and ecological significance are not synonymous, it is almost invariable that evaluation of monitoring results will rely to some extent on subjective judgement by experts. Such a requirement reinforces the value in having a single central coordinator and data repository for monitoring.

5.2.6. Part 6: Report, review, communicate and respond

Key elements

- Reporting of monitoring results
- Communicate results to stakeholders
- Implementation management responses as needed
- Review and refine the monitoring programme as appropriate

Reporting, programme review, communication to stakeholders, and implementation of appropriate management responses are all essential elements of a monitoring framework. An important aspect of the framework is recognition that evaluation of monitoring results may lead to a range of responses. For example, consent-related environmental monitoring may be increased, or mitigation steps put in place, if a monitoring trigger level or standard is breached. On the other hand, monitoring may decrease if no deterioration in environmental quality occurs over time. We do not delve into these or other aspects relating to Part 6 of the framework, as to do so is beyond our current scope. Further discussion on these matters can be found in other documents (*e.g.* Hedge *et al.* 2013; Newcombe & Cornelisen 2014).

5.3. Benefits of an integrated regional approach

Some of the benefits in undertaking a regional approach that integrates consent-related with SOE monitoring have been mentioned above, or will become evident in Reports 2 and 3. In our view, the considerable long-term benefits that could arise from a well-integrated regional monitoring programme will by far outweigh the initial effort involved in setting up the approach.

If deliberately integrated with consent monitoring, SOE monitoring has the potential to provide a broad characterisation of background environmental change within which local-scale changes from consented activities can be assessed. This is of particular benefit where environmental change is driven by natural processes or anthropogenic activities that are linked to events at scales greater than regional (*e.g.* climate change, ocean acidification).

Better integration would have a number of other benefits to WRC and/or consent holders, including an SOE programme that provides the right type of baseline data necessary for assessment of consented point-source effects. For example, some of the key indicators and biotic indices that are widely used to evaluate point source seabed effects of aquaculture are benchmarked against regional reference site conditions (Keeley *et al.* 2012). These reference conditions would most appropriately be characterised as part of the scope of SOE monitoring (see Report 3).

As a minimum, the SOE programme could provide additional baseline data or a rationalised suite of reference sites to improve the scientific rigour and efficiency of local-scale effects assessments. Consent holders would also have scope for achieving monitoring efficiencies by taking a 'consortium' approach, in which monitoring was based on representative sites. Such an approach would reduce emphasis on monitoring every point source (*e.g.* every separate marine farm), and has been adopted for mussel farm monitoring in the Wilson Bay Marine Farming Zone and for mussel farm extensions in the eastern Firth of Thames (Taylor *et al.* 2012).

Strong integration should also enable improvement and greater efficacy in the monitoring of consented point sources whose effects occur at scales greater than local (*e.g.* occurring kilometres or tens of kilometres from the source). The situation described in Box 1 relating to the disconnect between fish farm nutrient enrichment and phytoplankton blooms, has also been recognised as an issue for finfish aquaculture development in the Firth of Thames (Zeldis *et al.* 2010). In combination with other nutrient inputs (*e.g.* land-derived), excess nutrients from fish farms have the potential to contribute to the regional formation of harmful algal blooms. In such situations, a logical approach would be to manage risk and undertake monitoring from a regional perspective; for example, by considering maximum loads of nutrients from all sources, including real-time monitoring buoys and remote sensing to capture

changes in water quality over time and space, and by linking coastal SOE monitoring with monitoring of harmful phytoplankton already being conducted.

Finally, a well-integrated SOE and consent-related environmental monitoring programme, based on a common set of indicators and methods, would foster regional consistency, and an improved ability to detect spatial and temporal trends, including cumulative effects. As described above, the benefits in integrating consent-related and SOE monitoring using consistent methods would likely be greater if WRC managed and undertook (or at least coordinated) the monitoring programme. This would enable scientific consistency and quality control, a central repository for the data allowing for better transparency of the results, and cater for a standardised approach to evaluation of results and assessment of environmental quality from a regional perspective; these are all desirable features that are currently absent from most monitoring programmes.

