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Dear Dan

ADDENDUM TO ASSESSMENT OF EFFECTS OF COPPER AND ZINC FOR SALMON FARM RELOCATION SITES

Background

The Marlborough District Council and central government are working with the salmon aquaculture industry on options to implement the *Best Management Practice Guidelines for Salmon Farming*[1] in the Marlborough Sounds. Options include relocation of some existing salmon farms from 'low-flow' environments to more environmentally appropriate locations (see attached map), to ensure the guidelines can be met in the future. Six existing salmon farms are presently positioned at low-flow sites not ideally suited to modern salmon farming. Relocating these farms to more suitable sites is expected to result in better environmental, social and economic outcomes. Nine potentially suitable sites have been identified (see map, below), which now require an Assessment of Environmental Effects (AEE). The Ministry for Primary Industries (under a Heads of Agreement with New Zealand King Salmon Company Ltd [NZKS]) has contracted the Cawthron Institute to undertake several components of each of the AEEs.

An initial stage in this process was a gap analysis of the existing information regarding the potential farm relocation(s). This gap analysis was undertaken by MWH (NZ) Ltd[2] and presented in a letter dated 14 March 2016. The analysis identified, at a high level, the quality of the existing information and the amount of work required for inclusion in an updated AEE. This was categorised into five different levels ranging from where sufficient information exists for the AEE, to engaging a contractor and commissioning a full report. In terms of effects of copper and zinc inputs, the gap analysis recommended a requirement for an update or addendum letter confirming the previous conclusions and whether or not the information and/or recommendations remain relevant.

This letter addresses these aspects.

Scope of review of copper and zinc assessment

Inputs of copper and zinc, and their potential adverse environmental effects, from existing and proposed farms were addressed in 2011/12 as part of a proposal at that time by NZKS to develop

[1] Keeley et al. 2014. Best Management Practice guidelines for salmon farms in the Marlborough Sounds: Benthic environmental quality standards and monitoring protocol. Available at: http://www.marlborough.govt.nz/Environment/Coastal/Best-Practice-Guidelines-for-Salmon-Farming.aspx
[2] Marlborough Initiative - Gap Analysis. Letter to Hamish Wilson (MPI) from Nardia Yozin (MWH NZ Ltd) dated 14 Mar 2016. 7p.

several new salmon farm sites in the Marlborough Sounds. That proposal was assessed by the Environmental Protection Authority (EPA) via a Board of Inquiry (BOI) Hearing.

The documents produced during that process that are relevant to the relocation assessment are as follows:

- 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 Ltd. Cawthron Report No. 1984. 50p. plus appendices
- Sneddon R, Tremblay L, Stringer T 2012. Investigation of potential copper and zinc bioavailability and ecotoxicological status of sediments beneath salmon farms. Prepared for New Zealand King Salmon Ltd. Cawthron Report No. 2033. 31p. plus appendices
- Statement of evidence of Ian Ross Sneddon in relation to effects of copper and zinc inputs for the New Zealand King Salmon Company Limited, June 2012. 33p.
- Statement of rebuttal evidence of Ian Ross Sneddon in relation to effects of copper and zinc inputs for the New Zealand King Salmon Co. Limited, August 2012. 6p.

This addendum reviews the above documents to determine whether the conclusions and recommendations regarding potential effects of metals discharged from the farm are likely to be valid for the new locations.

The review and conclusions below are based on the understanding that the proposal is simply to move up to six existing farms from low-flow areas to six new locations situated in more dispersive and higher flow environments. For the purposes of this assessment, it is also assumed that antifouling and feeding practices will remain the same as those assessed in 2011. This includes the use of feeds containing organic-associated zinc from August 2011, which increases uptake by the fish and, therefore, reduces the amount released into the environment in their faeces.

Previous conclusions and updated information

There are three principal routes by which copper and zinc can enter the marine environment as a result of finfish farming:

1. Leaching from antifouling paint surfaces or deposited with paint particles dislodged by flexing or abrasion of the painted surface (copper and some zinc, depending on paint formulation). In the case of NZKS's operations, antifouling paint is used on the predator nets.
2. With the release of uneaten food (principally zinc).
3. Feed eaten by farmed fish and subsequently released in their faeces (principally zinc).

