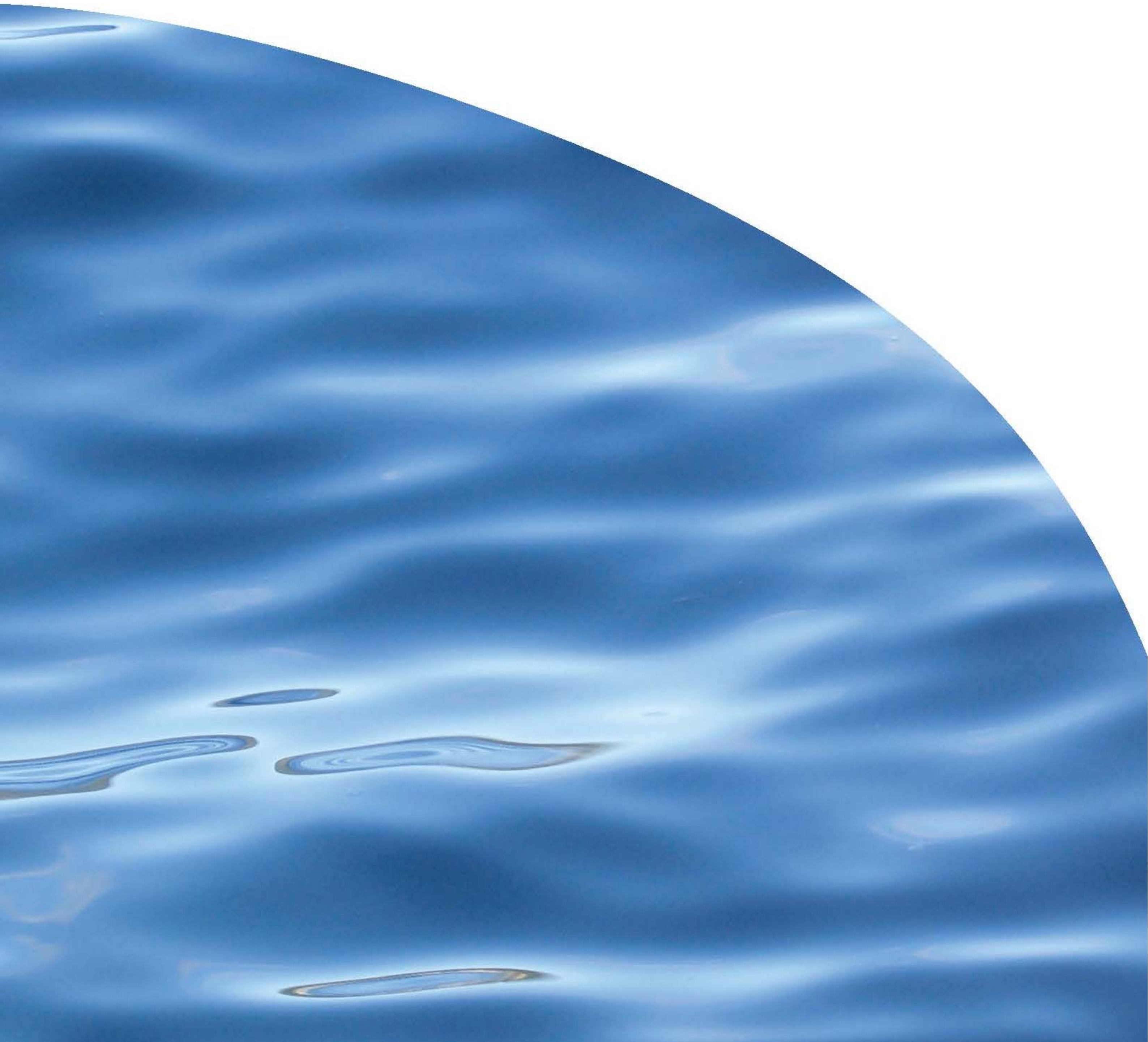
CAWTHRON INSTITUTE

REPORT NO. 2746

THE NEW ZEALAND KING SALMON CO. LTD ANNUAL MONITORING PLAN AND METHODS 2015: CLAY POINT, RUAKAKA, OTANERAU, FORSYTH, AND WAIHINAU FARM SITES



THE NEW ZEALAND KING SALMON CO. LTD ANNUAL MONITORING PLAN AND METHODS 2015: CLAY POINT, RUAKAKA, OTANERAU, FORSYTH, AND WAIHINAU FARM SITES.

DEANNA ELVINES, DAVID TAYLOR

Prepared for The New Zealand King Salmon Co. Ltd

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Nigel Keeley

APPROVED FOR RELEASE BY:
Chris Cornelisen

ISSUE DATE: 2 September 2013

RECOMMENDED CITATION: Elvines D, Taylor D 2015. The New Zealand King Salmon Co. Ltd Annual Monitoring Plan and Methods 2015: Clay Point, Ruakaka, Otanerau, Forsyth, and Waihinau farm sites. Prepared for The New Zealand King Salmon Co. Ltd.. Cawthron Report No. 2746. 15 p. plus appendices.

1. INTRODUCTION

The New Zealand King Salmon Company Limited (NZ King Salmon) operates eleven consented farm sites in the Marlborough Sounds (Table 1 and Figure 1). Each site is monitored pursuant to a marine environmental monitoring adaptive management programme (MEM-AMP). NZ King Salmon has requested that Cawthron Institute (Cawthron) provide an overview of the monitoring that will be undertaken at five of these farm sites (Clay Point, Ruakaka, Otanerau, Forsyth and Waihinau; Table 1) from July 2015–July 2016. Monitoring will be consistent with that undertaken in 2014, except for the alterations that this report outlines. Hence, this report constitutes an Annual Monitoring Plan for 2015 / 2016.

The Te Pangu, Waitata, Ngamahau, and Richmond sites are monitored under a separate monitoring programme (Elvines *et al.* 2015; Elvines & Taylor 2015). Sites MFL-032 and MFL-048 have been fallowed and are not planned to be stocked in the near future, therefore monitoring at these sites is no longer required.

Table 1. List of NZ King Salmon's marine farm sites in the Marlborough Sounds, including the associated monitoring plan they are covered under, number of the Consent relating to environmental monitoring where applicable, and the sites' anticipated operational status at the time of the proposed monitoring under this MEM-AMP.

Site location	Monitoring plan	Consent #	Operational status
Clay Point (CLA)	Current report	U060926	Stocked
Ruakaka (RUA)	Current report	U021247	Stocked
Otanerau (OTA)	Current report	U040217	Stocked
Forsyth (FOR)	Current report	U040412	Stocked May 2015. Propose to vacate October 2015
Waihinau (WAI)	Current report	MFL456*	To fallow 3rd quarter of 2015
Te Pangu (TEP)	Elvines & Taylor 2015	-	-
MFL-032	n/a	-	-
MFL-048	n/a	-	-
Waitata (WTA)	Elvines *et al.* 2015	-	-
Ngamahau (NGA)	Elvines *et al.* 2015	-	-
Richmond (RIC)	Elvines *et al.* 2015	-	-

*There is no requirement for environmental monitoring in the conditions of this Consent (*i.e.* monitoring at this site is voluntary).

