

# Trigger Points for Wilson's Bay Marine Farming Zone

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# Executive Summary

This report provides a summary of the process followed by Environment Waikato to identify trigger points for the Firth of Thames and Wilson's Bay Marine Farming Zone in the eastern Firth of Thames. The report recommends the trigger points and the associated management responses that will be adopted by Environment Waikato to assist with the management of shellfish farming in the Wilson's Bay Marine Farming Zone.

The Marine Farming Variation to the proposed Waikato Regional Coastal Plan provides for the staged development of marine farms within the Wilson's Bay Marine Farming Zone. As part of the staged development approach, Environment Waikato requires marine farmers to undertake environmental monitoring to ensure that adverse effects on the coastal environment are avoided as far as practicable.

Trigger points define levels of particular environmental variables that indicate a potential adverse environmental effect may occur. If these are exceeded, a management response is triggered. Trigger points are intended used as a management tool to provide an initial assessment of the effect, exceedance may result in a suite of management responses being triggered. The principal limitations to establishing adequate trigger points are an absence of appropriate site-specific knowledge upon which to base informed judgements, and insufficient knowledge about what constitutes an acceptable level of change in the natural ecosystem.

The process followed for establishing the trigger points is outlined. In 2001/02, Environment Waikato commissioned NIWA to propose a process to establish potential trigger points for the marine farms in the Wilson's Bay Marine Farming. In 2002/03, NIWA was commissioned to identify potential trigger points for the environmental variables being monitored around the marine farms in Zone. The resulting reports, as well as data from the Group A Marine Farming Consortium's environmental monitoring programme, were peer reviewed by independent scientists. Two workshops were convened in 2003 to identify and discuss potential trigger points. Participants included representatives from each of the groups of marine farmers involved in the Zone, scientists, and staff from Environment Waikato and other Regional Councils.

In their first report, NIWA recommended that the Limits of Acceptable Change (LAC) approach was best suited to determining critical levels of key environmental parameters for the Wilson's Bay Marine Farming Zone. The main elements of the LAC process are that it is transparent and collaborative; an on-going iterative process; criteria are flexible and based on current knowledge; and decisions are based on monitoring results. In the report, a suite of preliminary water column variables and possible trigger points were proposed.

The second report prepared by NIWA identified water quality trigger point values that, if exceeded, indicate changes from baseline or control conditions that warrant concern. The report also identified density changes in the benthic community that might be considered unusual relative to present natural conditions.

In workshop discussions it was decided to focus on developing chlorophyll-a as a water quality trigger point for management responses, because of the importance of phytoplankton for higher trophic levels in the coastal food web. Two potential trigger points (Firth of Thames-wide, and Marine Farming Zone specific) were discussed. The fortnightly sampling cannot monitor spatially-resolved depletion because it only samples at five sites relatively near to, or within, the farm. The best way to extrapolate depletion estimates made from monitoring to wider-scale depletion is to use biological modelling, in conjunction with an intensive, synoptic field survey. Synoptic surveys can be used to determine if the Farm-scale trigger is exceeded, and fortnightly monitoring data could indicate whether the Farm-scale trigger level was being approached. The

recommended trigger levels are calculated as the difference between the chlorophyll-*a* concentrations at the farm and control sites.

The workshop discussions considered a suite of benthic community and sediment variables, for which there was currently sufficient information available to derive trigger points. Benthic trigger points were based on the 75<sup>th</sup> and 95<sup>th</sup> percentile values for each environmental variable derived from the probability distribution of percentage differences between samples taken 50 and 100 m apart. The 75<sup>th</sup> percentile criterion reflects a spatial difference that occurred in the baseline survey 25% of the time, and the 95<sup>th</sup> percentile criterion a difference that occurred 5% of the time. Trigger points should be tested at 100 m from the edge of the Wilson's Bay Marine Farming Zone. Thus benthic trigger points are calculated by determining the average value for environmental variables on either side of the 100 m threshold, and calculating the difference between these values. The difference is converted to a magnitude, and expressed as percent of the maximum of the two values compared. These percent values are then compared to the trigger points for each variable to assess whether either the 75<sup>th</sup> or 95<sup>th</sup> percentile trigger points are exceeded.

The final recommended Firth of Thames wide water quality trigger point is: 'spatially and temporally averaged chl.-*a* depletion resulting from marine farming activities, and relative to un-impacted waters, should not exceed 20% over 10% of the area of the Firth of Thames'. The final recommended Marine Farming Zone water quality trigger point is: 'spatially and temporally averaged chl.-*a* depletion resulting from marine farming activities, and relative to un-impacted waters, should not exceed 25% over an area twice that of the Wilson's Bay Marine Farming Zone'. It is recommended that biological modelling be carried out to relate the Farm-scale effects to Firth-wide effects, that trigger levels be subject to refinements based on improved ecological knowledge, and that trigger points are developed for other water quality parameters.

The final recommended benthic trigger points are percentage differences that exceed the 75<sup>th</sup> and 95<sup>th</sup> percentile values in transects running north or south of the farm, for the following variables: 'number of mobile epifauna'; 'number of bioturbations'; 'Bray-Curtis similarity'; 'sediment clay content', 'sediment silt content' and 'sediment organic matter'. It is recommended that trigger points be developed to enable assessment of change within the Marine Farming Zone itself.

The management responses in the event that trigger points are exceeded are outlined. First a meeting should be held between Environment Waikato staff, marine farmers and appropriate scientists. Following the meeting full analysis of all data should be carried out, to determine if changes are attributable to farming activities. If the further analyses indicate that the changes are attributable to farming activities, no further marine farm development should proceed until information from additional studies is assessed, and further field investigations should be undertaken. Environment Waikato will aim to make any decisions regarding management responses in relation to a reduction of marine farming activity within the Zone collaboratively, seeking to minimise the significant adverse environmental effects.

The identification of trigger points will not replace the scientifically robust programme of environmental monitoring currently expected of the consent holders. At present there is insufficient knowledge to identify environmental variable(s) that will with certainty provide an indication of the sustainability of marine farming. The trigger points and the management responses will be subject to further iterations and refinement as more information becomes available. A review of the trigger points and the management process is proposed for 2006. The trigger points described in this report are specific to the Wilson's Bay Marine Farming Zone, and they cannot be applied directly to other marine farming areas, or necessarily to results arising from utilising different sampling methodologies. The use of trigger points is seen as a trial, and trigger points will only become incorporated into the statutory framework when there is a higher degree of certainty and confidence in their application.

# 1 Purpose of report

This report provides a summary of the process followed by Environment Waikato to identify trigger points for the Firth of Thames and Wilson's Bay Marine Farming Zone in the eastern Firth of Thames. The report recommends the trigger points and the associated management responses that will be adopted by Environment Waikato to assist with the management of shellfish farming in the Wilson's Bay Marine Farming Zone.

The objectives of developing a trigger point framework was to identify the levels of key environmental variables, which may indicate that significant adverse effects are occurring as a result of marine farming, to aid the management of the Wilson's Bay Marine Farming Zone.

Environment Waikato believes that it is important that trigger points should be developed and implemented through a proactive and collaborative process involving resource managers, marine farmers and scientists. Environment Waikato also considers it essential that the trigger points and the associated management responses identified in this report should be further improved and refined over time as more information becomes available, and therefore intend implementing a 3-yearly review of the trigger points and the management framework, to ensure the process remains relevant and collaborative.

It is important to note that the trigger points described in this report are specific to the Wilson's Bay Marine Farming Zone, and that they cannot therefore be applied directly to other marine farming areas, or necessarily to results arising from utilising different sampling methodologies.

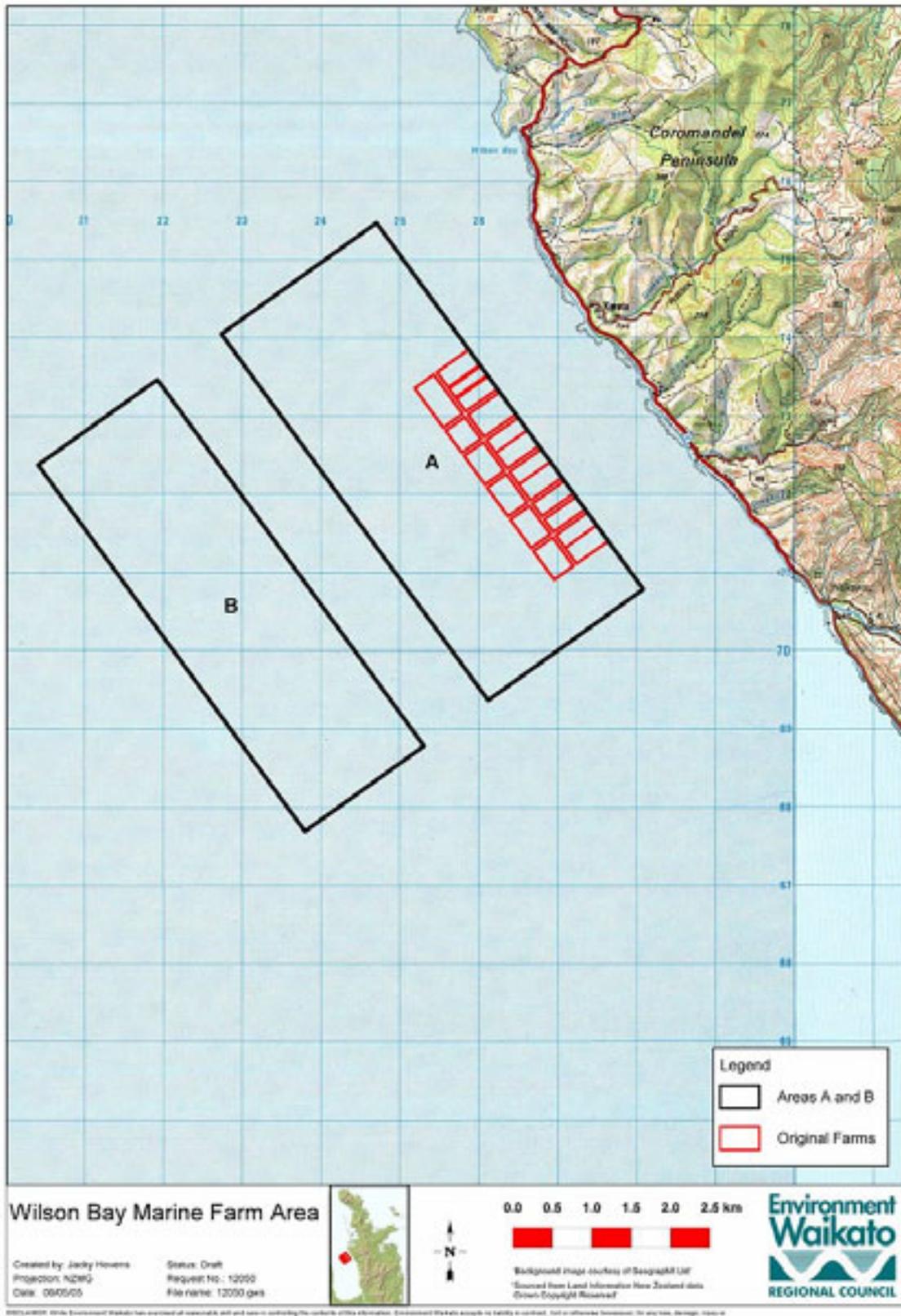


Figure 1: The location of the Wilson's Bay Marine Farming Zone.