Sneddon and Tremblay (2011) presented the monitoring data for copper and zinc in sediments below the net pens at the six existing farms over time. Concentrations of both metals were temporally and spatially variable at all farms, but concentrations of zinc were generally below the

ANZECC[3] Interim Sediment Quality Guidelines (ISQG)-Low criterion at high-flow sites and generally above it at low-flow sites. At low-flow sites the number of exceedances of ISQG-Low was larger for zinc than for copper. The pattern of exceedances was reversed for high-flow sites, with the number of copper exceedances larger than those for zinc. This was attributed to the greater dispersive influence of water currents on the feed and faecal component of deposition. It was suggested that extreme outliers in the metals data were the result of inclusion in the samples tested of large particulate matter, including flakes of antifouling paint in the case of copper.

The time-series of copper and zinc concentrations (2006–present) at the two existing high-flow sites (Clay Point, operating since 2007, and Te Pangu, operating since 1992) have been updated for the present assessment (Figure 1). Within-year variation continues to obscure temporal trends in metal concentrations. Across both farms, the number of exceedances of the ISQG-Low value for copper (15 of 77 samples) remained larger than that for zinc (6). The percentage of copper exceedances was similar at both sites (c. 20% of samples) but the percentage of zinc exceedances was larger at Te Pangu (11% vs 3%). The distribution of both metals in the updated data set showed outlying values, presumably due to large, contaminated particles such as flakes of antifouling paint and perhaps galvanised coating (assuming that farm structures are galvanised).

[3] ANZECC 2000. Australian and New Zealand guidelines for fresh and marine water quality 2000 Volume 1. National Water Quality Management Strategy Paper No. 4. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