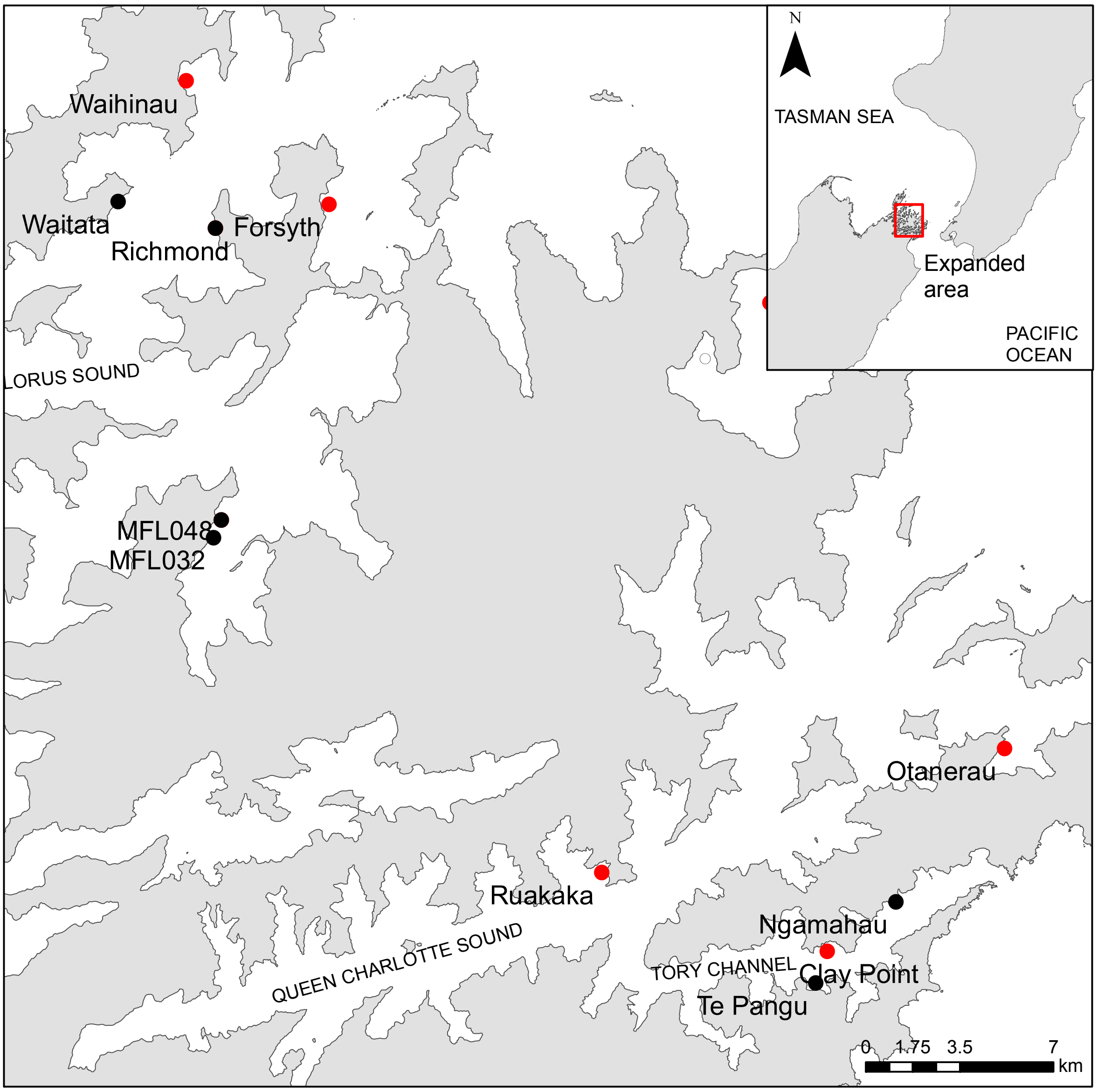


Figure 1. Locations of the NZ King Salmon farm sites in the Marlborough Sounds. Farm sites covered under this monitoring plan are shown as red dots. Remaining sites are shown as black dots.

2. PROPOSED MONITORING PROGRAMME FOR 2015-2016.

2.1. Overview

The types and levels of monitoring that will be conducted at each of the eight farm sites during the 2014 monitoring is summarised in Table 2. For some sites, additional reef and water column monitoring is required, either due to the farm's proximity to potentially sensitive reef habitats, or because it is one of the farms that was designated for local-scale water column monitoring.

The Forsyth Bay farm was stocked in May 2015 and will be fallowed in October 2015. The Waihinau Bay farm will be fallowed in September / October 2015. At this time it is not planned to restock either site during 2016.

Table 2. Summary of monitoring components and 'level' of copper (Cu) and zinc (Zn) monitoring for the upcoming year at each site. Varying levels of sampling intensity and investigation for Cu and Zn are based on the results of the 2014 annual monitoring (see Appendix 2 for decision tree).

Site	Water column	Seabed	Cu & Zn	Reefs	Inshore habitat
CLA	Yes	Yes	Level 1	Yes	-
OTA	Yes	Yes	Level 3+	-	No
RUA	Yes	Yes	Level 3+	-	No
WAI	Yes*	Yes	Level 3*	-	No
FOR	Yes*	Yes	Level 3+	-	No

* Net pen stations only: sites will be fallowed
+ Voluntarily higher level of sampling intensity above Level 3, but not as thorough as a full Level 5.

2.2. Clay Point Resource Consent conditions 38d-e

The Clay Point farm has two additional conditions that require monitoring of potential effects in the water column at the nearby Ngaruru Bay mussel farm (38d), and the effects of lighting on benthic and pelagic species (38e). A report considering these effects was prepared in 2015 (Taylor *et al.* 2015).

2.2.1. Condition 38d.

Potential water column effects at the Ngaruru Bay mussel farm relate to nutrient (nitrogen) enrichment. Although elevated nitrogen levels around the Ngaruru farm are a possible result of Clay Point farming effects, elevated nitrogen levels are unlikely to affect the phytoplankton biomass or composition at Ngaruru Bay because the phytoplankton in this region are not likely to be nitrogen limited (Taylor *et al.* 2015). As such, any potential water column effects from the Clay Point salmon farm on the Ngaruru Bay farm are unlikely. Further, in the event that effects do occur, they are considered likely to be only minor. Accordingly, no further monitoring is proposed under this MEM-AMP for this condition.

2.2.2. Condition 38e.

Taylor *et al.* (2015) concluded that effects of lighting are no more than minor, suggesting that further field surveys of lighting effects at Clay Point are unnecessary. However, the report also indicated that it would be beneficial to include Clay Point in the study investigating lighting effects for the salmon farm in Ngamahau Bay, once the latter is in full production. As the Ngamahau farm will not be in full production under the term of this MEM-AMP, no monitoring related to lighting is proposed at Clay Point at this time.

2.3. Seabed sampling

2.3.1. Sampling locations

The proposed sampling locations for the upcoming year are summarised in Table 3. Maps for each site are in Appendix 1.

Table 3. Summary of proposed benthic monitoring stations for each farm during the 2015 annual monitoring surveys. FF = Far field.

Farm	**Transect(s)**	**Pens** (or Zone 1/2 if 4-Zone)	**Zone 1/2** (or 2/3 if 4-Zone)	**Zone 2/3** (or 3/4 if 4-Zone)	**Ref-near**	**Ref-FF**
CLA	E W N	Pen 1 Pen 2	90 m 90 m	300 m 300 m	TC-Ctl-1 TC-Ctl-4	TC-Ctl-3
OTA	E	Pen 1 Pen 2 Pen 3	50 m	150 m	QC-Ctl-1	QC-Ctl-2
RUA	S	Pen 1 Pen 2	50 m	150 m	QC-Ctl-3	QC-Ctl-4
FOR	NE	Pen 1 Pen 2 Pen 3	50 m	150 m	PS-Ctl-2	PS-Ctl-3
WAI	SE	Pen 1 Pen 2		180 m	PS-Ctl-1	

2.3.2. Sampling design and adjustments

Clay Point

No changes are proposed from the sampling conducted in 2014. Sampling at the 90 m and 300 m stations, as well as the far-field control location (TC-Ctl-3) will be continued, consistent with 2014 and the most recent consent conditions. Copper and zinc results from 2014 warrant the continuation of Level 1 monitoring for these elements.

Notes on existing sampling design:

- *The Clay Point farm is monitored along the east and west transects because these down-current directions were selected from predictive modelling and subsequent effects monitoring. For the first three years after farm establishment a NE transect was also monitored, but this was discontinued in 2009.*

Ruakaka

Under the ‘best management practice’ (BMP) guidelines (MPI 2015), the high levels of bioavailable zinc in the net pen samples in 2014 would warrant more intensive (Level 5) sampling for this element at this site. Although there are no specific requirements to monitor metals in the Ruakaka consent, it is proposed that Zn sampling and analysis is extended to the 50 m station to assess the spatial extent of the higher Zn levels. Copper results from 2014 warrant the continuation of Level 3 monitoring for this element as per the BMP.