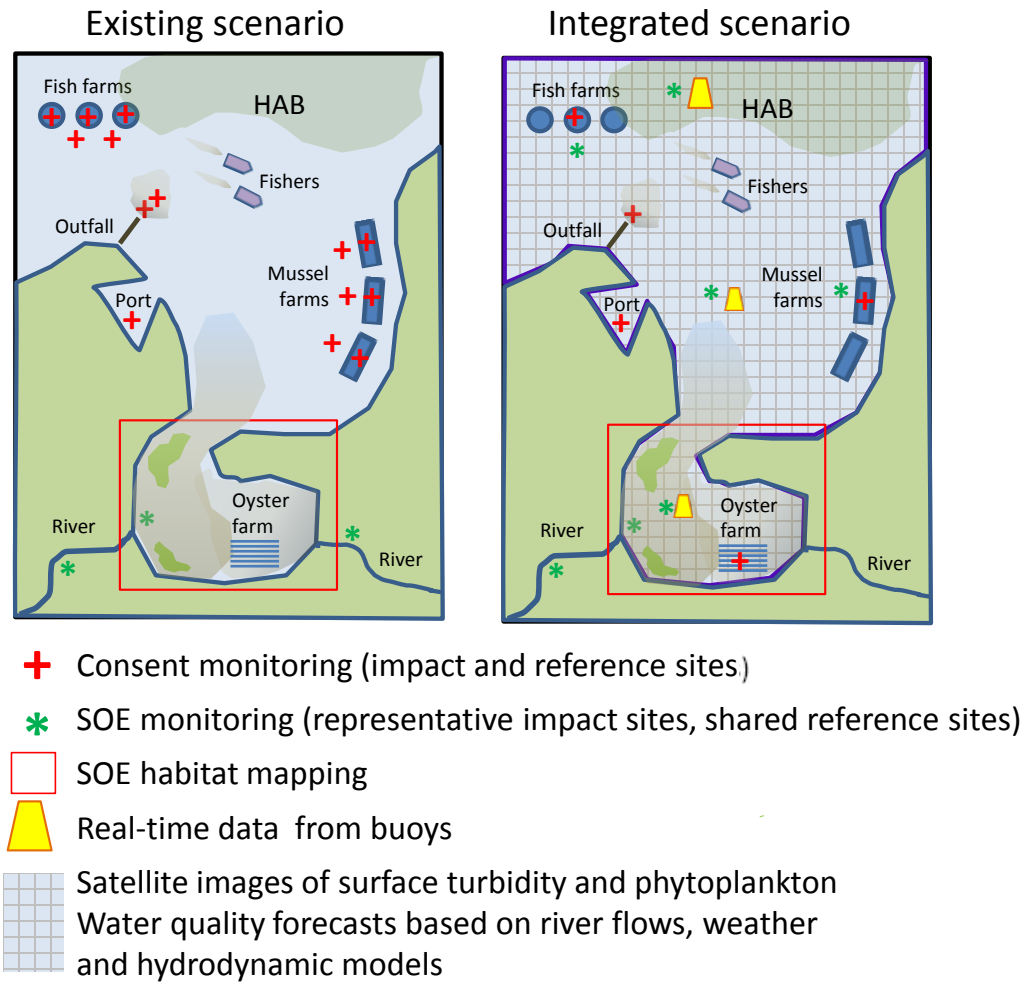
Box 5 depicts some hypothetical monitoring approaches to illustrate some of the benefits outlined above. In the **existing monitoring scenario**, the local scale effects of aquaculture (*e.g.* on the seabed and water quality) are assessed for individual mussel farm consents, each with an adjacent reference site. There is no monitoring of oyster farm effects, but some monitoring of effects from a coastal outfall. There is no coordination of monitoring among consent holders, and different providers and methods may be used, and results interpreted in different ways. Water quality monitoring is based on infrequent synoptic field surveys, which may not capture trends in the system or lead to timely detection of episodic events such harmful algal blooms. There is no monitoring of diffuse-source influences (*e.g.* from catchment river inputs), even though considerable dairy farming intensification is occurring.