## 2 Policy Background

### 2.1 The Proposed Waikato Regional Coastal Plan

The Marine Farming Variation to the proposed Waikato Regional Coastal Plan recognises marine farming as an important industry within the Waikato Region, contributing social and economic benefits to the local, regional and national economy. The Variation also recognises that, if not managed in a sustainable way, marine farm development may have adverse environmental effects, including cumulative effects, on the coastal environment. The Variation thus seeks to provide for the development of marine farming in an efficient and sustainable manner, which avoids adverse effects on the coastal environment as far as practicable. The provisions of the Plan are set out below. To the extent that they require marine farmers to monitor, provide information and report effects of their activities to Environment Waikato, these matters are implemented in practice through resource consents. For the Wilson's Bay Area A development, consents were granted in 2001 to a number of parties.

Rule 16.5.4 of the Variation provides for conventional longline marine farms and associated structures within the Marine Farming Zone at Wilson's Bay. Environment Waikato requires marine farmers to undertake environmental monitoring of the effects of marine farming on the environment, both in relation to the ecosystem near the marine farms, as well as the wider Firth of Thames area.<sup>1</sup>

Other Method 17.5.3 in the Variation provides for the staged development of marine farms within the Wilson's Bay Marine Farming Zone. Once the allocated farmed hectares in each Area of the Zone have been significantly developed (as defined in the Variation) and it has been demonstrated that there are no significant adverse environmental effects from the development, then further space within each Area of the Zone will be allocated. This method allows for further marine farm development to occur, while recognising the need to adopt a precautionary approach where the effects (including cumulative effects) associated with the large-scale development of marine farms are uncertain. All of these requirements are implemented, and if necessary can be enforced, through the consents granted.

This Method also states that as part of the staged development approach, Environment Waikato will require (through consents) marine farmers to undertake an environmental monitoring programme; results from this will enable specific trigger points for key environmental variables to be identified. Exceedance of these trigger points could result in the restriction of further development. The monitoring programme is to be reviewed at regular intervals and/or when adverse environmental effects are detected and need to be addressed. These provisions are implemented in practice through condition 10 of the 'Stage II' consents for Wilson's Bay.

Other Method 17.5.4 provides that Environment Waikato, in conjunction with marine farm applicants and farmers, will gather further information, including baseline data, on marine farming in the Region and its environmental effects (including cumulative effects), to support further policy development and resource consent decision-making in relation to marine farm development. This information will also be used to monitor the sustainability of marine farming within the Firth of Thames. This information will include, but will not be limited to, the effects on natural coastal processes (e.g. currents, hydrodynamic regimes, sediment transport processes and nutrient cycling processes), natural character, benthic communities, marine ecology, habitats of native flora and fauna and coastal water quality, and will be relevant not only to the marine

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<sup>1</sup> Note that in the context of this report a programme of environmental monitoring is considered in the broadest sense to include the routine monitoring of environmental variables (e.g. fortnightly monitoring of water quality variables), as well as any additional detailed studies undertaken at the completion of each stage of development within the Zone (e.g. synoptic surveys; studies of effects on waves and currents, etc.).

farm site, but will also address the potential impacts on the wider marine area. Other Method 17.5.4 is linked to Other Method 17.5.3, requiring sufficient monitoring to be undertaken to ensure any adverse environmental effects are identified and appropriately analysed.

Environment Waikato acknowledges that there is currently limited information on marine farming and its effects on the Region's coastal marine area. In particular, very little is known about the cumulative adverse effects of marine farms on the functioning of natural coastal processes and marine ecosystems over wider geographical areas, e.g. the Firth of Thames. The Variation identifies that the sustainability of the Firth of Thames ecosystem is critical.

## 2.2 Trigger points

Trigger points define levels of particular (monitored) environmental variables that indicate a potential adverse environmental effect may occur, and if exceeded, trigger a management response.<sup>2</sup> The trigger point for a particular environmental variable might represent a level below that at which the variable is known, or thought, to have, important ecological consequences, or it might be a statistical parameter used to indicate that an observed event would be considered an outlier under normal circumstances and therefore is worthy of further investigation. Comparison of values of the environmental variables at sites of interest with the values for the same environmental variables at relatively un-impacted control or reference sites; or assessing the changes in values of the environmental variables over time with those values representing baseline conditions, is the basis for detecting and assessing important and potentially adverse changes. Whether or not the actual change in condition at the site of interest has biological and/or ecological ramifications can often only be ascertained by further and more comprehensive investigation and analysis. Trigger points also need to be considered in the context of the inherent natural variability of the environmental variables of concern, and not all of this variation may be ecologically important.

Environmental variables to be measured as part of environmental monitoring programmes are often clearly specified (e.g. benthic species richness, sediment grain size, chlorophyll-*a*, etc.). Often however there has been no *a priori* determination of what constitutes an acceptable level of change in a variable – i.e. the size of an effect beyond which a management response is necessary has not been defined – yet extensive and expensive monitoring of that variable may be required. In this case, such monitoring is a data gathering exercise by which regulatory authorities may establish baselines, trends and thresholds of effects at a later date. Monitoring is most effective, and the natural environment best protected, if trigger points are established from the outset and monitoring is designed to verify effects compared with these performance criteria. It is important in all cases to maintain the integrity of the trigger points by adhering to the requirements for data quality and quantity through thorough monitoring.

Trigger points are not, however, meant to be magic numbers whereby an environmental effect is immediately inferred if they are exceeded. Rather they are intended used as a management tool, in conjunction with professional judgement, to provide an initial assessment of the effect. This may then result in a suite of management responses being triggered. The first response, to continue monitoring, occurs if the values of the environmental variables are less than the agreed trigger points, indicating that there is a low risk of an adverse environmental effect. The alternative management responses, further analysis and site-specific investigations and potentially some form of management action, occur if the values of the environmental variables exceeds the trigger point; thereby indicating that a potential risk exists that an adverse environmental effect is occurring. The aim of further analysis and site-specific investigations is to determine whether or not a real risk to the ecosystem exists. The trigger point approach should be seen as an early warning

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<sup>2</sup> See the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.

mechanism to alert resource managers, marine farmers and scientists to potential or emerging changes that should be followed up. Early information enhances the options for management. This will enable the implementation of appropriate management responses so that potentially substantial and ecologically important disturbances can be avoided.

As part of this process, Environment Waikato is seeking to identify the levels of key environmental variables which, when exceeded, indicate that potentially significant adverse environmental effects may occur as a result of marine farm development within the Wilson's Bay Marine Farming Zone. While the environmental variables will be monitored, and the effects managed, at the scale of the Marine Farming Zone, trigger points need to be set which will ensure the sustainable management of the whole of the Firth of Thames. By seeking to identify trigger points, Environment Waikato is interested in more than simply statistical significance, which is only a tool in the context of a specific monitoring programme design. The Regional Council is seeking to identify changes or departures considered to be ecologically significant. The identification of trigger points is thus based on decisions about the size of an effect, which describes how much deviation from the reference/control or baseline condition is considered acceptable before a management response is required. The identification of appropriate trigger points will ultimately lead to more certainty for marine farmers, resource managers and other stakeholders.

Setting acceptable trigger points is not always a straightforward task. The principal limitations to establishing adequate trigger points for many variables are:

1. An absence of appropriate site-specific (scientific) knowledge upon which to base informed judgements about the ecological consequences of an observed change of a given magnitude in an environmental variable.
2. An absence of appropriate knowledge about what constitutes an acceptable level of change in the natural ecosystem from the reference/control or baseline condition.

## 2.3 International context

The trigger point approach is similar to that recommended by GESAMP.<sup>3</sup> GESAMP have recommended that to ensure ecological effects associated with marine farming do not exceed pre-determined and acceptable levels of change, a management framework for marine farming should include the establishment of Environmental Quality Objectives (EQOs), from which Environmental Quality Standards (EQSs) are derived to safeguard the coastal ecosystems (GESAMP, 1991). Environmental Quality Objectives define the conditions to protect a particular use (e.g. tourism, aquaculture, fisheries, etc.); Environmental Quality Standards are levels of particular variables relevant to that use, which may be imposed to ensure that the objectives are not compromised (i.e. concentrations or changes observed in the environment are below those likely to cause environmental effects).

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<sup>3</sup> GESAMP is the IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution.