Notes on existing sampling design:

- *Sampling stations at this farm are aligned with the down-current direction (south).*

Otanerau

The altered position of the Ctl-1 station[1] (as used in 2014) will continue to be used in the 2015-2016 surveys. Under the BMP guidelines (MPI 2015), the high levels of bioavailable zinc in the net pen samples in 2014 would warrant more intensive (Level 5) sampling for this element at this site. Although there are no specific requirements to monitor metals in the Otanerau consent, it is proposed that Zn sampling and analysis is extended to the 50 m station to assess the spatial extent of the higher levels of Zn. Copper results from 2014 warrant the continuation of Level 3 monitoring for this element as per the BMP.

Notes on existing sampling design:

- *The Otanerau farm is sampled along an eastern transect, as opposed to the northern down-current direction because the farm structures are occasionally extended or contracted in the north direction. Sampling is required to be oriented*

[1] The QC-Ctl-1 station was moved 180 m to the east due to a mussel farm being positioned over the original station.

in relation to the net pen edge and therefore the 50 m site has historically been situated either in recovering sediments (beneath where the pens had recently been) or further away in an area that has had very little recent deposition.

- *Being a low-flow site, footprint deformity is considered negligible and therefore a perpendicular transect has been utilised to overcome the problem posed by altering pen configurations*.

Forsyth

Following recommendations from the 2014 annual monitoring results, the full suite of indicator variables will be measured from each sampling station (*i.e.* standard monitoring, as opposed to the reduced indicator monitoring undertaken in 2014). Under the BMP guidelines (MPI 2015), the high levels of bioavailable zinc in the net pen samples in 2014 would warrant more intensive (Level 5) sampling for this element at this site. Although there are no specific requirements to monitor metals in the Forsyth consent, it is proposed that Zn sampling and analysis is extended to the 50 m station to assess the spatial extent of the higher Zn levels. Copper results from 2014 warrant the continuation of Level 3 monitoring for this element as per the BMP.

Notes on existing sampling design

- *Forsyth is monitored at 50 and 150 m in an offshore direction to account for bathymetry and proximity to neighbouring mussel farms, both of which can confound results.*
- *Forsyth* is a very low-flow site, with correspondingly low footprint deformity; therefore the transect direction is not critical.

Waihinau

No changes are proposed from 2014. The 180 m station will continue to replace the traditional 50 m and 150 m stations, consistent with the BMP and the 2014 sampling programme. The copper and zinc results from 2014 warrant the continuation of Level 3 monitoring for these elements.

Notes on existing sampling design:

- *There are no existing benthic environmental quality standards at this site and NZKS commission monitoring at the site on a voluntary basis.*

2.3.3. Sampling protocol

At each sampling station, sediment samples will be collected using a suitable boat-operated grab. Each successful (full) grab will constitute a replicate (*i.e.* three independent grabs (replicates) are required when sampling in triplicate) that will be sub-sampled for the required parameters as below:

- A **sediment core** sample (63 mm diameter): qualitatively assessed for sediment colour, odour and texture. The top 30 mm will be quantitatively analysed for organic content as ash-free dry weight (AFDW).
- **Redox and sulphides:** Redox potential will be measured directly from the grab at 1 cm depth using a probe. Total free sulphides will be ascertained from a 5 ml syringe driven at a 45º angle into the surface sediment.
- A **macrofaunal core** sample (130 mm diameter, approx. 100 mm deep): the core contents will be gently sieved through a 0.5 mm mesh and animals retained will be preserved, identified and counted under a microscope by a suitably trained taxonomist.
- **Sediment photo-quadrats** and/or video footage will also be taken at each station to assess bacterial mat coverage, general seabed condition and presence of sediment out-gassing. The sea surface will also be scanned for visible sediment outgassing.

Following the BMP guidelines (MPI 2014), pen station samples (and 50 m station samples at RUA, OTA and FOR) will also be subsampled for:

- An **additional sediment core** (63 mm diameter): with the top 30 mm quantitatively analysed for copper and zinc concentrations as below (see Table 2 & Appendix 2):
    - Level 1: composited triplicates for total concentrations
    - Levels 3+: individual triplicates with both the fine (< 250 μm) and coarse (250 μm–2 mm) grain size fractions analysed separately for both total and dilute acid extractable fractions.

2.3.4. Data analysis

Enrichment stages

Benthic enrichment can be graded along a 7-stage Enrichment Stage (ES) scale (Figure 2) as detailed in the BMP guidelines (MPI 2014).

Following the best practice management guidelines, each environmental result (raw data) will be converted into an equivalent ES score using previously described relationships. Average ES scores will then be calculated for the sediment chemistry variables (redox and sulphides), the infauna composition variables (abundance, richness, diversity and biotic indices; Appendix 3) and organic content (as % AFDW). However, where best professional judgement needs to be employed, the equivalent ES score is manually allocated (MPI 2014). The overall ES for a given sample is calculated by determining the weighted average of those three groups of variables. Finally, the overall ES for the sampling station is calculated from the average of the replicate samples with the degree of certainty reflected in the associated standard error.

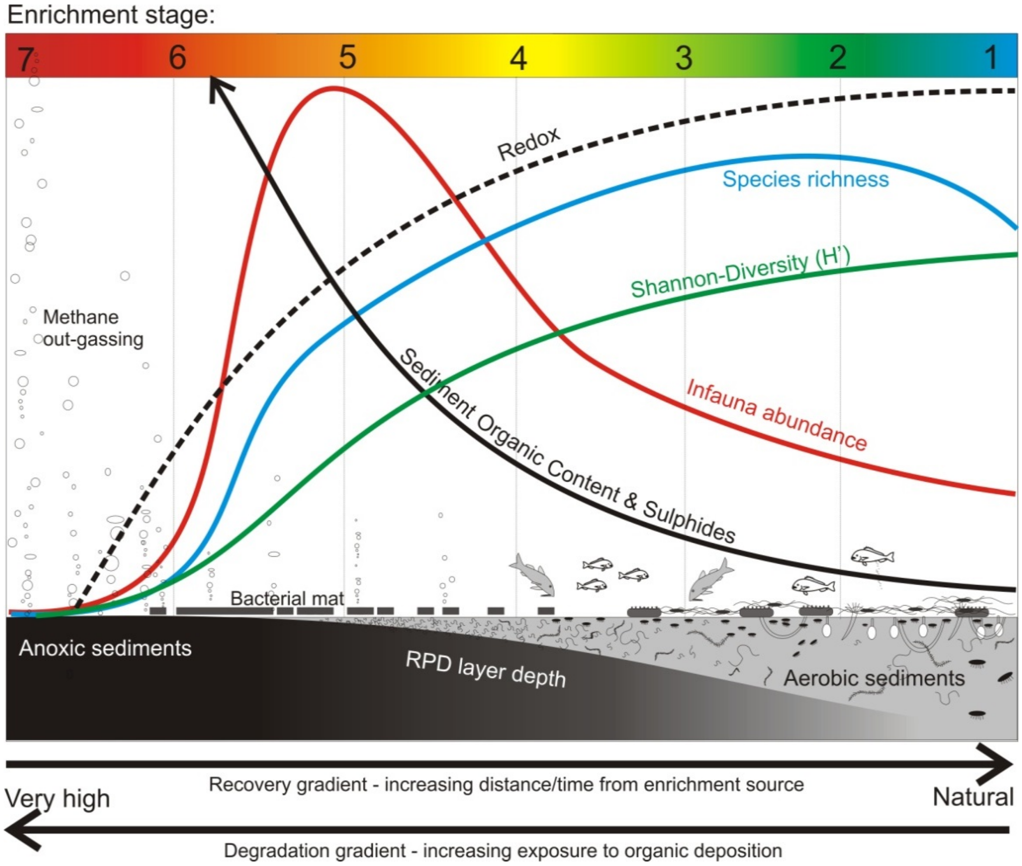


Figure 2. Stylised depiction of a typical enrichment gradient experienced at low flow sites, showing generally understood responses in commonly measured environmental variables (species richness, infauna abundance, sediment organic content and sulfides and redox). The gradient spans from natural or pristine conditions on the right (ES = 1) to highly enriched azoic conditions on the left (ES = 7).