The **'improved' monitoring scenario** includes effects monitoring of the coastal outfall, and of representative aquaculture sites, including oyster farms. Representative sites are located at farms that are operated in the same manner as the farms they represent, including identical species, similar stocking density and farm management practices. This enables monitoring results from the representative farm to be extrapolated to this group of farms. State of the environment monitoring provides a suite of reference sites against which the effects of the consented point-sources or representative sites are assessed. Site selection for SOE monitoring is complicated as the various purposes of monitoring (SOE monitoring, reference conditions for consent monitoring) and logistical constraints (for example shipping channels, regional boundaries) will require thorough assessment. For most applications there won't be one site that meets all requirements perfectly so compromises will be required.

Assessment of effects is based on a common suite of indicators (to the extent feasible) and sampling surveys are coordinated so that they are conducted at the same time using the same methods. Results are interpreted in relation to environment standards that have been simultaneously developed. Synoptic water quality surveys

are supplemented by continuous real-time monitoring for key indicators. Together with broad scale satellite imagery, these data capture background environmental conditions, provide a context for interpreting the synoptic survey data, and an understanding of the importance of different stressor sources (*e.g.* consent-related vs catchment derived). Monitoring data enables the development of forecasting tools for assessing threats to environmental or resource quality (*e.g.* forecasting of shellfish harvest closures due to land-derived contaminants or harmful algae).

Box 5. Integration of synoptic surveys, real-time and forecasting tools to improve design and implementation of environmental monitoring. HAB = Harmful Algal Bloom.



6. CONCLUDING REMARKS

The focus of this report has been on the integration of consent-related and SOE monitoring across the CMA. Achieving such integration is a significant undertaking, and requires addressing activities or stressors whose effects cross regional boundaries, or for which regional councils have no control. As a step towards achieving this, the second and third reports in this series on regional coastal monitoring will build on the framework and ideas in this report, facilitating an improved approach to aquaculture monitoring. However, there will be a range of practical issues and limitations that will need to be addressed if WRC is to achieve in practice strong integration of consent-related and SOE monitoring.

The expiry of existing consents, or new consent applications, will provide an opportunity for WRC to revise or develop consent monitoring conditions and monitoring plans that are better integrated within a regional SOE approach. However, many consents have a long term duration, and expire at different times, meaning that an improved system may take many years to implement in full. In these instances an alternative approach would be for WRC to work collaboratively with the consent holder(s) to revise consent monitoring conditions to obtain the mutual benefits generated by an application of the framework.

Early consultation within WRC, with consent holders or applicants and with other stakeholders, will clearly be critical to success, as the overall approach we are suggesting has some fundamental differences to the status quo (*e.g.* centralised monitoring and data storage). Such approaches may meet resistance unless the benefits (such as more efficient, cost-effective and useful monitoring) are clearly understood.

In the meantime, WRC can improve coastal SOE monitoring and reporting that assists in contextualising consent-related monitoring and begins to address the issue of cumulative effects. Indeed, the Council has already taken steps to collect long-term accessible data for a range of purposes using moored instrumentation (real-time water quality monitoring buoys) and is also developing tools (forecasting models, remote sensing imagery) for providing spatial forecasts and accessible monitoring data and information describing wider environmental conditions in the CMA.

7. ACKNOWLEDGEMENTS

We are grateful to Hilke Giles (Coastal Scientist WRC) for providing the text describing SOE monitoring in the Waikato region (Appendix 2), other background information used in the report (*e.g.* Appendix 1), and for helpful comments on drafts. External reviews by Richard Ford, Mark James and Bruce Cardwell were greatly appreciated. We also thank Grant Hopkins for peer review, and Gretchen Rasch for editorial and report production assistance.

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9. APPENDICES

Appendix 1. Examples of projects conducted in New Zealand, relevant to the development of a monitoring framework for Waikato Regional Council during the time this report was prepared.