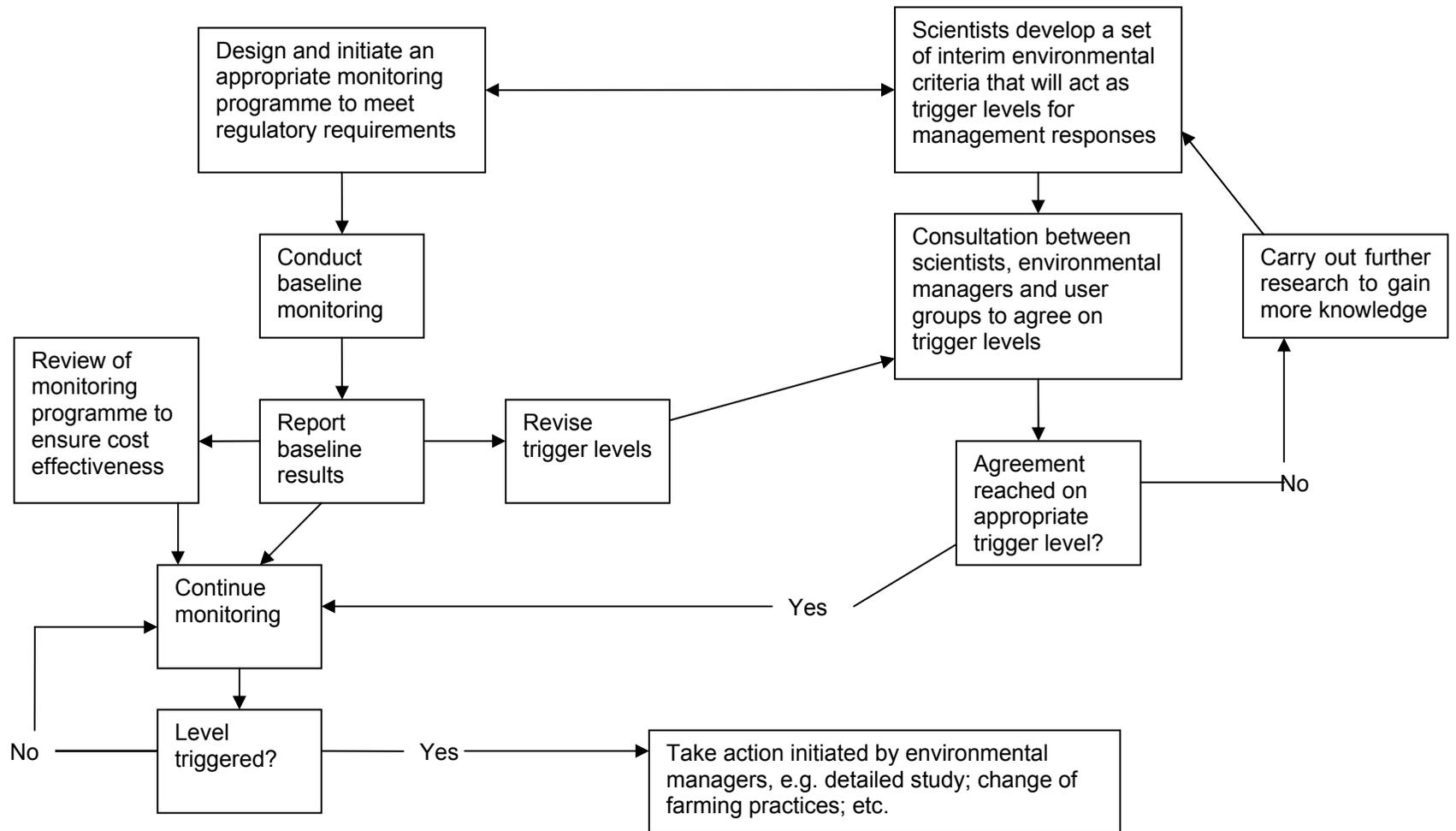


Figure 2: Overview of the intended trigger point process. From: Hatton et al. (2002).

# 3 Process for establishing and implementing trigger points

## 3.1 Process employed by Environment Waikato

In 2001/02, Environment Waikato commissioned NIWA to propose a process to establish potential trigger points (environmental standards or performance criteria) for the marine farms in the Wilson's Bay Marine Farming Zone in the eastern Firth of Thames. The report *Marine Farming in the Firth of Thames – Monitoring and Performance Criteria* (Hatton et al., 2002), included:

1. An overview of the existing marine farms and monitoring programmes currently in place in the Firth of Thames.
2. A literature review of New Zealand and international approaches to monitoring and performance standards for marine shellfish farming.
3. An assessment of how these approaches could apply to the Firth of Thames at various scales and locations.
4. The development of a pathway to establish appropriate trigger points for the Wilson's Bay Marine Farming Zone.
5. Preliminary identification of potential trigger points for monitored benthic community, seafloor and water column variables.

In 2002/03, NIWA was commissioned by Environment Waikato to undertake further work to identify potential trigger points for the environmental variables being monitored around the marine farms in the Wilson's Bay Marine Farming Zone. The report *Marine Farming in the Firth of Thames – Discussion Document on Monitoring and Performance Criteria – Stage 2* (Hatton et al., 2003), included recommendations for potential trigger points and management options for the benthic community, the seafloor and the water column. These were based on a combination of literature values and baseline information collected during the environmental monitoring programme undertaken by the Group A Consortium as part of resource consent conditions for marine farm development in Area A of the Wilson's Bay Marine Farming Zone. No trigger points were recommended for wave and current parameters. In the report it was indicated that long-term data and computer simulation would be required before it would be possible to identify trigger points for wave and current parameters.

Following discussions between Environment Waikato and the Group A Consortium, it was agreed that these reports, as well as the data from the Consortium's environmental monitoring programme used by NIWA to assist with the identification of the trigger points, should be independently peer reviewed by scientists from the Cawthron Institute. The Cawthron Institute provided a written report incorporating their comments: *Review of the Proposed Performance Indicators and Trigger Levels for the Marine Farming Zone in Wilson's Bay* (Gibbs and Forrest, 2003).

Environment Waikato considers that it is important that trigger points should be developed through a collaborative process involving resource managers, marine farmers and scientists. Two workshops were convened in February 2003 and May 2003 to identify and discuss potential trigger points for the Wilson's Bay Marine Farming Zone. Representatives from each of the groups of marine farmers involved in the Zone participated in the workshops. This included representatives from Group A (who currently have resource consent to undertake farming of *Perna canaliculus* in Area A of the Zone), Group B (who have applied for resource consent to undertake spat collection of *Perna canaliculus* in Area B of the Zone) and Group C (who have existing marine farms in Area A of the Zone). Scientists from NIWA and the Cawthron Institute also participated in the workshops, as Environment Waikato considered it important that decisions about trigger points should be informed by science. Staff from Environment Waikato, as well as Auckland Regional Council and Environment Bay of

Plenty participated in the workshops. Staff from the Department of Conservation Waikato Conservancy Office were also invited to participate, but were unavailable to do so. The workshops were facilitated by an independent facilitator. The two NIWA reports (Hatton et al. 2002, 2003) and the Cawthron report (Gibbs and Forrest, 2003), were made available to participants prior to the workshops as background material.

A further meeting between representatives for the marine farmers and Environment Waikato staff and senior managers was held in March 2003 to discuss specific issues arising from the first workshop.

Two documents summarising the workshop proceedings were prepared and distributed to all participants:

1. *Wilson's Bay Marine Farming Zone – Outcomes from the Workshop on Trigger Points (or Performance Criteria)*. Grosvenor Motor Inn, Hamilton (27 February 2003). NIWA Project: EVW03249.
2. *Wilson's Bay Marine Farming Zone – Outcomes from the Second Workshop on Trigger Points (or Performance Criteria)*. Council Chambers, Environment Waikato, Hamilton (7 May 2003). NIWA Project: EVW03249.

## 3.2 The Limits of Acceptable Change planning framework

NIWA (Hatton et al., 2002) recommended that the approach that would be best suited to determining critical levels of key environmental parameters for the Wilson's Bay Marine Farming Zone is one based on the Limits of Acceptable Change (LAC) process.

The Limits of Acceptable Change planning framework was initially proposed in the early 1980s as a means of dealing with the issue of recreational carrying capacity in wilderness areas. For that purpose, the LAC process sought to explicitly define a compromise between resource/visitor experience protection and recreation use goals. It has also been used to manage environmental performance of marine dredging operations offshore from Townsville (Great Barrier Reef) adjacent to highly valued coral reefs and seagrass beds.

The key elements of the LAC process (Cole and McCool, 1998; Cole and Stankey, 1998; Oliver, 1995) include:

- 1) The notion of transparency. The LAC process is a means of avoiding and resolving conflict between potentially opposing resource management goals. Procedurally, this is accomplished through the explicit specification of performance standards, which are statements of acceptable change in environmental conditions. LAC standards are limits – lines-in-the-sand – which, if exceeded, elicit well-defined management responses.
- 2) The LAC process should be collaborative, with decisions reflecting the input from relevant stakeholders.
- 3) The LAC process should be considered to be 'a process' rather than 'a product', and it should be continuous and ongoing, rather than a one-off undertaking. It is a framework for rationally and openly dealing with certain issues, rather than a means of developing a written, comprehensive management plan.
- 4) The LAC process is iterative, rather than 'set in stone', and it acknowledges that it is difficult to define acceptable ecological change. Nonetheless, it requires that a suite of environmental standards and associated trigger levels (degrees of change), be agreed upon.
- 5) The process advocates developing flexible criteria on the basis of current knowledge – acknowledging that criteria may need to be changed in the light of further knowledge.
- 6) Monitoring, to a level which allows a decision to be made on whether or not LAC standards have been met, is a critical elements of LAC.

It is in the context of these key elements of the LAC process that Environment Waikato has sought to identify trigger point variables and associated limits of acceptable change in values of these variables, and seeks to carry the process into the future.

## 4 Proposed trigger points

### 4.1 Preliminary trigger points put forward for discussion in the NIWA 2002 report

The first report prepared by NIWA (Hatton et al., 2002) presented preliminary trigger points for monitored water column, benthic community and seafloor variables.

#### 4.1.1 Water column

The report proposed a suite of preliminary water column variables and possible trigger points (Table 1). The report identified that trigger points should be set at levels shown by field and experimental observation, monitoring and/or simulation to have an impact on the system (e.g. on phytoplankton biomass, secondary production etc.). The report suggested that trigger points could be based on values outside the expected ranges of water column variables for the Firth of Thames and assessed using existing time-series data (e.g. NIWA's FoRST-funded C-SEX programme; MAF Fisheries information; data collected during the environmental monitoring programme being undertaken by the Group A Consortium). The report concluded that further detailed studies would be necessary to identify trigger points specific to the Wilson's Bay Marine Farming Zone.

**Table 1: Proposed (2002) water column trigger points for the Wilson's Bay Marine Farming Zone.**

Suggested variable	Possible trigger point
Nutrients (e.g. nitrate and ammonium nitrogen)	Increases by $\geq 5 \mu\text{M l}^{-1}$ in the mixed layer within the farm plume.
Phytoplankton	Values $< 0.5 \mu\text{g chl.-a l}^{-1}$ – indicative of phytoplankton depletion; values of $> 4 \mu\text{g chl.-a l}^{-1}$ (autumn/winter) or $> 7 \mu\text{g chl.-a l}^{-1}$ (spring/summer) – indicative of phytoplankton enhancement.
Zooplankton	Depletion.