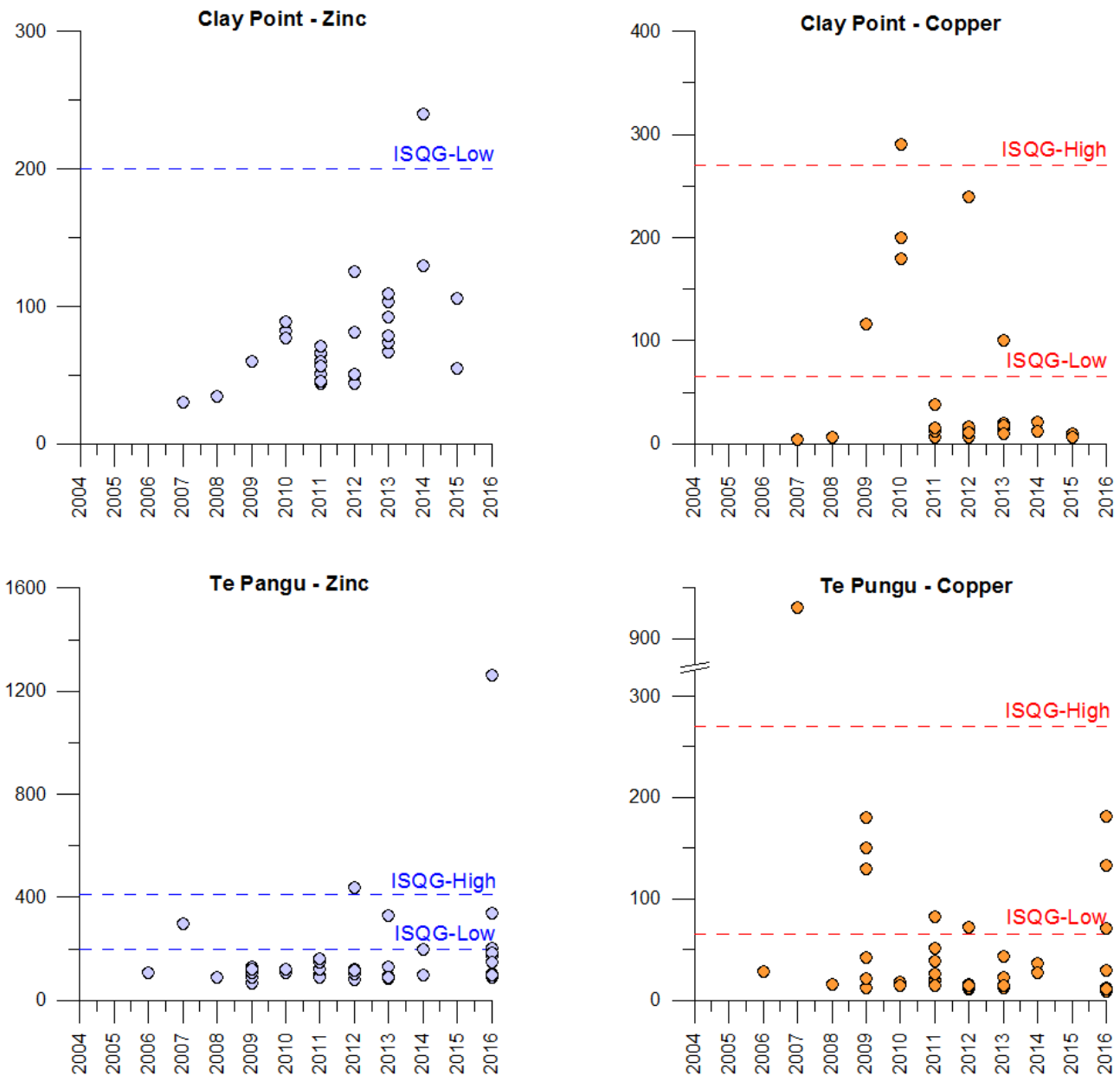

Figure 1 Concentrations of total recoverable copper and zinc at the two existing high-flow salmon farms for the years since 2006. Data are shown for individual replicate samples collected at the edge of the net pens. Note axis break to accommodate an outlying copper value at Te Pangu. ANZECC ISQG criteria are also shown.

Sneddon and Tremblay's (2011) predictions of effects from copper and zinc discharges from farms were summarised in their Table 4 and are briefly restated here. In essence, they concluded that:

- copper and zinc would accumulate beneath farms but that the spatial extent would be very limited
- the bioavailability of accumulated metals in sediments is difficult to predict and management of farms should be based on compliance with ANZECC ISQG criteria until site-specific criteria can be developed (where appropriate)

- water column effects are unlikely to be ecologically significant and will be limited to areas immediately adjacent to the farms
- the dispersive nature of the farm sites means that inputs of metals do not have significant ecological implications for the wider Marlborough Sounds area, however
- although accumulation of metals to concentrations likely to have ecological effects is unlikely, in the case of high-flow sites some low-level accumulation could conceivably occur where hydrodynamic conditions exist to re-concentrate transported particulate matter in depositional areas away from the farm.

Applicability of previous conclusions to new farm sites

The dispersion of copper and zinc from the farms, and subsequent deposition on the seabed, will depend largely on the hydrodynamic conditions of the surrounding environment. The assessment by Sneddon and Tremblay (2011) used the time-series of copper and zinc concentrations in sediments beneath and around existing salmon farms to estimate likely concentrations around nine proposed sites. The existing sites include low-flow and high-flow locations whereas the sites proposed at that time, like the currently proposed sites, are in high-flow locations. The predictions for the proposed high-flow locations, and the recommendations for management of copper and zinc discharges from them, can be extended to the nine new sites under consideration in this addendum if environmental conditions are comparable.

Detailed information on the locations of the new sites relevant to their dispersive properties was not available at the time of writing but the sites have been chosen specifically for their dispersive, high-flow characteristics. What information is currently available on the new sites (Table 1) supports this, with at least five of the new sites having similar water depths and current speeds to the two existing high-flow sites (in contrast, near-bed mean current speeds at low-flow sites are c. 3 cm/s). This suggests that the assessment of effects for high-flow sites in the 2011 AEE are likely to be valid for the new sites.