Sea Change–Timu Tai Pari—Hauraki Gulf Marine Spatial Plan

This project is being led by a partnership between mana whenua, Auckland Council, Waikato Regional Council, territorial authorities, the Department of Conservation, Ministry for Primary Industries and Hauraki Gulf Forum. In recognition of the need for a better coordinated approach to managing the Hauraki Gulf, this partnership will develop the *Sea Change*/ *Tai Timu Tai Pari* plan by 2015. While not legally binding in itself, it will provide a strong framework to guide the management of the Hauraki Gulf, and help shape future agreements and statutory plans. Outcomes include a number of datasets that will support state of the environment assessments of the Waikato region's east coast.

For more information and project updates see: http://www.seachange.org.nz

Datasets for the Waikato region are available at: http://www.waikatoregion.govt.nz/Environment/Environmental-information/REDI/2854814/ and http://www.waikatoregion.govt.nz/Environment/Environmental-information/REDI/2722827/

Revision of Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)

Australian and New Zealand environment ministers have given approval to undertake a revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. These guidelines are a key resource for managing water quality and protecting aquatic ecosystems in Australia and New Zealand.

The ANZECC 2000 guidelines provide methods for setting appropriate limits on pollutant concentrations to protect different types of water bodies and sediments. They recommend developing criteria that are locally appropriate for specific ecosystem types, but where this is not possible, the guidelines provide default 'trigger values'. Exceedance of these values is intended to trigger further investigations or management responses. In New Zealand there are many situations in which these trigger values are used.

The ANZECC guidelines are an important source document used by regional councils, consultants and other resource management practitioners to guide water and sediment management decision-making. The guidelines have no statutory status, except where they are adopted in regional plans. However, the guidelines are widely used to develop water and sediment quality objectives and to make decisions on contaminant concentrations for resource consents.

For more information and links see:
http://www.mfe.govt.nz/publications/water/anzecc-water-quality-guide-02/revision-water-quality.html

This project has experienced a number of delays and complications, and there is uncertainty if it will be completed as originally designed.

Review of the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment)

The Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (2003) assist councils and agencies to better inform their communities of the risks related to swimming at their bathing beaches. They help control the public health risk from microbiological contamination in recreational waters and provide a framework for monitoring and reporting on the general health of beaches.

The guidelines incorporate a risk-based approach to monitoring water quality promoted by the World Health Organization. The guidelines are the result of consultation with regional councils, territorial local authorities and public health agencies.

A review of these guidelines is planned but at the time of completion of this report there has been no progress beyond an initial scoping out the work areas required for the review. For more information on these guidelines see:
https://www.mfe.govt.nz/publications/water/microbiological-quality-jun03/

Environmental reporting framework (Ministry for the Environment)

Consistent with international best practice, the Ministry for the Environment is broadening the scope of its current environmental reporting to include more than just the biophysical condition of natural resources. By expanding the scope, two objectives will be addressed. The first is to improve the understanding of the links and dependencies inherent in the economic, environmental, social and cultural systems, so that the Ministry can move with confidence to improve the system overall. The second is to enable the Ministry to provide a report that is coherent and consistent and that informs the public about the condition of the environment, the multiple pressures that put long term use of the environment at risk, and the economic, environmental, social and cultural significance of the current trends and condition.

To achieve these two objectives, the Ministry is developing an environmental reporting framework that will take into account measures of economic, cultural and social pressures as well as impacts of biophysical change. Early framework development stages have been undertaken using a collaborative approach including regional council representation on a working group.

A very important part of reforming reporting is to ensure independence of reporting. The Minister for the Environment has announced plans to introduce legislation to make environmental reporting mandatory and to ensure its independence by legislating a co-production by the Ministry for Environment and Statistics New Zealand, with sign-off by the respective agency executives.

Updates of this project will be made available at:

http://www.mfe.govt.nz/environmental-reporting/about-environmental-reporting/reporting-programme/monitoring-and-reporting-enviroment.html

Marine Environmental Monitoring in New Zealand (Ministry for Primary Industries)

Long-term datasets that track persistent change in the environment are a critical component of any modern ecosystem-based approach to natural resource management and sustainable growth. NIWA has built the New Zealand Catalogue of Marine and Environmental Monitoring Programmes, which holds information about data owners and their contact details, variables monitored, where they are collected and how often. The data from these datasets provides context for policy development around management actions, spatial and temporal planning, and a basis for looking ahead at different scenarios.