#### 4.1.2 Benthic community and the seafloor

The report proposed a suite of preliminary benthic community and seafloor variables and possible trigger points on the basis of data from other NIWA studies (e.g. in the Mahurangi Harbour) and data collected during the first year of the environmental monitoring programme being undertaken by the Group A Consortium. The report concluded that further detailed studies would be necessary to identify trigger points specific to the Wilson's Bay Marine Farming Zone.

##### 4.1.2.1 Specific biological variables

A number of specific biological variables and associated trigger points over and above natural variation were suggested (Table 2).

**Table 2: Proposed (2002) benthic biological variables and possible trigger points.**

<b>Suggested variable</b>	<b>Possible trigger point</b>
Density of adult horse mussels	Changes by $\geq 20\%$
Density of predatory/scavenging starfish	Changes by $\geq 10\%$
Number of taxa present	Changes by $\geq 10\%$
Number of individuals of a given species present	Changes by $\geq 20\%$
Density of hermit crabs	Changes by $\geq 20\%$
Density of mobile epifauna	Changes by $\geq 20\%$
Density of total number of sedentary species	Changes by $\geq 10\%$
Density of heart urchins	Changes by $\geq 10\%$

#### 4.1.2.2 Surrogate biological variables

A number of surrogate biological variables and possible trigger points over and above natural variation were also proposed (Table 3).

**Table 3: Proposed (2002) surrogate benthic biological variables and possible trigger points.**

<b>Suggested variable</b>	<b>Possible trigger point</b>
Density of burrows > 1cm diameter	Changes by $\geq 20\%$
Density of holes > 0.5 cm diameter	Changes by $\geq 20\%$
Density of heart urchin tests	Changes by $\geq 10\%$
Number of tracks present	Changes by $\geq 25$

#### 4.1.2.3 Multivariate community changes

A measure of multivariate change and associated possible trigger point was also proposed (Table 4).

**Table 4: Proposed (2002) benthic multivariate variable and possible trigger point.**

<b>Suggested variable</b>	<b>Possible trigger point</b>
Epifaunal assemblage composition	Deviation by 50% Bray-Curtis similarity

#### 4.1.2.4 Sediment variables

A number of sediment variables and associated possible trigger points over and above natural variation were also proposed (Table 5).

**Table 5: Proposed (2002) sediment variables and possible trigger points.**

<b>Suggested variable</b>	<b>Possible trigger point</b>
Mussel shell hash	Increases by $\geq 20\%$ under the farm. Defined relative to current variation along monitored transects outside farm.
Fine material (sediment grain-size)	Increases by $\geq 20\%$ under the farm. Decreasing amount along monitored transects outside farm to a determined point beyond which natural levels should be maintained.
Organic content	Changes by $\geq 20\%$ under the farm.

## 4.2 Further development of preliminary trigger points put forward for discussion in the NIWA 2003 Report

The second report prepared by NIWA (Hatton et al., 2003) included recommendations for potential trigger points and management options for the water column, benthic community, and seafloor. The potential trigger points and management options formed the basis for the workshop discussions.

### 4.2.1 Water column

The report identified trigger point values that, if exceeded, indicate changes from baseline or control conditions that warrant concern and suggest that additional information need be considered. Part of the report determined the sampling intensity required to gain confidence that should such changes occur, they would be detected for chlorophyll-a; phytoplankton; micro-zooplankton; inorganic nutrients and organic suspended solids. This indicated that for most variables the monitoring would be able to reliably detect changes in the order of 20% to 50% from baseline at most sites, should such changes occur and persist for periods of at least six to 24 months. The report emphasised that these changes did not necessarily imply ecological importance or represent a threat to the sustainability of the Firth as a whole, as they could not be related to effects beyond the monitoring area. It was also noted that the analyses were based on only one year of samples from monitoring.

The report also identified 'extreme thresholds' on the basis of historical information from the Hauraki Gulf (Zeldis et al., in press). These represented maximum non site-specific thresholds which have been observed to cause large effects on larval fish survival across the entire Hauraki Gulf and to persist for a number of months. Examples included:

1. Decrease in chlorophyll-a concentrations from 2.0 to  $\leq 1.0 \mu\text{g l}^{-1}$ .
2. Large decreases in the densities of larval copepods from circa 15 to 3 animals  $\text{l}^{-1}$ .

These extreme thresholds represent changes in the order of 50% or greater. The report recommended that should such changes occur at sites likely to be impacted by marine farming activities, but not at control sites, this would clearly indicate that an extreme threshold was being approached. Analysis to determine whether the changes were attributable to natural events or farming activities would be important.

### 4.2.2 Benthic community and the seafloor

The report identified density changes in the benthic community that might be considered unusual relative to present natural conditions (as indicated by the information from the first year of the environmental monitoring programme being undertaken by the Group A Consortium) and which would therefore warrant further investigation. It is important to note that the proposed trigger points do not necessarily define an ecologically important change, but serve as an alert of a potential or emerging change that should be followed up. The report recommended that the ecological significance (if any) of the actual change in key environmental variables at a site be ascertained by more comprehensive investigations.

Two important considerations underlie the preliminary trigger points presented in the report (see Table 6 below):

1. A 100 m spatial threshold out from the boundary of the farmed areas was set, beyond which the footprint of the farms should not extend without triggering some management action. This threshold was based on the small-scale variability in benthic community structure within the study area and the data available from the environmental monitoring programme undertaken by the Group A Consortium.
2. Trigger points were based on the 75<sup>th</sup> and 95<sup>th</sup> percentile values for each environmental variable derived from the probability distribution of percentage

differences. Thus, the first level criterion (75<sup>th</sup> percentile) is based on identifying a spatial difference that occurred in the baseline survey 25% of the time, and the second level criterion (95<sup>th</sup> percentile) reflects a spatial difference that only occurred 5% of the time. The natural spatial variability for each environmental variable was determined by calculating the magnitude (i.e. the positive or negative aspect is removed), of difference between pairs of samples separated by 50 m or 100 m along the four monitored transects, and converting these to percent of the maximum of the two values. From this data a probability distribution for the magnitude of percentage differences for each environmental variable at two scales (50 m and 100 m) was derived and used to determine the 75<sup>th</sup> and 95<sup>th</sup> percentiles of variation.

Exceedance of the percentile values would result in one of two levels of management response.

**Table 6: Proposed (February 2003) benthic variables and associated 75th and 95th percentiles of variation. Values in percent.**

<b>Suggested variable</b>	<b>75<sup>th</sup> percentile</b>	<b>95<sup>th</sup> percentile</b>
Number of mobile epifauna	30	60
Number of stationary epifauna	insufficient data available	insufficient data available
Number of burrows	insufficient data available	insufficient data available
Number of holes	30	80
Number of tracks	50	90
Number of live <i>Echinocardium</i>	insufficient data available	insufficient data available
Number of dead <i>Echinocardium</i>	insufficient data available	insufficient data available
Number of bioturbations	40	60
Number of different objects	33	50
Shannon-Wiener diversity	40	95
Bray-Curtis % similarity	85	95
% sediment clay content	30	40
% sediment silt content	20	25
% sediment gravel content	70	85
% sediment organic content	15	25
Depth of redox potential	60	70

These trigger points only apply to benthic communities and the seafloor in areas extending north and south of the Wilson's Bay Marine Farming Zone (as opposed to inshore or offshore of the Zone), which is consistent with the predominant direction of the residual circulation parallel to the shoreline in the Wilson's Bay area. The trigger points are also only applicable to data collected following the sampling methodology outlined in the Environment Waikato approved monitoring programme (Zeldis et al., 2001), or methods that have been formally assessed to produce identical or very similar results and approved by Environment Waikato. Further work will need to be undertaken to develop trigger points for the benthic communities and the seafloor within the farming zone, in offshore areas, and in inshore areas which are likely to be the areas with more sensitive benthic communities.

It should also be noted that the identified trigger points are predominantly based on information from a single sampling event in the environmental monitoring programme (baseline conditions). Implicit in basing trigger points on set of data is the possibility that the trigger points may be exceeded as a result of natural variability outside that which was observed on that single sampling occasion. This will need to be considered

in any assessment of the implications of trigger point exceedance, and a review of these trigger points will be conducted in 2006 as part of the review process.

### 4.2.3 Currents and wave action

The NIWA report identified that specifying trigger points for properties such as wave attenuation and current modification around marine farms is a complex process. The report recommended that, at this stage, trigger points for wave and current parameters cannot be set without further long-term field data and computer simulations.

## 4.3 Workshop discussions

### 4.3.1 Water column

On the basis of the scientific knowledge currently available it was considered that it was appropriate to focus on developing chlorophyll-*a*, a measure of phytoplankton biomass, as a trigger point for management responses. This is because of the importance of phytoplankton for higher trophic levels in the coastal food web (Broekhuizen et al., 2002; Zeldis et al., in press). Two potential trigger points for chlorophyll-*a* were proposed for discussion:

**Table 7: Proposed (May 2003) chlorophyll-*a* trigger points for the Wilson's Bay Marine Farming Zone.**

<b>Firth of Thames-wide trigger point</b>	<b>Marine Farming Zone trigger point</b>
Spatially and temporally averaged chl.- <i>a</i> depletion resulting from marine farm development and relative to un-impacted waters, should not exceed 20% over 10% of the area of the Firth of Thames <sup>4</sup> .	Spatially and temporally averaged chl.- <i>a</i> depletion resulting from Stage 1 development and relative to un-impacted waters, should not exceed 30% within an area twice the size of the Stage 1 Area (i.e. ½ Area A).

Initial discussions focused on ensuring sustainable development at the scale of the entire Firth of Thames. Hence, the first trigger point (Firth-wide-scale) was developed to identify a level of phytoplankton depletion, which if reached, would be considered to be unacceptable. While this was considered a maximum level of acceptable depletion, it was noted that it was considerably less than the extreme threshold previously identified (Section 4.2.1), in that it set a 20% rather than > 50% depletion, and applied to 10% of the Firth rather than averaged over the entire area.

The second trigger level (Farm-scale) was proposed because environmental performance of the development is to be monitored routinely using the fortnightly water quality sampling in the immediate farm vicinity. However, it was concluded in the meeting that, instead of the Farm-scale trigger level given above which refers to the Stage 1 Area, it was preferable to manage for the Wilson's Bay Marine Farm Zone (Areas A and B combined), because that would be the ultimate size of the development, if it complied with staged development criteria. Therefore, it was agreed that the Farm-scale trigger should be designated with respect to the Wilson's Bay Marine Farming Zone, and it was recommended that:

*Spatially and temporally averaged chlorophyll-*a* depletion, resulting from marine farming activities and relative to un-impacted waters, should not exceed 25% over twice the area of the Wilson's Bay Marine Farming Zone.*

This trigger was considered conservative, with respect to the Firth-wide trigger, because while it is set at 25% depletion instead of 20%, it covers an area of 5.6% of the Firth instead of 10%.