Copper and zinc

The BMP guidelines names the ANZECC (2000) ISQG-Low criteria for copper and zinc as the most appropriate trigger values for sediments beneath farms (MPI 2014), and therefore they should be used as the first tier trigger level for further actions (Table 4). For more information regarding the ecological effects of copper and zinc and the EQS, readers are referred to the BMP guidelines (MPI 2014).

Table 4. ANZECC (2000) Interim Sediment Quality Guideline (ISQG) concentrations for copper and zinc (mg/kg).

	ISQG-Low	ISQG-High
Copper	65	270
Zinc	200	410

2.3.5. Interpretation of compliance

Enrichment stages

The permitted levels of effect on the seabed are 'zoned' around each farm in accordance with pre-specified (and generally narrative) environmental quality standards (EQS) detailed in the Consent for that site. The EQS relate to the magnitude (or 'severity') and spatial extent of effects.

Some consent conditions set precise parameters for the allowable environmental states within the zones. However, it is acknowledged that others have some ambiguity around how EQS translate to the ES scale. In these cases, reference is made to the BMP guidelines (MPI 2014).

Copper and zinc

Although an adaptive management decision tree (Appendix 2) was developed in conjunction with the NZKS application for new farm space in 2012, the monitoring of copper and zinc sediment concentrations is not a requirement of the conditions of consent for the existing low-flow farms (Forsyth, Waihinau, Otanerau and Ruakaka), and is therefore done on a voluntary basis.

2.4. Inshore / reef habitats

2.4.1. Qualitative assessment

Farming sites at Ruakaka, Otanerau, Forsyth and Waihinau have no significant reef habitats within their primary depositional footprint. However, inshore habitats are qualitatively assessed for general health with respect to signs of excessive organic deposition and obvious changes in visual characteristics over time. This assessment is undertaken biennially, and was last undertaken in 2014. As such, this component will not be required in 2015.

2.4.2. Quantitative assessment

The farm site at Clay Point is located in proximity to significant reef habitat. An ongoing reef monitoring programme (undertaken in conjunction with the Te Pangu farm site) surveys the Clay Point reef habitat annually (*e.g.* Dunmore *et al.* 2015).

Sampling design

The sampling design detailed in this section is based on the existing reef monitoring programme (*e.g.* Dunmore *et al.* 2015). Reef monitoring for the Te Pangu farm is undertaken jointly with that for the Clay Point farm. However, the following summarises only the monitoring design for the Clay Point site.

There are four reef sampling sites established for the Clay Point reef monitoring, as follows:

- Three potential 'impact' sites at Clay Point (CP1, CP2 and CP3) located ~60–200 m away from the pens.
- One[2] reference site (CP4) that lies outside the primary depositional footprint and is established on areas of reef that are as comparable as possible to impact sites in terms of depth, substrate, aspect and habitats.

To maintain consistency with historical timing for the reef monitoring, monitoring will continue to be undertaken in October / November 2015, concurrent with Clay Point reef monitoring.

Sampling protocol

At each reef site, four replicate stations are permanently marked with a pair of pins cemented into the rock at a distance apart that corresponds to the short side of a rectangular 0.25 m^2 photo-quadrat. The pins are identified with yellow cattle tags (marked with the site and station name, and upper or lower pin relating to position) and some of the pins are marked with a float on a short nylon cord (Figure 3). This set-up aids relocation of the stations and allows the precise repositioning of six 0.25 m^2 photo-quadrats such that the same exact patch of reef, and individual, sessile (attached) macrobiota, can be monitored through time.

Six photo-quadrats will be taken at each station, producing four replicate clusters of six per site (*e.g.* Figure 3). Photos will be taken with a 10-megapixel digital SLR camera attached at a set distance from the 0.25 m^2 quadrat. Each photo will be qualitatively compared to the photos from the same position in previous years, and quantitatively analysed (see next section). Randomly allocated photo-quadrats will also be taken in the general vicinity of each sampling station, to encompass larger spatial extents and taxa that may be sensitive to disturbance caused while finding tags and collecting photos. These photographs will be archived and can be used at a future date if necessary. As a recommendation from the 2014 report (Dunmore *et al.* 2015), video footage will continue to be collected around the potential impact sites to characterise the general areas, encompassing a larger spatial extent than that captured by photo-quadrats. Footage will be reviewed and archived for the assessment of any obvious visual changes over time.

[2] Two more reference sites are also monitored as part of the joint reef monitoring programme between Clay Point and Te Pangu.

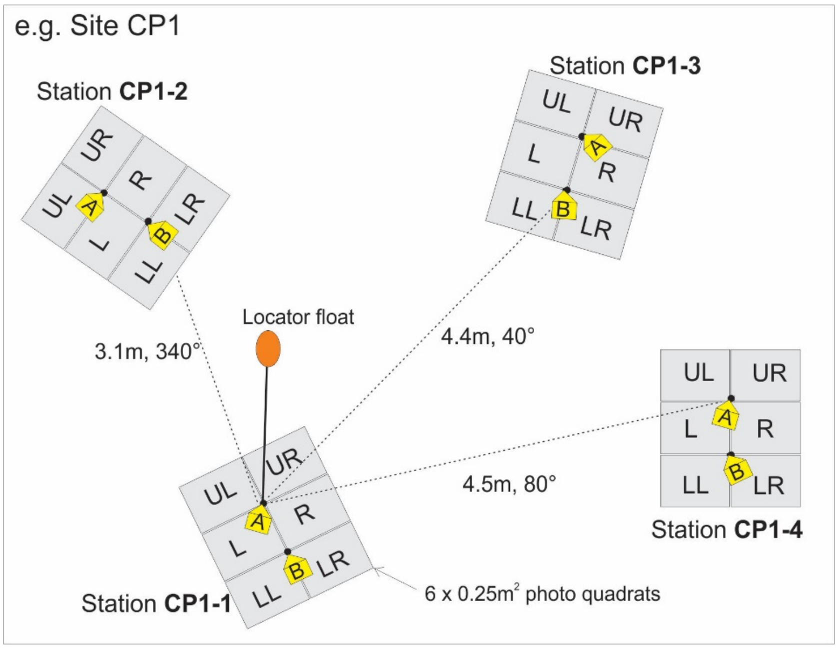


Figure 3. Example of the arrangement of the four photo-quadrat stations that are set up at each sampling site. Each rectangular sampling station comprises a 2 × 3 cluster of 0.25 m^2 photo-quadrats, aligned according to the two permanent marker pins. UL, UR, L, R, LL and LR denote upper-left, upper-right, left, right, lower-left and lower-right, respectively.

Data analyses

The primary purpose of the reef monitoring is to track the fate of a few representative sessile organisms (*e.g.* hydroids and sponges) that are considered potentially sensitive to deposition of organic material over time. This will be achieved by obtaining sequential images for each site and assessing them qualitatively for presence / absence of representative organisms and any changes in community composition or sedimentation.

Although quantitative analyses is possible (and has been done in the past), permanent photo-quadrats will only be qualitatively analysed in 2015[3], as recommended by Dunmore *et al.* (2015).

2.5. Water column sampling

2.5.1. Sampling locations

The overall sampling design is based on monitoring the 'worst-case scenario' at the pen edges, and then along the anticipated gradient at the Zone 2/3 and 3/4 boundaries (*e.g.* 50 m and 150 m down-current for the RUA farm) to evaluate near-

[3] The quantitative analysis will be performed on alternate years unless feed use and/or farming arrangements change appreciably.

farm mixing. As a continuation of the 2014 sampling regime[4], full-scale water column monitoring during 2015 / 2016 will be undertaken at all of the currently stocked farm sites, while the fallowed sites (Waihinau and Forsyth) will have a lower intensity of sampling.

At each site, sampling stations (listed by site in Table 5) will be selected along transects orientated according to the tidally reversing current flows (determined at the time of sampling).

Table 5. Stations to be sampled as part of water column monitoring during the 2015–2016 annual monitoring.