For more information and links see:
http://www.niwa.co.nz/coasts-and-oceans/projects/marine-environmental-monitoring-in-new-zealand

Ecological guidance for aquaculture (Ministry for Primary Industries)

The Ministry for Primary Industries has developed the Aquaculture Ecological Guidance Package to provide current and science-based information and advice on the ecological effects of marine-based aquaculture to assist local authorities, the aquaculture industry, and other stakeholders with their planning for and management of aquaculture. These resources are a collaborative working partnership with science providers, councils, the Department of Conservation, the aquaculture industry, and others with an interest in the coastal environment. The package includes a comprehensive Literature Review of Ecological Effects of Aquaculture, a summary overview, a Decision-makers' Dashboard (in development) and an Aquaculture Risk Screening Tool for identifying and prioritising the ecological risks of new aquaculture proposals (in development).

For more information on MPI aquaculture ecological guidance see:
http://www.fish.govt.nz/en-nz/Commercial/Aquaculture/Marine-based+Aquaculture/Aquaculture+Ecological+Guidance.htm

Biosecurity projects (Ministry for Primary Industries)

The Ministry for Primary Industries has a range of current projects on marine biosecurity and funds a national marine high-risk site surveillance programme for target pests. This programme includes Waitemata and Tauranga harbours, and MPI assisted WRC with a recent response to an incursion of the fanworm *Sabella spallanzanii* (designated an unwanted organism under the Biosecurity Act). A recent project of particular relevance is the national pathways projects, for which MPI commissioned reviews of practical measures for reducing the spread of potentially harmful marine organisms via human transport pathways within New Zealand (NIWA), and policy options for promoting the implementation of risk reduction measures (Cawthron). During two workshops held in Wellington in 2013, representatives of the aquaculture, commercial fishing, marine transport, mining and exploration, research and education, and sport and recreation pathways were invited to identify and discuss risk reduction options and potential barriers to their implementation. The aim was to engage industry, government, tangata whenua, councils, and other stakeholders in the development of a recommended package of measures and policies for reducing the domestic spread of marine pests within New Zealand. NIWA and Cawthron have recently produced reports on risks and management options, which are now being considered by MPI.

For more information on MPI marine biosecurity see:
http://www.biosecurity.govt.nz/biosec/camp-acts/marine-biosec-programme

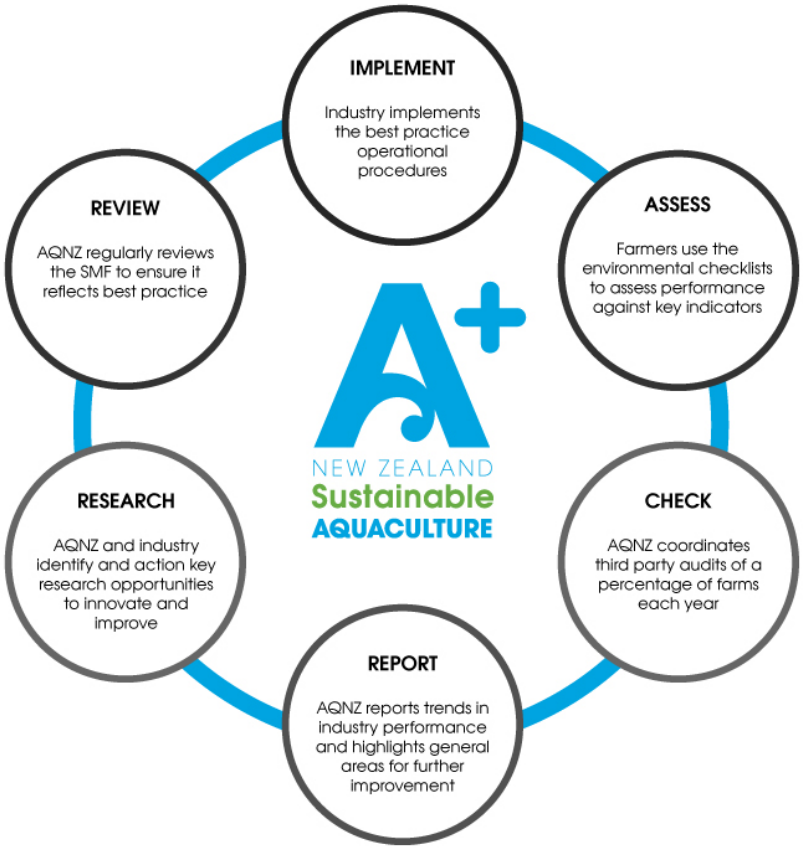
A+ New Zealand Sustainable Aquaculture programme (Aquaculture New Zealand)