It was acknowledged in the meeting that the fortnightly sampling cannot monitor spatially-resolved depletion (either Firth-wide or over an area twice the WBMFZ)

<sup>4</sup> The Firth of Thames is defined as the area south of a line from north-east Waiheke Island to Coromandel.

because it only samples at five sites relatively near to, or within, the farm. Thus, an estimate of depletion at the farm centre that would correspond to a potential breach of the Firth-wide or Farm-scale triggers, is required. It was considered that the best way to make such an estimate would be to use biological modelling, in conjunction with an intensive, synoptic field survey, to extrapolate depletion estimates made from monitoring, to wider-scale depletion. At the time of the May 2003 meeting, however, the modelling and synoptic survey had not been implemented.

Since the May 2003 meeting, both the synoptic survey and the biological modelling have been carried out (Gall et al., 2003; Broekhuizen et al., 2003). Furthermore, a verification study comparing the output from the biological modelling with the field results of the synoptic survey has been completed (though not yet finalised as of December 2004). Thus, the capability now exists to make estimates of farm-centre depletion (estimated from the monitoring programme) corresponding to Firth-wide and Farm-scale trigger levels.

In the meeting, it was considered that the synoptic survey, which was spatially resolved in the farm vicinity and about three times the area of the WBMFZ, can be used to determine if the Farm-scale trigger was exceeded. Furthermore, it was considered that fortnightly monitoring data could indicate that the Farm-scale trigger level was being approached, if they showed depletion approaching 25% at the farm centre. It was therefore recommended that the Farm-scale trigger be assessed by considering both monitoring and synoptic survey results. Improved confidence that farm-centre (i.e. fortnightly) estimates from monitoring reflect changes at the Farm-scale could be gained from biological modelling.

As mentioned above, the Farm-scale trigger is considered a more local indicator of the Firth-wide trigger, and one which is more closely related to the synoptic survey and fortnightly monitoring. It is considered that performance of the farm with respect to the Farm-scale trigger would indicate its performance Firth-wide. This is accounted for in the management responses to the water column trigger levels in Section 6.2.1.

The percent depletions in the recommended trigger levels are calculated as the difference between the chlorophyll-*a* (chl.-*a*) values (in  $\mu\text{g l}^{-1}$ ) at the farm and control sites. Recommended methods for implementing the trigger level and management responses arising from breaches are given in Section 6.

An advantage of using deviations of chlorophyll-*a* at the farm site to a control site is that it avoids the need to specify changes in absolute amounts of chlorophyll-*a*. The trigger point is thus corrected for 'natural' variability in the distribution of chlorophyll-*a* values at the monitoring sites, because control and farm sites are monitored simultaneously over time. Thus, the effects of natural temporal trends such as long-term climate changes and seasonality are accounted for.

The outcome of the May 2003 meeting was thus the following recommended trigger points:

**Table 8: Proposed (outcome of workshop May 2003) water column trigger points for the Wilson's Bay Marine Farming Zone**

<b>Firth of Thames-wide trigger point</b>	<b>Marine Farming Zone trigger point</b>
Spatially and temporally averaged chl.- <i>a</i> depletion resulting from marine farming activities, and relative to un-impacted waters, should not exceed 20% over 10% of the area of the Firth of Thames.	Spatially and temporally averaged chl.- <i>a</i> depletion resulting from marine farming activities, and relative to un-impacted waters, should not exceed 25% over an area twice the size of the Wilson's Bay Marine Farming Zone.

The trigger levels will be assessed using fortnightly monitoring results from the farm centre and control sites, and synoptic survey results. In the future, the farm-centre depletion corresponding to the Farm and Firth scale trigger levels should be

determined using biological modelling, to better assess whether such levels are being approached in the fortnightly monitoring data.

### 4.3.2 Benthic community and the seafloor

A reduced suite of key benthic community and sediment variables, for which there was currently sufficient information available to derive 75<sup>th</sup> and 95<sup>th</sup> percentile values as trigger points, were proposed for discussion. The 75<sup>th</sup> and 95<sup>th</sup> percentile values were proposed as the percentile change in spatial variation used to indicate greater than natural variability, with trigger points tested at 100 m from the edge of the Wilson's Bay Marine Farming Zone.

**Table 9: Proposed (May 2003) benthic variables and associated 75th and 95th percentiles of variation. Values in percent.**

Variable	75 <sup>th</sup> percentile	95 <sup>th</sup> percentile
Number of mobile epifauna	30	60
Number of bioturbations	40	60
Shannon-Wiener diversity	40	95
Bray-Curtis % similarity	85	95
% sediment clay content	30	40
% sediment silt content	20	25
% sediment gravel content	70	85
% sediment organic content	15	25

After discussion at the workshops it was agreed that the following main environmental variables with their associated 75<sup>th</sup> and 95<sup>th</sup> percentile trigger points tested at 100 m from the edge of the Zone, should be utilised to trigger management responses:

- Number of mobile epifauna;
- Amount of bioturbation;
- Bray-Curtis similarity;
- % mud (silt/clay content);
- % sediment organic content.

Using the data from the environmental monitoring programme, the average value for these environmental variables on either side of the 100 m threshold is determined (e.g. from video data collected on either side of the threshold). The difference between these values on either side of the 100 m threshold is then calculated, converted to a magnitude, and expressed as percent of the maximum of the two values compared. These percent values are then compared to the trigger points for each variable to assess whether either the 75<sup>th</sup> or 95<sup>th</sup> percentile trigger points are exceeded. Note that as the magnitude of change is calculated, rather than the actual difference, both increases and decreases will trigger a management response. Note also that the likelihood of the trigger points being successful in detecting changes related to farm impacts rely on these changes occurring a maximum of ~100 m from the farm; if impacts occur further away, chances are that differences on either side of the 100 m boundary will not be large enough to exceed the trigger points. No exceedance of trigger points is therefore no guarantee that adverse environmental impacts have not occurred.

Further development of the benthic trigger points was carried out following the Assessment of Environmental Effects of the Stage 1 development. New trigger points were calculated for the Bray-Curtis dissimilarity index for the 75<sup>th</sup> and 95<sup>th</sup> percentiles by adding data from the second year of monitoring, from the last 500 m (to avoid farm effects) of each of the four monitoring transects, to the data from the first year of monitoring. This added a measure of variability between years. Within-farm benthic

trigger points were also calculated, based on the data collected from within the farmed area in the first year of monitoring.

### **4.3.3 Other potential trigger points**

Some other potential trigger points were discussed at the workshops – e.g. the period of time required for mussels to reach a certain size. None of these were progressed further at this stage.

## **4.4 Trigger points – some important considerations**

The NIWA reports and the Cawthron Institute report identified a number of important considerations in relation to the development and implementation of trigger points.

The Cawthron Institute (Gibbs and Forrest, 2003) recommended that in setting out to define trigger points for environmental variables, the following criteria should be met:

1. The variable must directly measure some ecological, physical or chemical property or process, or index (track) such as process; i.e. it must measure something that is directly relevant and interpretable, and also be consistent with current understanding of the effects of an activity.
2. The variable must be easily measured in a cost-effective manner using standard techniques.
3. The trigger point defined for each variable must be scientifically defensible. If this criterion is not met, future management may be compromised by a lack of agreement over the effects of the activity on the environment, which may result in litigation and/or inappropriate management of the activity.

NIWA (Hatton et al., 2003) identified that it is important to remember:

1. Setting acceptable trigger points is not a straightforward process, as no two marine farms are the same and therefore trigger points established here are applicable only to the Wilson's Bay Marine Farming Zone.
2. Trigger points need to be judged against the broader spatial and temporal variation in environmental and ecological variables.
3. The suggested trigger points are iterative and should be adjusted as more relevant information is collected.

## **5 Trigger points – management responses**

Based on the LAC process, which reinforces the need for collaboration between the stakeholders involved, there are a number of possible management responses that may be implemented if one or more of the trigger points are exceeded:

1. Watch-and-wait;
2. Further analysis of available data;
3. Further investigations and collection of new data;
4. Changes in practice;
5. Restoration or mitigation.

The most appropriate management response should be determined after reviewing the available information, and following further collaborative discussions between resource managers, marine farmers and scientists.

## 6 Recommendations

Following the process discussed above, Environment Waikato would like to put forward the following recommendations.

### 6.1 Trigger points

#### 6.1.1 Water column

It is proposed that, on the basis of the currently available information, the following Wilson's Bay Marine Farming Zone chlorophyll-*a* trigger points be adopted by Environment Waikato:

**Table 10: Recommended water column trigger points for the Wilson's Bay Marine Farming Zone**

<b>Firth of Thames wide trigger point</b>	<b>Marine Farming Zone trigger point</b>
Spatially and temporally averaged chl.- <i>a</i> depletion resulting from marine farming activities, and relative to un-impacted waters, should not exceed 20% over 10% of the area of the Firth of Thames.	Spatially and temporally averaged chl.- <i>a</i> depletion resulting from marine farming activities, and relative to un-impacted waters, should not exceed 25% over an area twice that of the Wilson's Bay Marine Farming Zone.

It is recommended that the Farm-scale trigger point be used to indicate whether the Firth-wide trigger is being approached, and that in general the Farm-scale trigger be used in conjunction with verified biological modelling to determine the relationship of Farm-scale effects to Firth-wide effects. It is further recommended that modelling be used to determine the relationship of farm-centre depletion estimates made using the monitoring programme, to Farm and Firth-wide-scale trigger levels. Finally, it is recommended that the trigger levels be subject to refinements based on improved ecological knowledge.

To date, chlorophyll-*a* depletion at the Farm-centre has been measured by comparing means of deviations between the time when the farm was not stocked, i.e. the year prior to September 2002, and in the two years after that time, when the farm was stocked with growing mussels (Zeldis et al., 2004a, b). These means are formed using annual averages of the deviations, because of high variability in the chlorophyll-*a* data: an analysis of the statistical correlation between control sites and the farm site prior to aquaculture development (Zeldis et al., 2004a) has shown that only about half of the variability at the farm site can be explained by natural variation in common with the control sites. Thus, there is considerable variability in chlorophyll-*a* among sites over monthly and seasonal timeframes. It was determined that to reliably detect a 25% change in deviations between the first year of monitoring and subsequent years, should it occur, time-series about one year long (i.e. about 26 fortnightly samples) are required (Zeldis et al., 2004a).