Table 1 Depths (m) and current speeds (cm/s) at two existing high-flow farm sites (Sneddon and Tremblay 2011) and five of the new sites for which data are available (data collected or generated by Cawthron on behalf of MPI). * indicates that current speeds were derived from a numerical hydrodynamic model.

Site no.	Site name	Depth	Max depth-averaged current speed	Near-bed mean current speed
Existing				
	Clay Point	30-40	79	19
	Te Pangu	27-31	63	19
New				
106	Richmond South	30-60	c. 50	18
124	Horseshoe Bay		c. 35	12
42	Tipi Bay	20-34	45*	16*
82	Motukina	30-35	41*	19*
47	Te Weka Bay	30-35	38*	14*

The nine new sites, being categorised as high-flow, are likely to have relatively coarse sediments and develop less organic enrichment than existing low-flow sites. Consequently, although there is likely to be less accumulation of metals in the sediments beneath the farms, their bioavailability may be greater because there will be less tendency for them to bind to fine sediment particles under the chemically reducing conditions caused by organic enrichment. In this respect, conditions at the new sites are likely to be similar to those at the high-flow sites considered by Sneddon and Tremblay (2011), and the biological effects (including toxicity and bioaccumulation) of copper and zinc predicted for those sites will also be valid for the new sites. Management of the farms to avoid or remedy exceedance of the ISQG trigger values will minimise the risk of adverse ecological effects even when bioavailability of metals is relatively high because the guidelines are based on concentrations of bioavailable, rather than total, metals.

Higher exposure to currents means that there is a greater chance of resuspension and remobilisation of metals at high-flow sites. However, concentrations of bioavailable metals in the water column will be within the assimilative capacity of the environment in the wider area because of the high degree of dispersion and their affinity for sediment particles and resulting low partition rate into the water column. Consequently, toxic effects of exposure to metals in the water column are not likely, even in the immediate environment of the new sites.

Adverse effects on the wider environment could conceivably arise from the potential accumulation of contaminated fine sediments in localised depositional areas. Such effects are highly unlikely to re-concentrate metals to the same orders of magnitude as those beneath farms in low-flow sites, and exceedance of ISQG trigger values is correspondingly very unlikely. This prediction is supported by the fact that increases in concentrations of metals in sediment have not been detectable against background spatial variability beyond several hundred metres from existing low-flow farms.

Sneddon and Tremblay (2011) recommended an Adaptive Management Plan, based on a decision tree incorporating ISQG criteria[4], to provide a hierarchical schedule of monitoring of metals in sediments at the farm boundary, with increasing focus and intensity of sampling and, ultimately, management action, when ISQG criteria are exceeded. This approach is equally applicable to the nine newly proposed, high-flow sites.

Notwithstanding the very low probability of accumulation of farm-derived metals in depositional areas away from farms, it may be appropriate to determine the overall spatial extent of the copper and zinc footprints of farms in dispersive sites, as proposed by the *Best Management Practice guidelines for salmon farms in the Marlborough Sounds*. Results of monitoring at depositional environments down-current from the farm would be compared with background values to identify spatial and temporal trends, and used to inform possible management options.

[4] Note that the most recent version of the decision tree can be found in Ross Sneddon's Statement of Evidence (June 2012) and in the *Best Management Practice Guidelines*.

Summary

In terms of the proposed relocation of up to six farms, the potential adverse effects of copper and zinc discharge will be ameliorated by moving the sites to more dispersive, higher-flow environments. Sneddon and Tremblay's conclusions from the 2012 BOI hearing remain valid and siting the existing farms in a more dispersive area, coupled with adaptive management, means that effects of discharges will be less than minor if not negligible.

I trust that the above addendum on effects of copper and zinc inputs is sufficient for MPI's needs. However, please don't hesitate to contact us if you require further information.

Yours sincerely

Scientist

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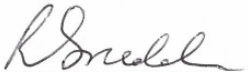
Reviewed by



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