The A+ programme provides New Zealand marine farmers with the practical tools to demonstrate transparency around their environmental performance.

A+ objectives align with those of world leading accredited certification programmes - such as Aquaculture Stewardship Council (ASC) and Best Aquaculture Practice (BAP). This association further substantiates ‘the importance we [the aquaculture industry] place on our role of being outstanding guardians of our place and people’. The A+ programme focuses on the following areas:

- Healthy ecology
- Clean clear water quality
- Responsible waste management
- Efficient use of resources
- Guarantee of food safety
- Valuing Iwi participation
- Enhancing our communities

The framework formalises a cycle of continuous reporting, review and improvement and provides a great platform for the community and industry to engage on their sustainability aspirations.



At the heart of the A+ programme is a set of sustainable management objectives that support aquaculture's vision to positively contribute to New Zealand's people and places. The key driving principles of A+ include:

- Kaitiaki – care of people and place – through clear environmental objectives and best management practices
- Integrity – responsibility and trust – proof of sustainability through a system of self-reporting and third party assessments
- Resourcefulness – innovation and creativity – regularly reviewing our progress and identifying new ways to manage our industry sustainably

The A+ programme standardises sustainability for future prosperity. It aligns with the New Zealand Story http://www.nzstory.govt.nz/ – supporting the distinctly kiwi attributes that make New Zealand unique and enhance aquaculture's value as an industry and as New Zealand as a country.

The A+ brand story informs a stronger and more recognisable collective industry voice – so that aquaculture's unique sustainability story can reach a wider audience and the benefits flow through to all New Zealanders and future generations. For more information on the A+ programme see:
http://www.aplusaquaculture.nz/.

Aquaculture on-farm biosecurity (MPI and Aquaculture New Zealand)

Background

The Ministry for Primary Industries and Aquaculture New Zealand have collaborated on a project to provide options to enhance on-farm biosecurity protection for New Zealand's commercial and non-commercial aquaculture sectors. Species included in this project are; green-lipped mussels, Pacific oysters, Chinook salmon, dredge oysters, trout, and paua.

Maintaining good on-farm biosecurity practices can minimise the potential impact of pests and pathogens to farms, sectors, industry and New Zealand's environment. Following good biosecurity practices also demonstrates to others that the New Zealand aquaculture industry is a responsible user of the aquatic environment and ensures New Zealand's reputation for high environmental performance.

The project has three phases:

- Phase I – understanding practices, priorities and perceptions;
- Phase II – risk profiling (organism and pathway risk) and option identification; and
- Phase III – testing the options with industry before releasing for use to manage biological risk.

Phase I – Completed

To develop the on-farm biosecurity management options, it was first necessary to understand the current farming practices, on-farm biosecurity management, and concerns and perceptions of the farmers themselves. MPI commissioned an independent researcher to carry out this research with in-kind support from Aquaculture New Zealand. This report will be available at the completion of all three phases. Phase 1 highlighted that the biosecurity practices and awareness of the aquaculture industry did not match the industry's concerns. The research confirmed that improvements are important if the industry and production is to continue to grow sustainably and access current and new markets.

Phase II – Completed

Using scientific literature and national and international codes of best practice, this phase of the project identified influences, pathways and vectors of biosecurity risk organisms onto, within and from aquaculture facilities. A biosecurity objective for each identified influence, pathway and vector was given, and potential preventive and management options of biosecurity best practice identified. These options were based on broad identifications of biosecurity risk organisms to New Zealand aquaculture species and other New Zealand core values (*i.e*. wild aquatic populations, ecosystem services), as well as examining core pathways that industry has some control over.