##### 6.1.1.1 Further work

It is recommended that:

1. The Farm-scale trigger be used in conjunction with verified biological modelling to determine the relationship of Farm-scale effects to Firth-wide effects;
2. Biological modelling be used to determine the relationship of farm-centre depletion estimates made using the monitoring programme, to Farm and Firth-wide scale trigger levels;
3. Trigger levels be subject to refinements based on improved ecological knowledge;
4. Work be directed towards assessing the feasibility and desirability of developing and implementing trigger points for other monitored water column variables (e.g. ammonium nitrogen; zooplankton; suspended particulate organic matter).

5. Studies of the broader ecological implications of trigger levels be supported.

## 6.1.2 Benthic community and the seafloor

It is proposed that, on the basis of the information currently available, the following trigger points for benthic community and sediment variables will be adopted by Environment Waikato. It should be noted that these triggers apply to changes outside the Wilson’s Bay Marine Farming Zone in areas extending north and south of the zone, and do not cover the benthos inshore or offshore of the Zone.

**Table 11: Recommended benthic trigger variables and associated 75th and 95th percentiles of variation. Values in percent.**

Variable	75 <sup>th</sup> percentile	95 <sup>th</sup> percentile
Number of mobile epifauna	30	60
Number of bioturbations	40	60
Bray-Curtis % similarity	85	95
% sediment clay content *	30	40
% sediment silt content *	20	25
% sediment organic content	15	25

\* Note that at the workshop it was proposed that a single % sediment mud (silt/clay) content trigger point should be adopted. However, review of the second year of results from the Group A Consortium environmental monitoring programme, suggests subtle differences are being recorded between the % sediment clay and % sediment silt content. It is thus recommended that (at least initially) separate trigger points for the two sediment fractions should be retained.

These trigger points are to be tested at 100 m from the boundary of the Zone (the 100 m threshold is the recommended spatial threshold beyond which the footprint of the farms should not extend without triggering a management response) as outlined in Section 4.3.2. For example, if the difference in number of mobile epifauna is greater than 30% of the maximum of the two values being compared, the 75<sup>th</sup> percentile value is exceeded and the first level of management response would potentially be triggered; if the difference in number of mobile epifauna observed is greater than 60% of the maximum of the two values, the 95<sup>th</sup> percentile is exceeded, which would potentially trigger the second level of management response (see Section 6.2.2).

### 6.1.2.1 Further work

1. The identified trigger points only apply to benthic communities and the seafloor in areas extending north and south of the Wilson’s Bay Marine Farming Zone (as opposed to inshore or offshore of the Zone), which is consistent with the predominant direction of the residual circulation parallel to the shoreline in the Wilson’s Bay area. Further work will need to be undertaken to develop trigger points for the benthic communities and sediments in inshore areas, which are likely to be the areas with more sensitive benthic communities, and offshore areas. Different management responses may be appropriate for under farm effects compared to beyond farm boundary effects.
2. It is recommended that a suite of trigger points be developed to enable assessment of change within the Marine Farming Zone itself. This information could inform decisions regarding what may happen over the longer term further from the Marine Farming Zone.

The Wilson’s Bay Marine Farming Zone is an explicitly defined area in the Firth of Thames where conventional long-line farming activities have been provided for in the proposed Regional Coastal Plan. Environment Waikato acknowledges that implicitly there is the potential for an environmental effect within the Zone itself. Environment Waikato will be seeking to ensure that environmental effects are contained within this Zone, thereby minimising the extent of any environmental degradation outside of the Zone. Nevertheless, the environmental conditions within the Zone (in particular given

its size) are still an important consideration. Environment Waikato does not consider that the area within the Zone should be allowed to become a degraded environment, and Environment Waikato will be seeking to ensure that severe environmental effects do not occur within the Zone. There is also an expectation that the area would recover reasonably rapidly if marine farming activity was to cease in the Zone.

## **6.2 Management responses**

Environment Waikato considers that it is important to apply the trigger points in a proactive way. It is envisaged that the first step in the event that a trigger point or suite of trigger points is exceeded, would involve timely discussions between Environment Waikato staff, marine farmers and appropriate scientists. It is considered important that there are opportunities for discussions and the incorporation of additional information, at all stages prior to any management response being implemented. It is acknowledged that the development and application of trigger points to assist with the adaptive management of the Wilson's Bay Marine Farming Zone is a novel approach in New Zealand. It is important therefore that the management responses and the timeframes over which discussions and additional work should be undertaken, as outlined in the Tables in Sections 6.2.1 and 6.2.2 and in Figures 1 and 2, should be considered as preliminary and subject to refinement as more information becomes available.

As a requirement of the resource consent conditions, consent holders are responsible for implementing an environmental monitoring programme to determine the environmental effects of marine farm development in the Zone. Also as a requirement of consent conditions, the data, and interpretations of these, from the environmental monitoring programme, are to be provided to Environment Waikato on an annual basis. A review meeting is convened annually to discuss the results and conclusions from the environmental monitoring programme. Given the existing reporting timeframes, it is at these annual review meetings that trigger point non-exceedance or exceedance will most likely first be discussed within the context of the interpretation of the available monitoring data. It is recommended that in the event that the annual review process indicates that any trigger point has been approached over the previous year, there may need to be a more frequent programme of reporting and review implemented by mutual agreement between all the stakeholders involved. This would be in preference to waiting for the next scheduled annual review. Environment Waikato expects that, in the event that marine farmers or the scientific consultants engaged to undertake the environmental monitoring programme on behalf of the consent holders, became aware of a significant environmental effect which was likely to result in trigger point exceedance, the Regional Council would be immediately notified of this occurrence.

Note that while it is acknowledged that watch-and-wait is one possible management response, given the information currently available and the ecological, cultural, social and economic significance of the Firth of Thames ecosystem, it is proposed that Environment Waikato will adopt a more conservative/precautionary approach and initiate other management responses when one or more trigger points are exceeded. The only instance when this would not be the proposed course of action is when additional information is available to irrefutably indicate that any exceedance is not a direct result of the marine farming activity itself.

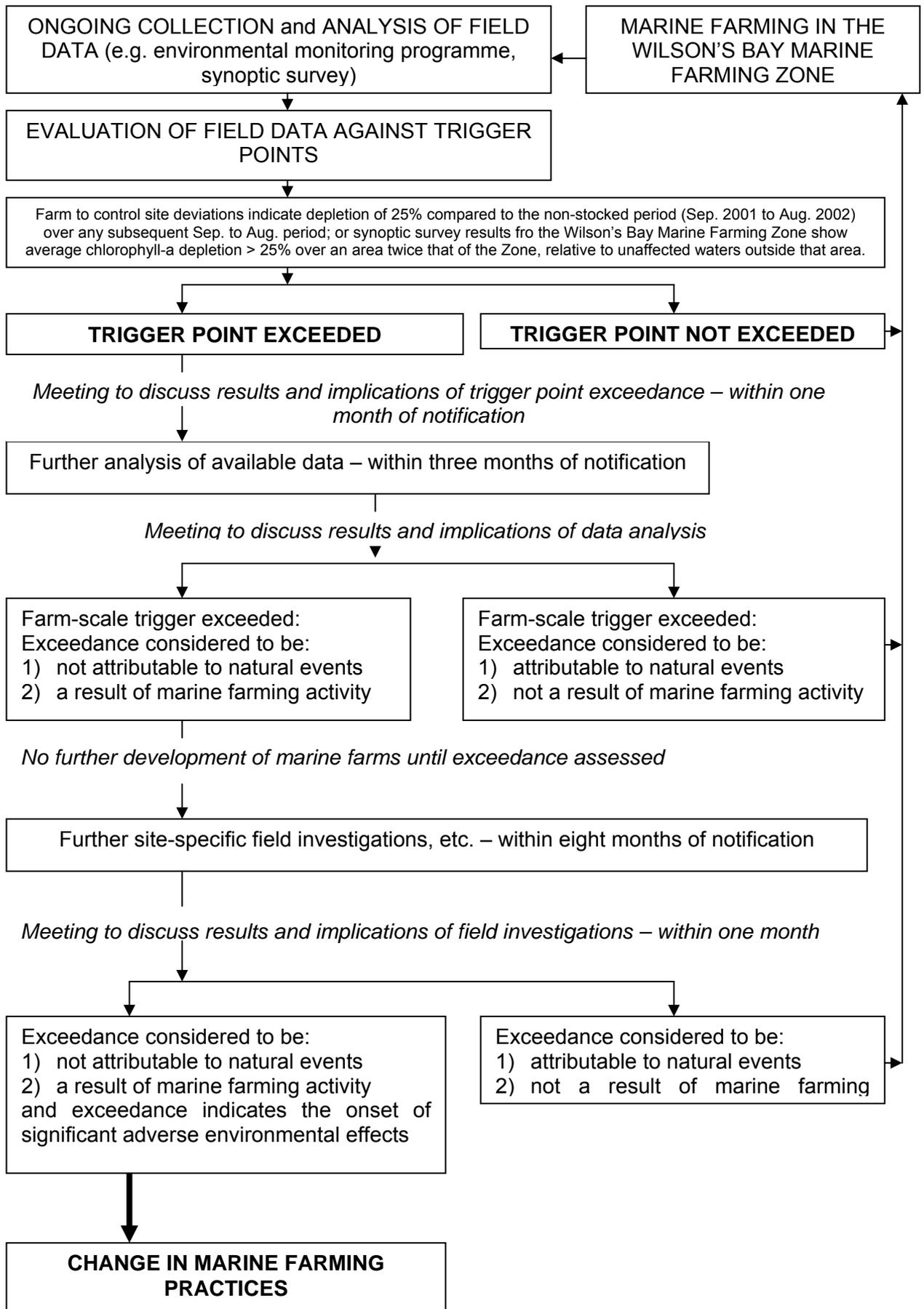
### **6.2.1 Water column**

The following management responses (Table 12) are proposed. A framework for applying the chlorophyll-a trigger point is outlined in Figure 3.