Farm	Pens (or Zone 1/2 if 4-Zone)	Zone 1/2 (or 2/3 if 4-Zone)	Zone 2/3 (or 3/4 if 4-Zone)	Ref
CLA	Pen 1	90 m	300 m	TC-Ctl-2
OTA	Pen 1	50 m	150 m	QC-Ctl-2
RUA	Pen 1	50 m	150 m	QC-Ctl-3
WAI	Pen 1			PS-Ctl-1
FOR	Pen 1			PS-Ctl-3

2.5.2. Sampling protocol

At each station, the following parameters will be measured across the depth profile, *in situ* using a submersible sensor array (CTD: conductivity, temperature and depth):

- salinity
- temperature
- fluorometry (a proxy for chlorophyll-*a*)
- optical backscatter (a proxy for turbidity)
- dissolved oxygen (DO).

Monitoring results will be used to quantify the effect of individual farms on the surrounding near-field water column environment where the potential for detecting change / effects is greatest.

[4] which was agreed upon with Marlborough District Council (MDC) and NZ King Salmon

2.6. Reporting and recommendations

Annual monitoring reports will be provided to Council in draft as soon as practically possible following the completion of the monitoring (and no later than 28 February 2016), with a final report to follow no later than 30 March 2016. The reports will include the following as per the consent conditions:

1. Presentation and interpretation of the monitoring results.
2. A comprehensive and integrated report on the effects of the development and operation of the farm to date; this includes incorporating data on the maximum biomass of fish and feed volumes for the past year into farm operations to date.
3. An assessment as to whether or not the farm is having a significant adverse effect on the environment.

Additionally, the consent holder and / or the research provider will provide:

4. Recommendations to avoid, mitigate or remedy environmental effects (if required).
5. Comments on the adequacy of the monitoring program and any recommendations relating to changes and/or improvements (*e.g.* frequency, parameters to be measured *etc.*).

The reef habitat monitoring data from the Clay Point site will be combined with those from the Te Pangu site (see Elvines & Taylor, in prep) and will be analysed qualitatively in 2015. These results will be provided in a separate report to Council in draft no later than 30 March 2016.

3. REFERENCES

Borja, A., Franco, J., & Perez, V. (2000). Guidelines for the use of AMBI (AZTI's marine biotic index) in the assessment of the benthic ecological quality. Marine Pollution Bulletin 50: 787-789.

Elvines D, Morrisey D, Taylor D 2015. New Zealand King Salmon Company Ltd. Annual Monitoring Programme and Methods; New farm sites - June 2015 to July 2016. Prepared for The New Zealand King Salmon Co. Ltd. Cawthron report 2679. 38 p. plus appendices.

Elvines D, Taylor D, In prep. The New Zealand King Salmon Co. Ltd Annual Monitoring plan and methods 2015-2016: Te Pangu. Prepared for The New Zealand King Salmon Co. Ltd. Cawthron Report No. 2748.

Dunmore R, Keeley N, Peacock L 2015. Reef environmental monitoring results for the Clay Point and Te Pangu salmon farms: 2014. Prepared for New Zealand King Salmon Limited. Cawthron Report No. 2687. 25 p. plus appendices.

Keeley N 2012. Assessment of enrichment stage and compliance for salmon farms–2011. Prepared for New Zealand King Salmon Company Limited. Cawthron Report No. 2080. 15 p.

Margalef R 1958. Information theory in ecology. International Journal of General Systems 3: 36-71.

MPI 2015. Best Management Practice guidelines for salmon farms in the Marlborough Sounds: Part 1: Benthic environmental quality standards and monitoring protocol (Version 1.0 January 2015). Prepared for the Ministry for Primary Industries by the Benthic Standards Working Group (Keeley, N., Gillard, M., Broekhuizen, N., Ford, R., Schuckard, R., & Urlich, S.).

Muxika, I., Borja, A., & Bald, J. (2007). Using historical data, expert judgement and multivariate analysis in assessing reference conditions and benthic ecological status according to the European Water Framework Directive. Marine Pollution Bulletin 55: 16-29.

Rosenberg, R., Blomqvist, M., C Nilsson, H., Cederwall, H., & Dimming, A. (2004). Marine quality assessment by use of benthic species-abundance distributions: a proposed new protocol within the European Union Water Framework Directive. *Marine Pollution Bulletin, 49*(9), 728-739.

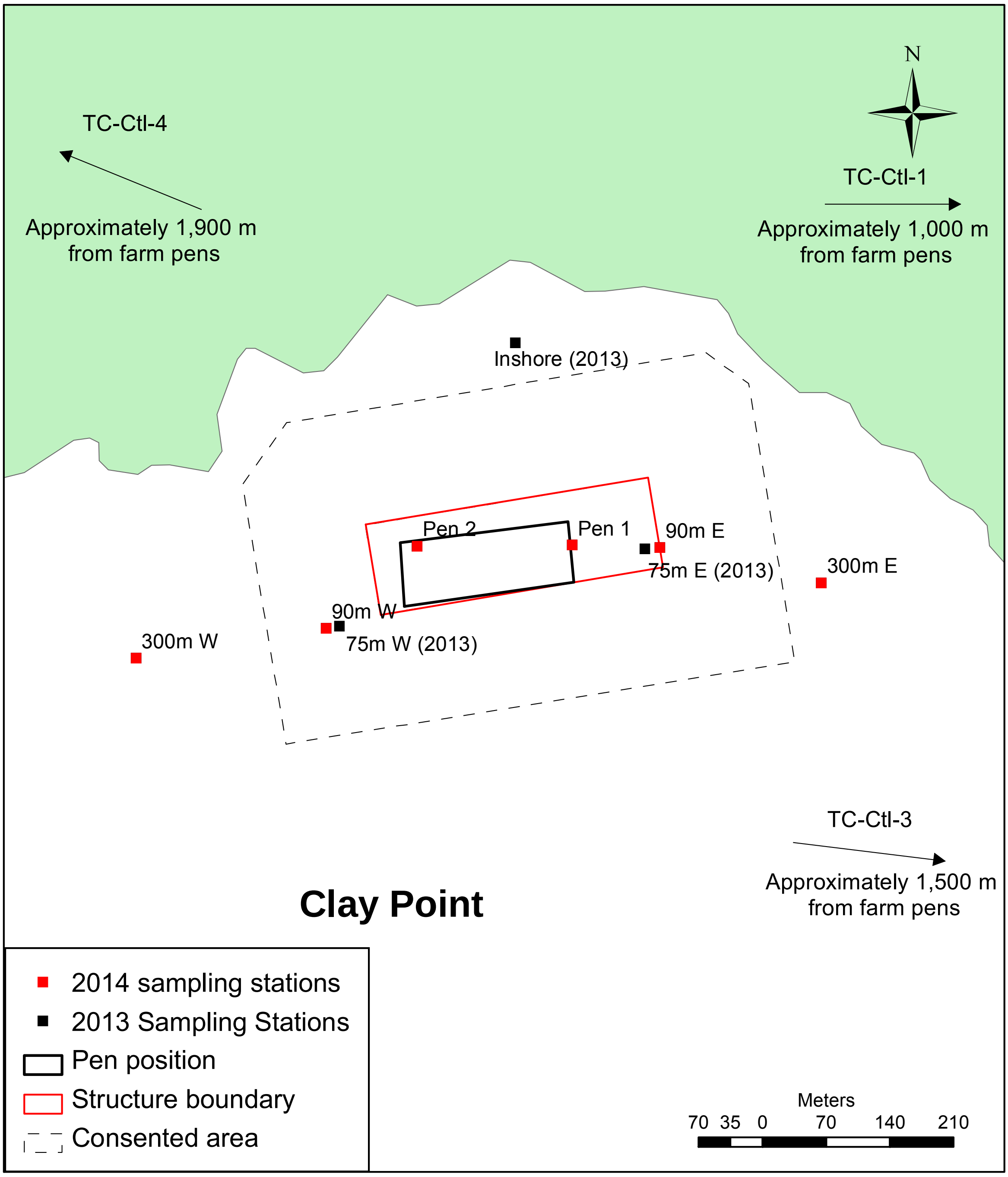
Pielou EC 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13: 131-144.