For each of New Zealand's major commercial and non-commercial aquaculture sectors, this included:

- the identification of the known pests and pathogens (nationally and internationally);
- the identification of knowledge gaps with respect to pests and pathogens;

- the means by which these pests and pathogens could enter production cycles; and
- the identification of options based on best practice to prevent or manage these pests and pathogens.

Phase II provided a technical guide to national and international “best practice” based on regulator and aquaculture industry perspectives, as at December 2014.

Phase III – due to be completed by early 2016

Following input from the commercial and non-commercial aquaculture sectors, MPI has used the outputs of phases I and II to finalise the options into a product that can be used to inform on-farm biosecurity management. Uptake of these options may flow into updated industry environmental management systems, sustainable management frameworks, operational procedures and any future biosecurity planning whether voluntary or more formally agreed readiness and response measures as part of a Government Industry Agreement.

Final outputs

The final set of options from Phase 2 and 3 will be in the form of a technical reference document. A user-friendly Aquaculture Biosecurity Manual and biosecurity plan template are also being developed. The Aquaculture Biosecurity Manual provides a set of key principles, that when followed, will assist farmers to strengthen their on-farm biosecurity management.

Material from this project will be available to in early 2016. Importantly the information provides voluntary guidance and implementation of some of the options to meet good and best practice biosecurity practices may take time. Therefore, further work will be needed to identify the practical minimum requirements and future requirements form a regulatory perspective.

For more information on the Aquaculture On-farm Biosecurity project contact Richard Fraser at the MPI Aquaculture Unit (Richard.Fraser@mpi.govt.nz).

Appendix 2. Proposed changes envisaged by Waikato Regional Council (WRC) for coastal state of the environment (SOE) monitoring.

Waikato Regional Council is in the process of improving coastal SOE monitoring in the Waikato region. Progress has been made in some areas, but most components are still in conceptual stages as they are elements of (or closely integrated with) the regional monitoring approach developed in this project.

The improved monitoring approach comprises three core components (Figure A2.1).

- Prioritisation
- Monitoring
- Communication

The approach was developed based on the guidelines presented by Ferreira *et al.* (2007) but modified to meet the New Zealand legislative requirements and WRC's needs.

State of the environment (SOE) monitoring must cover a diverse range of complex processes over a large area comprising different coastal landforms. Due to logistic and financial constraints it is necessary to prioritise monitoring activities according to the management issues at hand. Systematic prioritisation based on an ecosystem's state, exposure to pressures and susceptibility to degradation as well as WRC's policies and plans and the interests and concerns of the public is an integral component of WRCs coastal monitoring approach. The prioritisation approach also reveals knowledge gaps. Waikato Regional Council intend different levels of monitoring based on priorities and processes to be monitored. Additionally, existing information, models and prior monitoring efforts may provide enough insight into an ecosystem to improve efficiency by reducing sampling in time and space, using a more minimalist approach but still achieving monitoring objectives.

Long-term monitoring will be an important component of an improved SOE approach. This is synonymous with 'surveillance monitoring' as defined by Ferreira *et al.* (2007). This includes the long-term monitoring of the overall status of an ecosystem component (*e.g.* coastal vegetation, coastal water quality) in order to obtain information on long-term changes in natural conditions and changes resulting from anthropogenic activities. Where surveillance monitoring indicates a risk of the ecosystem component failing to meet environmental objectives or standards, more targeted operational monitoring may be conducted. Operational monitoring would generally focus on a subset of quality elements (*e.g.* water oxygen saturation) and/or a sub-area.

In addition to this multi-tiered monitoring of ecosystems and their components, it is intended that results will be integrated in order to assess cumulative effects. Cumulative effects assessments will also incorporate information from other sources, *e.g.* environmental

monitoring required in consent conditions or data from other agencies. Finally, communication via different media will ensure the public can access environmental monitoring data and information that is clear, timely and relevant.