**Table 12: Proposed water quality trigger points and recommended associated management responses. Timeframes are indicative; suggested actions should be carried out within the proposed timeframe, or if this is not possible, as soon as practicable thereafter.**

Trigger Point	Management Response
<p>The farm to control site deviations indicates depletion of 25% or more compared to the non-stocked periods (Sep. 2001 to Aug. 2002) over any subsequent Sep. to Aug. period,</p> <p>Or</p> <p>Synoptic survey results for the Wilson's Bay Marine Farming Zone show average chlorophyll-a depletion &gt; 25% over an area twice that of the Zone, relative to unaffected waters outside that area.</p>	<ul style="list-style-type: none"> <li>• Meeting convened between Environment Waikato staff, marine farmers and scientists. <i>Timeframe: within one month of notification of trigger point exceedance.</i></li> <li>• Full analysis of available data (e.g. monitoring programme data, coincidental environmental data and any other available information). To be undertaken in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within three months of notification of trigger point exceedance.</i></li> <li>• If the further analyses indicate that the changes are attributable to farming activities, no further marine farm development to proceed until information from additional studies is assessed. <i>Timeframe: immediate.</i></li> <li>• If the further analyses indicate that the changes are attributable to farming activities, further field investigations (e.g. synoptic survey) and/or additional modelling scenarios undertaken. To be carried out in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within eight months of notification of trigger point exceedance.</i></li> <li>• If the further investigations indicate that the changes are attributable to farming activities, and that the Farm-scale trigger is exceeded, meeting convened <i>within one month</i> between Environment Waikato staff, marine farmers and scientists to determine what actions should be taken to avoid/mitigate the adverse effects. Where agreement is reached the actions will be implemented immediately. Where agreement cannot be reached, Environment Waikato will activate an immediate review of the consent conditions under s.128 of the RMA.</li> </ul>

**Figure 3: A framework for applying the water column trigger points**



## 6.2.2 Benthic community and the seafloor

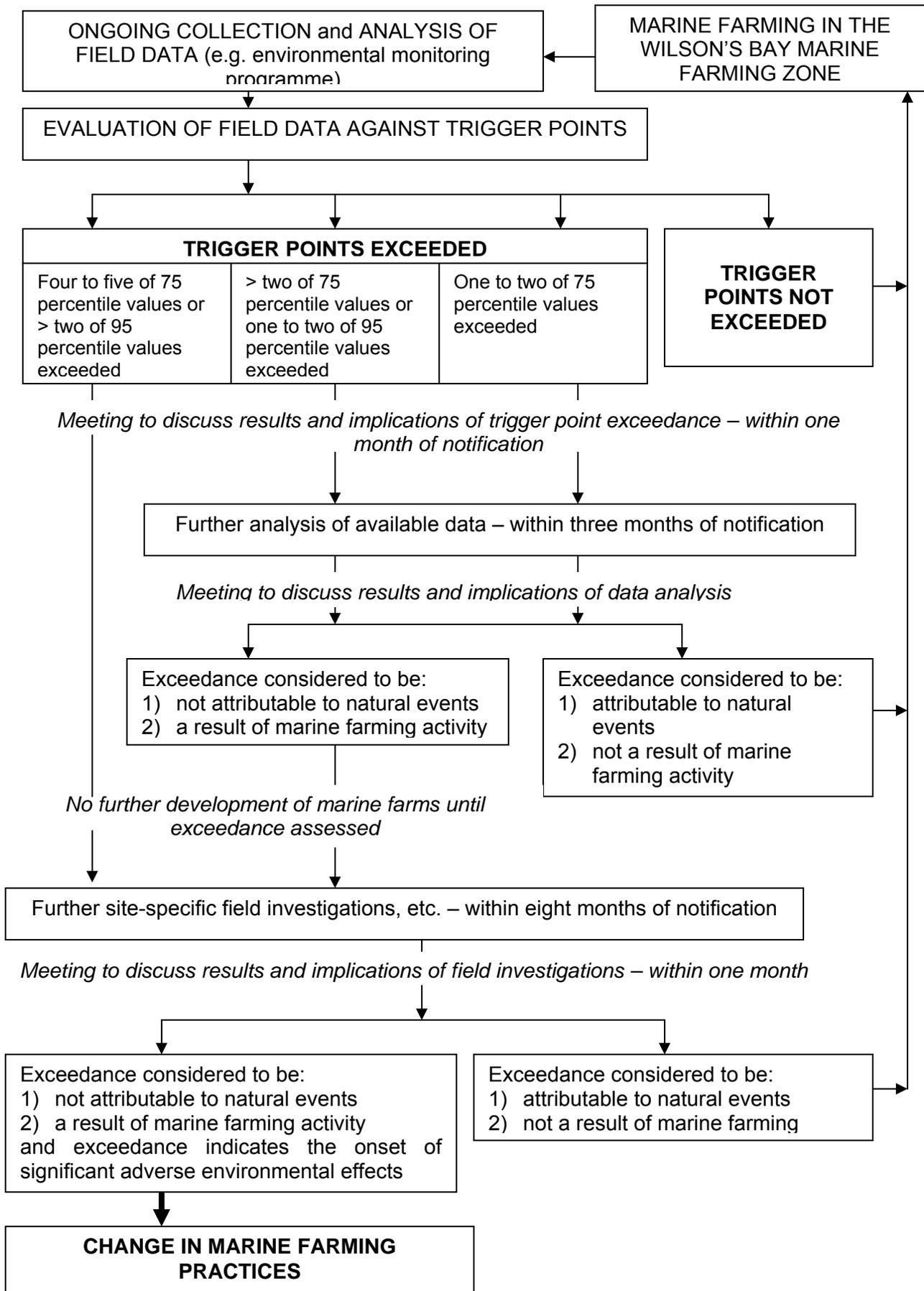
The following management responses (Table 13) are proposed. A framework for applying the benthic community and sediment trigger points is outlined in Figure 4.

**Table 13: Proposed benthic trigger points and recommended associated management responses. Timeframes are indicative; suggested actions should be carried out within the proposed timeframe, or if this is not possible, as soon as practicable thereafter.**

Trigger Point	Management Response
<p>1. One or two of the 75 percentile values for any of the trigger points (i.e. % clay, % silt, % organic matter content, # mobile fauna, amount of bioturbation, Bray-Curtis similarity) is exceeded at any time.</p>	<ul style="list-style-type: none"> <li>• Meeting convened between Environment Waikato staff, marine farmers and scientists. <i>Timeframe: within one month of notification of trigger point exceedance.</i></li> <li>• Further analysis of available data by scientists – including monitoring programme data, and any other available information (e.g. gradient analysis of the data over the sample transects to identify spatial extent of the change). To be undertaken in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within three months of notification of trigger point exceedance.</i></li> <li>• If the further analyses indicate that the changes are attributable to farming activities, further field investigations (e.g. information collected through video-monitoring and grab sampling would be complemented by intensive benthic core sampling programme and more detailed assessment of sediment characteristics both outside and within the Marine Farming Zone) and/or additional modelling scenarios to be undertaken. To be carried out in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within eight months of notification of trigger point exceedance.</i></li> <li>• If the further investigations indicate that the changes are attributable to farming activities, meeting convened <i>within one month</i> between Environment Waikato staff, marine farmers and scientists to determine what actions should be taken to avoid/mitigate the adverse effects. Where agreement is reached the actions will be implemented immediately. Where agreement cannot be reached, Environment Waikato will activate an immediate review of the consent conditions under s.128 of the RMA.</li> </ul>
<p>2. More than two of the 75 percentile values or one to two of the 95 percentile values for any of the trigger points (i.e. % clay, % silt, % organic matter content, # mobile fauna, amount of bioturbation, Bray-Curtis similarity) are exceeded at any time.</p>	<ul style="list-style-type: none"> <li>• Meeting convened between Environment Waikato staff, marine farmers and scientists. <i>Timeframe: within one month of notification of trigger point exceedance.</i></li> <li>• Further analysis of available data – including information provided by suites of monitored variables for which no trigger points have been set and other information along the transect lengths (e.g. aggregative sampling). To be undertaken in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within three months of notification of trigger point exceedance.</i></li> <li>• If the further analyses indicate that the changes are attributable to farming activities, no further marine farm development to proceed until information from additional studies assessed (e.g. to establish whether the change in benthic community reflects a loss in ecosystem function). <i>Timeframe: immediate.</i></li> <li>• If the further analyses indicate that the changes are attributable to farming activities, further field investigations (e.g. information collected through video-monitoring and grab sampling would be complemented by intensive benthic core sampling programme and more detailed assessment of sediment characteristics both outside and within the Marine Farming Zone) and/or additional modelling scenarios to be undertaken. To be carried out in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within eight months of notification of trigger</i></li> </ul>

	<p><i>point exceedance.</i></p> <ul style="list-style-type: none"> <li>• If the further investigations indicate that the changes are attributable to farming activities, meeting convened <i>within one month</i> between Environment Waikato staff, marine farmers and scientists to determine what actions should be taken to avoid/mitigate the adverse effects. Where agreement is reached the actions will be implemented immediately. Where agreement cannot be reached, Environment Waikato will activate an immediate review of the consent conditions under s.128 of the RMA.</li> </ul>
<p>3. Four or five of the 75 percentile values and more than two of the 95 percentile values for any of the trigger points (i.e. % clay, % silt, % organic matter content, # mobile fauna, amount of bioturbation, Bray-Curtis similarity) are exceeded at any time.</p>	<ul style="list-style-type: none"> <li>• Meeting convened between Environment Waikato staff, marine farmers and scientists. <i>Timeframe: within one month of notification of trigger point exceedance.</i></li> <li>• No further marine farm development to proceed until information from additional studies assessed. <i>Timeframe: immediate.</i></li> <li>• Further field investigations and/or additional modelling scenarios to be undertaken. To be carried out in consultation with Environment Waikato staff and marine farmers. <i>Timeframe: to be completed within eight months of notification of trigger point exceedance.</i></li> <li>• If the further investigations indicate that the changes are attributable to farming activities, meeting convened <i>within one month</i> between Environment Waikato staff, marine farmers and scientists to determine what actions should be taken to avoid/mitigate the adverse effects. Where agreement is reached the actions will be implemented immediately. Where agreement cannot be reached, Environment Waikato will activate an immediate review of the consent conditions under s.128 of the RMA.</li> </ul>

**Figure 4: A framework for applying the benthic community and sediment trigger points**



### **6.2.3 How Environment Waikato proposes to implement management responses**

In the event that the results of any of the environmental monitoring programmes being undertaken as part of resource consent conditions, or any other work commissioned by Environment Waikato (or any other party / agency), conducted using the same methodology as that detailed in the Group A monitoring programme, indicates that one or more of the trigger points have been exceeded, then Environment Waikato will convene a meeting between representatives of all the affected marine farmers within the Wilson's Bay Marine Farming Zone – i.e. representatives from Group A, Group B, and Group C. 'Affected' in this context means that that Group has been granted resource consent. All representatives will be invited and encouraged to participate in the ensuing discussions and decisions. Environment Waikato will aim to make any decisions regarding management responses in relation to a reduction of marine farming activity within the Zone collaboratively, seeking to minimise the significant adverse environmental effects. Environment Waikato acknowledges that the trigger points identified here are based on environmental variables, and that any management response to trigger exceedance will also need to consider other factors and constraints.