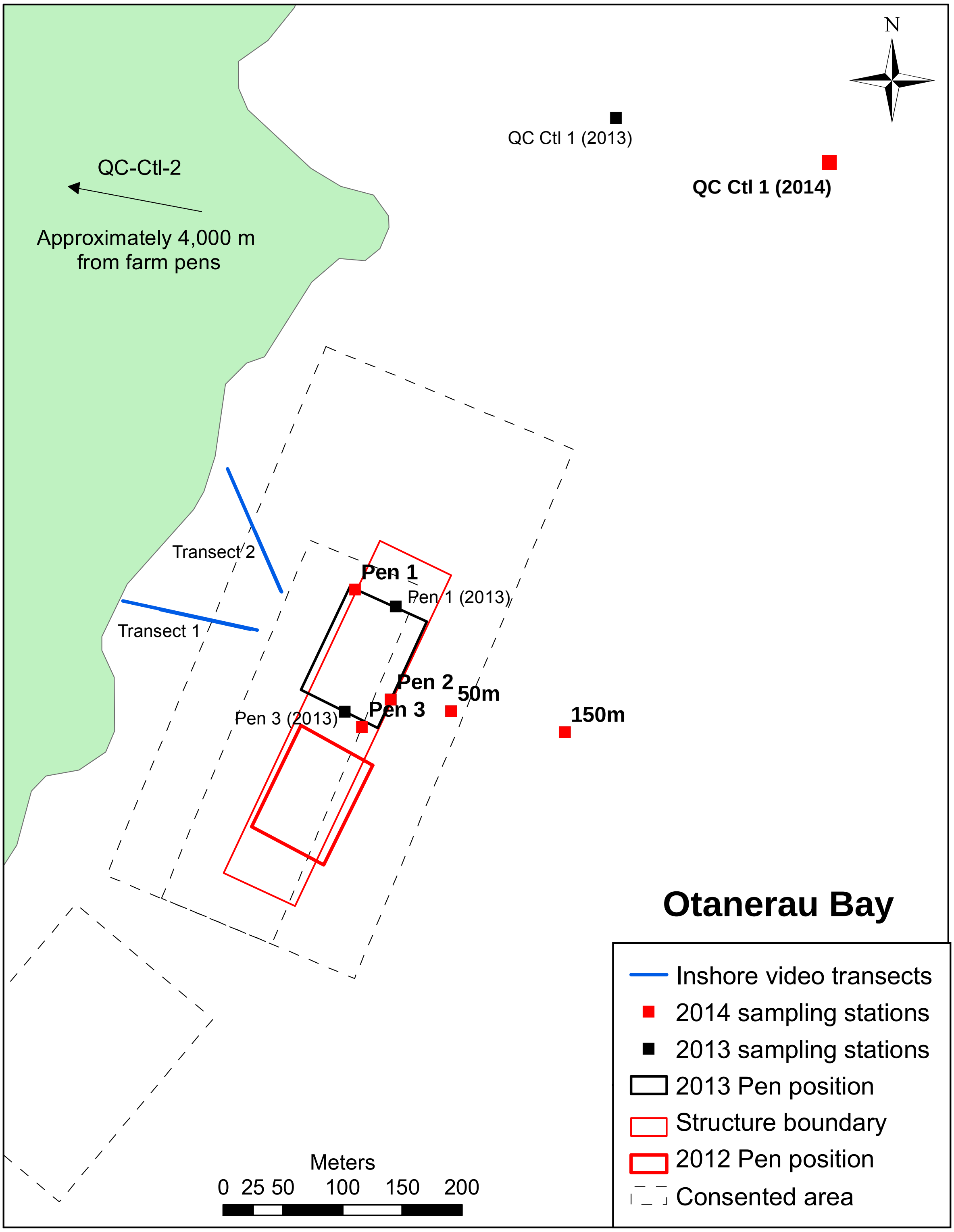
Sneddon R, Tremblay L 2011. The New Zealand King Salmon Company Limited: Assessment of environmental effects - copper and zinc. Prepared for New Zealand King Salmon Company Ltd. Cawthron Report No. 1984. 53 p plus appendices.

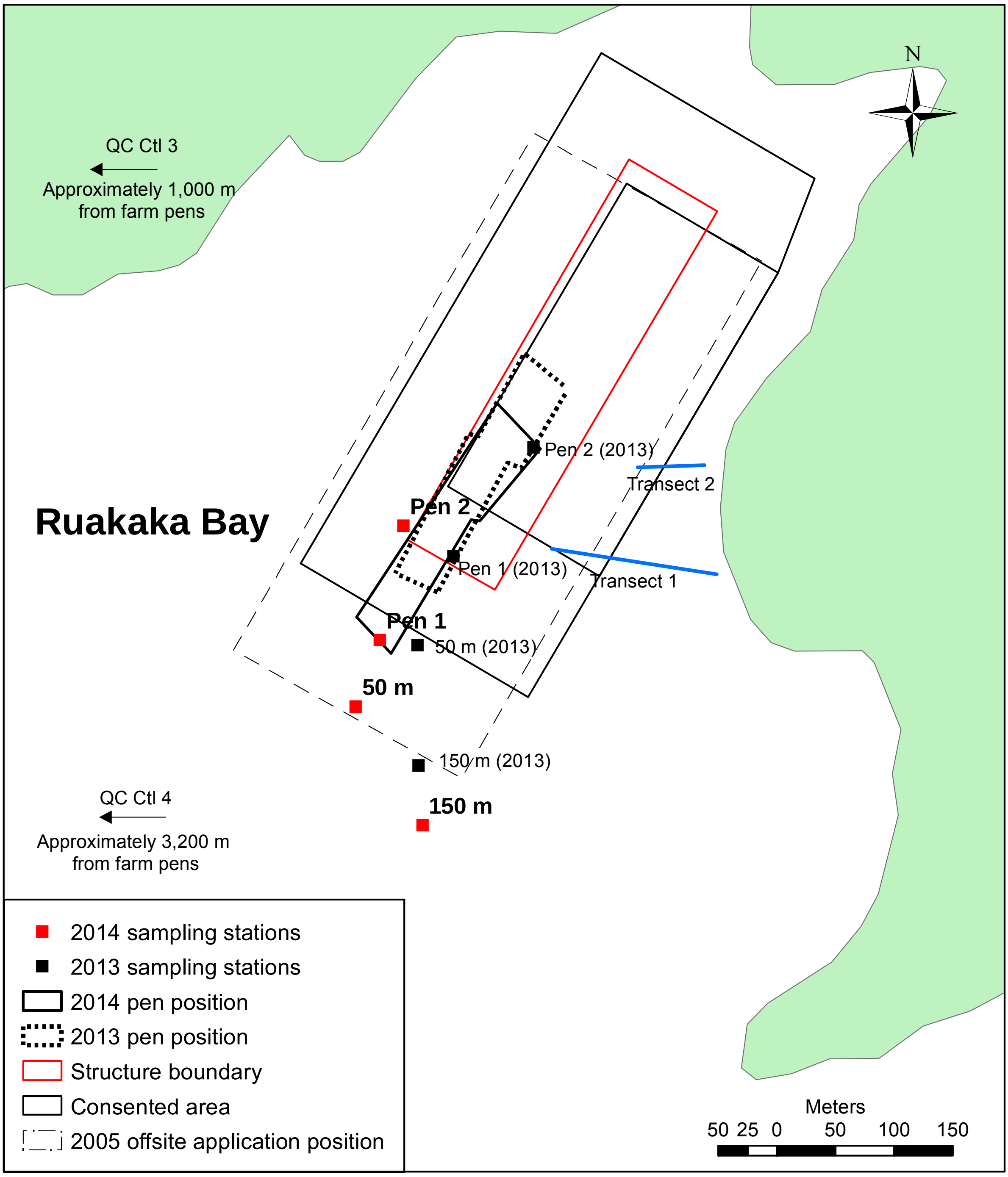
Taylor D, Knight B, Elvines D, Cornelisen C 2015. Environmental impacts of the Clay Point salmon farm: annual monitoring 2014: Addendum. Prepared for The New Zealand King Salmon Co. Limited. Cawthron Report No. 2632A. 5 p.