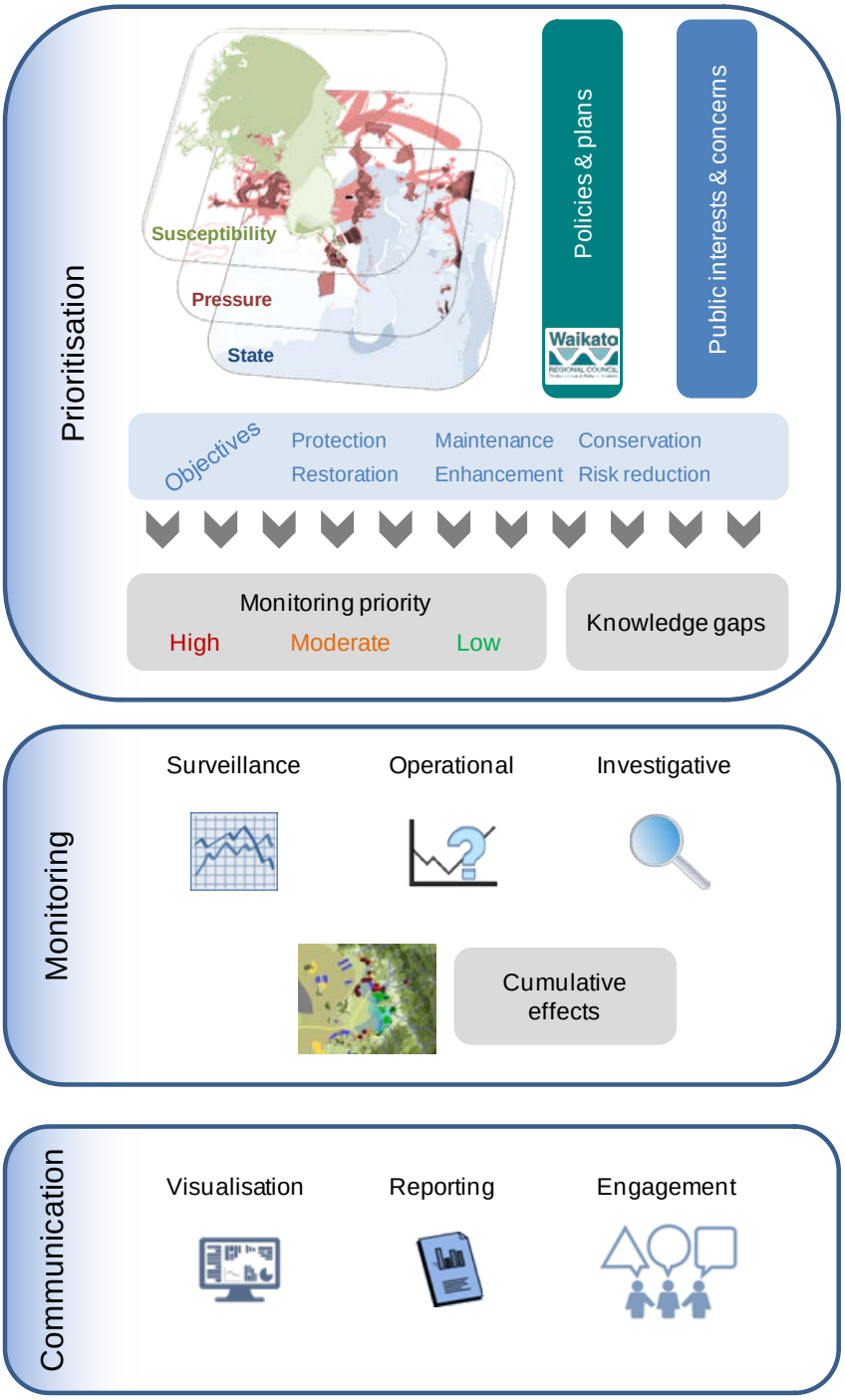


Figure A2.1. State of the environment (SOE) monitoring approach being envisaged by WRC to improve efficacy of coastal monitoring.