## **6.3 Additional comments**

### **6.3.1 Environmental monitoring**

The identification of trigger points will not replace the scientifically robust programme of environmental monitoring currently expected of the consent holders. At this stage we do not have sufficient knowledge to identify one (or a small sub-set of) environmental variable(s) that will with certainty provide an indication of the sustainability of marine farming either in the Wilson's Bay Marine Farming Zone or in the wider Firth of Thames. While the trigger points that have been selected are those for which we have some level of information and understanding, none of the trigger points are considered to be perfect. The additional information collected through monitoring a broader suite of environmental variables will be important in assisting with the interpretation of the trigger points (in particular exceedances). Environment Waikato acknowledges that this situation may change in the future, as more information becomes available, and as the Wilson's Bay Marine Farming Zone is fully developed.

Equally, the absence of an identified trigger point for any of the monitored environmental variables does not imply that information collected through the environmental monitoring programme on these variables will not be employed in an assessment of whether there are any significant adverse environmental effects associated with marine farm development. This is particularly important in the case of effects of the development on currents and wave action, which at this stage have had no trigger points identified.

It should be noted that the fact that there is one trigger point recommended for the water column and a suite of trigger points recommended for the benthic community and seafloor is not a reflection on the perceived significance of any potential adverse environmental effects or the importance or value of any part of the environmental monitoring programmes. It is a reflection of the nature of the processes driving the different components of the system, and how easy or difficult it is to predict change and understand the effects of that change.

### **6.3.2 Future refinement of trigger points**

Environment Waikato does not envisage that the trigger points and the management responses proposed in this document are definitive (i.e. set-in-stone). Instead it is envisaged that the trigger points and the management responses will be subject to further iterations and refinement as more information becomes available. This process

of review can be initiated by either Environment Waikato or marine farmers at any time. Prior to a review being implemented, it is recommended that discussions between Environment Waikato, marine farmers and appropriate scientists should address the nature and objectives of the proposed review.

Given that the recommended trigger points have at this stage been based on relatively limited information (two years of monitoring data), Environment Waikato is proposing that in any event there should be a review of the trigger points and the management process in 2006. By this time there will be additional information available to enable refinement of the values for the trigger points if this is warranted. Such a review will also provide an opportunity to reassess whether the most appropriate trigger points have been adopted or whether other environmental variables need to be considered; whether the timeframes and management responses are still appropriate; and whether the trigger points are achieving their purpose.

It should be noted that the trigger points identified to date have been largely derived from information provided through the results of the first year of the environmental monitoring programme undertaken in Area A by the Group A Consortium. In some instances (particularly for the benthic monitoring) the trigger points are specific to the sampling methods and protocols for this monitoring programme, and would therefore need to be re-determined if alternative methods and protocols are implemented. This will need to be considered prior to the implementation of environmental monitoring programmes in Area B or the area of existing farms.

The recommended trigger points apply to the whole of the Marine Farming Zone – not only Area A or Area B or the area of existing farms, or any individual farm within these Areas. It is Environment Waikato's intent to manage for the effects over the whole Zone. Environment Waikato's preference would be for there to be one integrated environmental monitoring programme in place for the whole of the Marine Farming Zone, with a single suite of trigger points.

### **6.3.3 Allocation of costs**

Environment Waikato envisages that the costs associated with any additional analyses or field investigations identified as being required to assess whether trigger point exceedance is attributable to farming activities will be met by marine farmers within the Zone as part of their environmental monitoring programmes, or through other charging regimes such as consent holder charges or occupation charges.

Costs associated with the refinement of trigger points and the levels for these trigger points should be met by the initiating party, or preferably as a collaborative effort between Environment Waikato and marine farmers.

### **6.3.4 Status of the trigger points**

Environment Waikato does not propose that either the environmental variables for which trigger points are identified or the values for these trigger points, will become incorporated into statutory documents (e.g. resource consents) at this time. It should, however, be noted that the concept of trigger points is included within the proposed Regional Coastal Plan and Environment Waikato considers that the identification of trigger points is consistent with an adaptive management approach to the management of the Wilson's Bay Marine Farming Zone.

It is the view of Environment Waikato that the trigger points will provide long-term benefits in terms of the management of potential environmental effects associated with the Wilson's Bay Marine Farming Zone through ease of use and ultimately cost-savings. However, due to the current information limitations, their use is primarily seen as a trial in the first instance, and trigger points would only become incorporated into the statutory framework when there was a higher degree of certainty and confidence in their application. Once the degree of certainty has increased and there is a greater degree of confidence that the identified trigger points do indicate potentially significant

environmental effects, Environment Waikato envisages that the trigger points would be incorporated into the monitoring plan for the Wilson's Bay Marine Farming Zone. It is envisaged that this would reduce the overall extent of monitoring with reliance on the trigger point approach to highlight potential problems and initiate a response of increased targeted monitoring.

### **6.3.5 Trigger points specific to the Firth of Thames and Wilson's Bay Marine Farming Zone**

The trigger points and the associated management responses are specific to the Firth of Thames and Wilson's Bay Marine Farming Zone and the sampling methodology specified in the current Area A environmental monitoring programme, and should not be applied to other sites in the Region (i.e. outside the Firth of Thames, or elsewhere around New Zealand) without further scientific assessment.

# References

- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000: *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
- Broekhuizen, N.; Ren, J.; Zeldis, J.; Stevens, S. 2003: *Ecological sustainability assessment for Firth of Thames shellfish aquaculture: Tasks 2-4 – Biological modelling. (NIWA Client Report HAM2003-120)*. Environment Waikato Technical Report 2005/06. Environment Waikato, Hamilton
- Broekhuizen, N.; Zeldis, J.; Stephens, S.A.; Oldman, J.W.; Ross, A.H.; Ren, J.; James, M.R. 2002: *Factors related to the sustainability of shellfish aquaculture operations in the Firth of Thames: a preliminary analysis. (NIWA Client Report EVW02243)*. Environment Waikato Technical Report 2002/09. Environment Waikato, Hamilton
- Cole, D.N. and McCool, S.F. 1998: The Limits of Acceptable Change process: Modifications and Clarifications. In *Proceedings – Limits of Acceptable Change and Related Planning Processes: Progress and Future Directions*, MT. Gen. Tech. Rep. INT-GTR-371.
- Cole, D.N. and Stankey, G.H. 1998: Historical development of Limits of Acceptable Change: Conceptual clarifications and possible extensions. In *Proceedings – Limits of Acceptable Change and Related Planning Processes: Progress and Future Directions*, MT. Gen. Tech. Rep. INT-GTR-371.
- Gall, M.; Zeldis, J.; Image, K. 2003: *An assessment of phytoplankton depletion associated with Area A in the Wilson's Bay marine farming zone. NIWA Client Report CHC2003-092*. National Institute of Water and Atmospheric Research Ltd (NIWA), Christchurch
- GESAMP 1991: Reducing Environmental Impacts of Coastal Aquaculture. *Reports and Studies GESAMP*, No 47;
- GESAMP 1996: Monitoring the Ecological Effects of Coastal Aquaculture Wastes. *Reports and Studies GESAMP*, No 57.
- Gibbs, M.; Forrest, B. 2003: *Review of the Proposed Performance Indicators and Trigger Levels for the Marine Farming Zone in Wilson's Bay. Cawthron Report No. 800.*, Cawthron Institute, Nelson
- Hatton, S.; Inglis, G.; Thrush, S.; Zeldis, J. 2002: *Marine Farming in the Firth of Thames – Monitoring and Performance Criteria. NIWA Client Report EVW02238*, National Institute of Water and Atmospheric Research Ltd (NIWA), Hamilton.
- Hatton, S.; Hewitt, J.; Stevens, C.; Thrush, S.; Zeldis, J. 2003: *Marine Farming in the Firth of Thames – Discussion Document on Monitoring and Performance Criteria – Stage 2. NIWA Client Report HAM2002-039*. National Institute of Water and Atmospheric Research Ltd (NIWA), Hamilton.
- Oliver, J.K. 1995: Is the "limits of acceptable change" concept useful for environmental managers? A case study from the Great Barrier Reef Marine Park. In: Grigg, G.C., Hale, P.T., & Lunney, D. (Eds.) *Conservation through sustainable use of wildlife*, pp: 131-139. Centre for Conservation Biology, University of Queensland, Brisbane, Australia.
- Zeldis, J.; Broekhuizen, N.; Gall, M.; Hewitt, J.; Oldman, J.; Stephens, S.; Thrush, S. 2004a: *Stage 1 of mussel farm development at Wilson's Bay, Firth of Thames: assessment of environmental effects. NIWA Client Report: CHC2003-119*. National Institute of Water and Atmospheric Research Ltd (NIWA), Christchurch
- Zeldis, J.; Broekhuizen, N.; Gall, M.; Hewitt, J.; Oldman, J.; Stephens, S.; Thrush, S. (2003) *Stage 1 of mussel farm development at Wilson Bay, Firth of Thames:*

*assessment of environmental effects. NIWA Client Report CHC2003-119. National Institute of Water and Atmospheric Research Ltd (NIWA), Christchurch.*

Zeldis, J.; Lohrer, D.; Hewitt, J.E.; Funnell, G.A.; Thrush, S.R. 2004b: *Wilson's Bay marine farm monitoring annual report for 2004. NIWA Client Report CHC2004-123. National Institute of Water and Atmospheric Research Ltd (NIWA), Christchurch*

Zeldis, J.; Oldman, J.; Ballara, S.; Richards, L. (in press) Physical fluxes, pelagic ecosystem structure, and larval fish survival in Hauraki Gulf, New Zealand. *Canadian Journal of Fisheries and Aquatic Sciences*.

Zeldis, J.; Thrush, S.; Oldman, J.; James, M.; Hooker, S. 2001: *Environmental monitoring programme for Wilson's Bay Mussel Farm Development. National Institute of Water and Atmospheric Research Ltd (NIWA), Hamilton*