4. APPENDICES

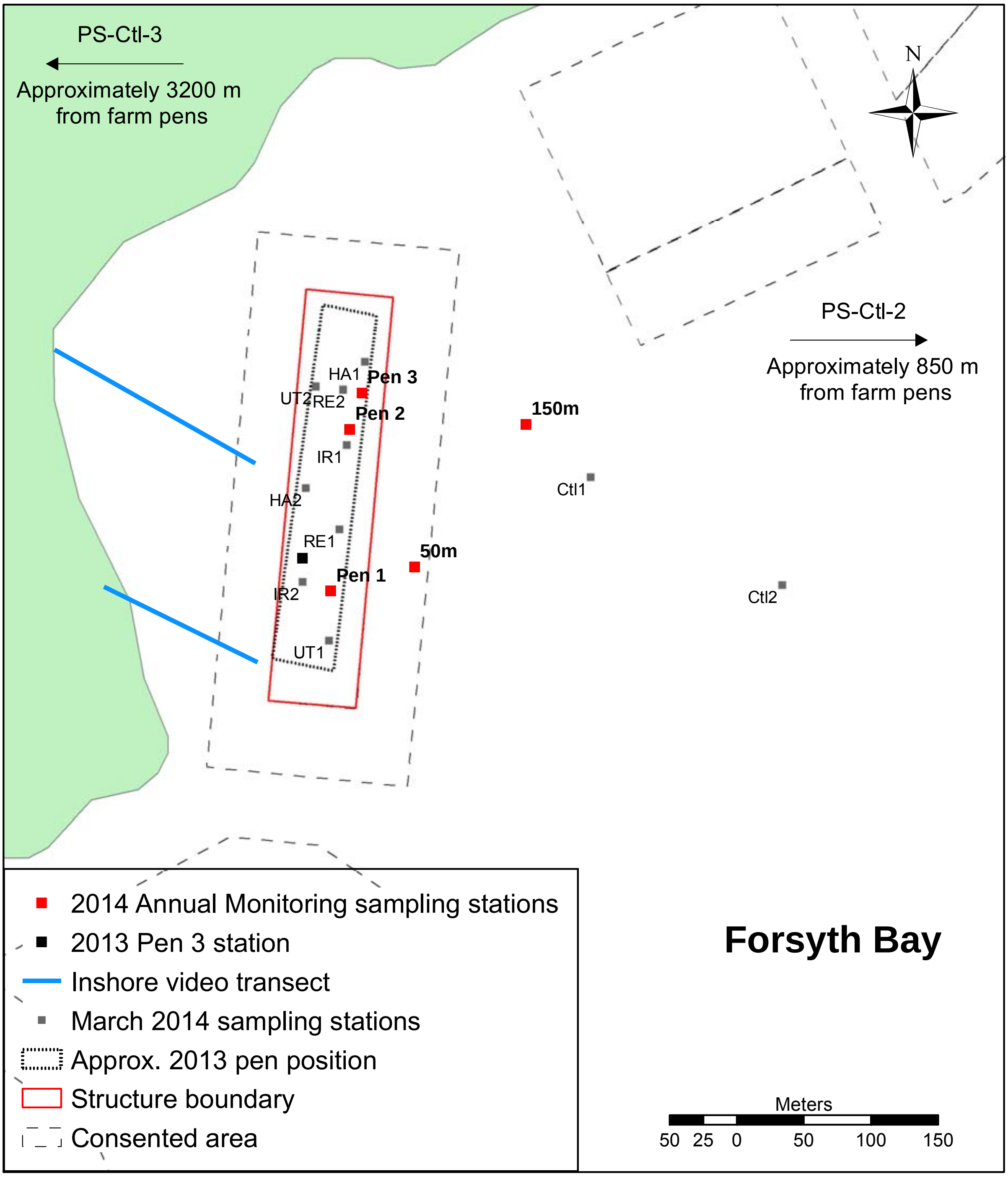
Appendix 1. Map for each site from the previous annual monitoring reports. Note sampling locations do not necessarily reflect exact locations for the 2015-2016 monitoring (due to farm movements).

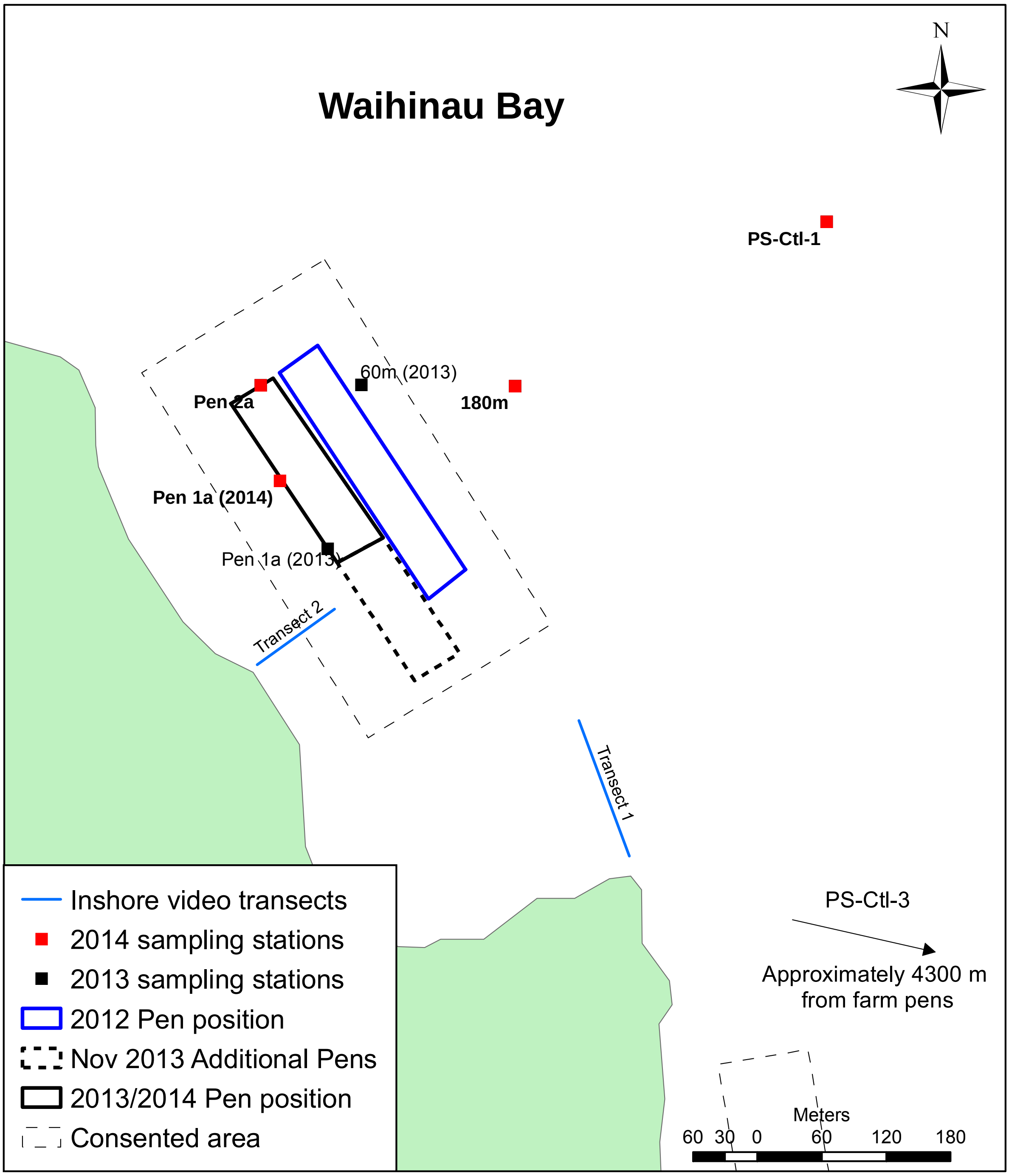



N
QC Ctl 1 (2013)
QC Ctl 1 (2014)
QC-Ctl-2
Approximately 4,000 m
from farm pens
Transect 2
Transect 1
Pen 1
Pen 1 (2013)
Pen 2
50m
Pen 3
150m
Pen 3 (2013)
Otanerau Bay
Inshore video transects
2014 sampling stations
2013 sampling stations
2013 Pen position
Structure boundary
2012 Pen position
Consented area
Meters
0 25 50 100 150 200

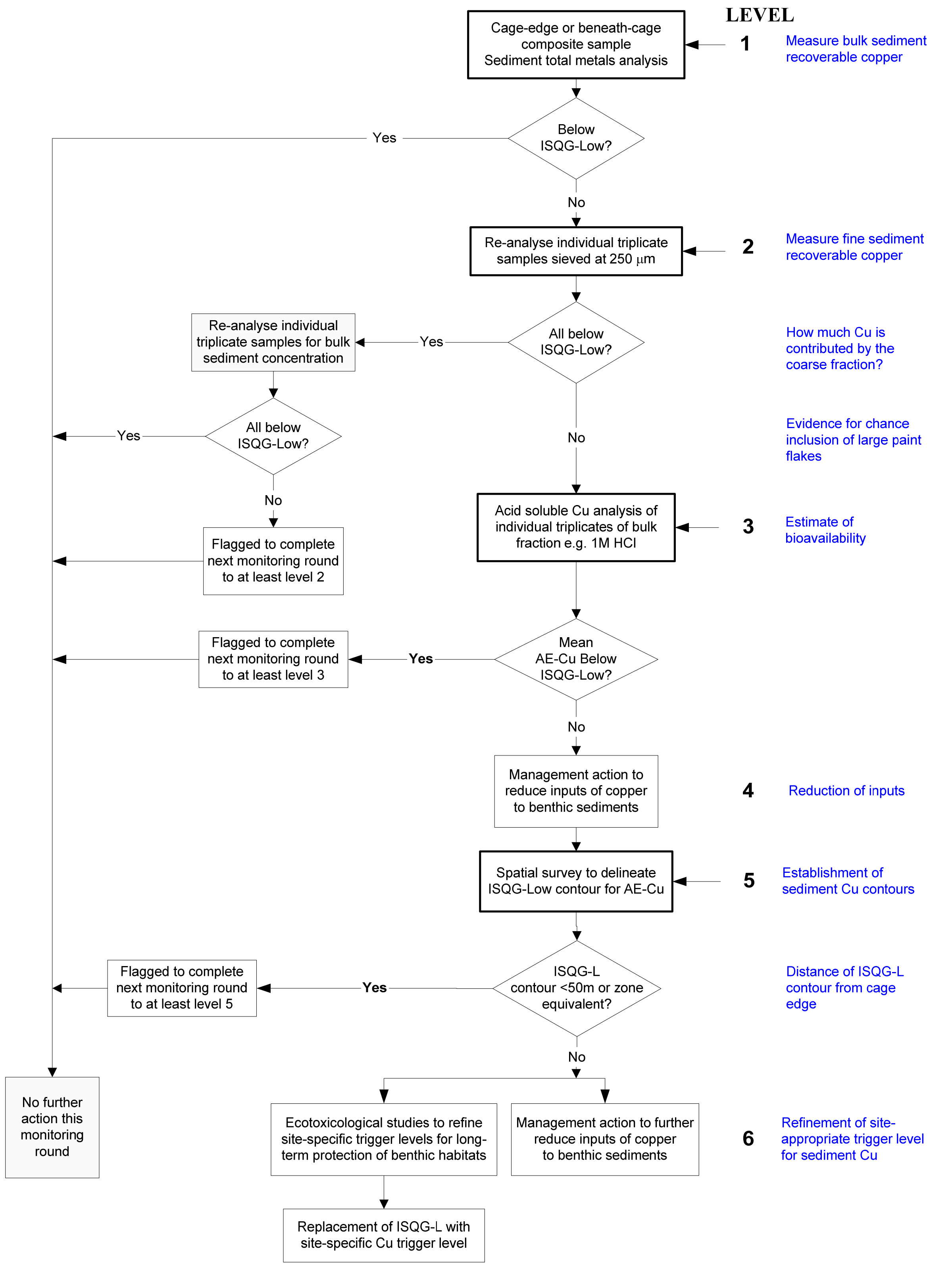


N
QC Ctl 3
Approximately 1,000 m
from farm pens
Ruakaka Bay
Pen 2 (2013)
Transect 2
Pen 2
Pen 1 (2013)
Transect 1
Pen 1
50 m (2013)
50 m
150 m (2013)
150 m
QC Ctl 4
Approximately 3,200 m
from farm pens
2014 sampling stations
2013 sampling stations
2014 pen position
2013 pen position
Structure boundary
Consented area
2005 offsite application position
Meters
50 25 0 50 100 150


PS-Ctl-3
Approximately 3200 m
from farm pens
N
PS-Ctl-2
Approximately 850 m
from farm pens
HA1
Pen 3
UT2
RE2
Pen 2
150m
IR1
Ctl1
HA2
RE1
50m
Pen 1
IR2
Ctl2
UT1
2014 Annual Monitoring sampling stations
2013 Pen 3 station
Inshore video transect
March 2014 sampling stations
Approx. 2013 pen position
Structure boundary
Consented area
Forsyth Bay
Meters
50 25 0 50 100 150


Waihinau Bay
N
PS-Ctl-1
60m (2013)
Pen 2a
180m
Pen 1a (2014)
Pen 1a (2013)
Transect 2
Transect 1
PS-Ctl-3
Approximately 4300 m
from farm pens
Meters
60 30 0 60 120 180
Inshore video transects
2014 sampling stations
2013 sampling stations
2012 Pen position
Nov 2013 Additional Pens
2013/2014 Pen position
Consented area

Appendix 2. Decision response hierarchy for metals tiered monitoring approach (from MPI 2014).



Appendix 3. Definitions of selected biological indicators.

Indicator	Calculation and description	Source reference
N	Sum (n) Total infauna abundance = number of individuals per 13 cm diameter core	-
S	Count (taxa) Taxa richness = number of taxa per 13 cm diameter core	-
d	(S-1) / log N Margalef's diversity index. Ranges from 0 (very low diversity) to ~12 (very high diversity)	Margalef (1958)
J'	*H'* / log S Pielou's evenness. A measure of equitability, or how evenly the individuals are distributed among the different species. Values can range from 0.00 to 1.00, a high value indicates an even distribution and a low value indicates an uneven distribution or dominance by a few taxa.	Pielou (1966)
H'	$-\sum_i p_i \log(p_i)$ where p is the proportion of the total count arising from the *i*th species Shannon-Weiner diversity index (SWDI). A diversity index that describes, in a single number, the different types and amounts of animals present in a collection. Varies with both the number of species and the relative distribution of individual organisms among the species. The index ranges from 0 for communities containing a single species to high values for communities containing many species with each represented by a small number of individuals.	-
AMBI	= [(0 × %GI + 1.5 × %GII + 3 × %GIII + 4.5 × % GIV + 6 × %GV)]/100 where GI, GII, GIII, GIV and GV are ecological groups (see Section 2.3). Azites Marine Biotic Index: relies on the distribution of individual abundances of soft-bottom communities according to five Ecological Groups (GI-GV). GI being species sensitive to organic pollution and present under unpolluted conditions, whereas, at the other end of the spectrum, GV species are first order opportunists adapted to pronounced unbalanced situations (*e.g. Capitella capitata*). Index values are between 1 (normal) and 6 (extremely disturbed)	Borja *et al.* (2000)
M-AMBI	Uses AMBI, S and H', combined with factor analysis and discriminant analysis (see source reference). Multivariate-AMBI. Integrates the AMBI with measures of species richness and SWDI using discriminant analysis (DA) and factorial analysis (FA) techniques. Utilises reference conditions for each parameter (based on 'pristine conditions') that allows the index to be tailored to accommodate environments with different base ecological characteristics. Scores are from 1 (high ecological quality) to 0 (low ecological quality).	Muxika *et al.* (2007)
BQI	$= \left(\sum_{i=1}^{n}\left(\frac{A_i}{totA} \times ES50_{0.05i}\right)\right) \times {}^{10}\log(S+1)$ Where ES50 = expected number of species as per Hurlbert (1971) And, $ES50_{0.05}$ the species tolerance value, given here as the 5th percentile of the ES50 scores for the given taxa as per Rosenberg *et al.* (2004). Benthic quality index: uses species specific tolerance scores ($ES50_{0.05}$), abundance and diversity factors. Results can range from 0 (being highly impacted) and 20 (reference conditions).	Rosenberg *et al.* (2004)