Response to questions for peer-review of Council's preliminary analysis of consent compliance New Zealand

for

Marlborough District Council

provided by

Professor Kenneth D. Black

SAMS Research Services Ltd.

Scottish Marine Institute

Oban

Argyll

PA37 1QA

UK

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www.samsrsl.co.uk

The complete document sent to SRSL for response is reproduced below with my comments in red italics added at the appropriate points. These are based on my reading of the several Cawthron Survey reports from November 2014 supplied to me by MDC.

Professor Kenneth D Black

8th April 2015

Questions for peer-review of Council's preliminary analysis of consent compliance

Introduction

New Zealand King Salmon (NZKS) operate six active marine farms under separate resource consents ("consents") in the Marlborough Sounds. These consents individually require annual monitoring reports of benthic and water column conditions. Monitoring reports were submitted to Council on the 3rd March 2015.

Monitoring of the farms occurred in November 2014 by the Cawthron Institute. The monitoring methodology[1] was submitted to Council on 29 October 2014 and approved by Council subject to revision on 30 October 2014.

Four of the farms are at sites characterised as "low flow" (<10cm/s mid-water average flow) as they are all in relatively sheltered bays: Waihinau and Forsyth in the outer Pelorus Sound, and Otanerau and Ruakaka in Queen Charlotte Sound. The two Crail Bay farms (Pelorus Sound) have not been utilised for several years and no monitoring occurred in 2014 as per a new consent condition.

Two of the farms are classed as "high flow": Te Pangu and Clay Point, which are in Tory Channel. This flow distinction is important as it influences the capacity of the benthos to assimilate and process organic material, and the spatial footprint of depositional effects.

The following analyses of consent compliance focus primarily on data presented on benthic conditions. Water column data are discussed for the Waihinau farm in light of another reported summer mass mortality event.

Council's preliminary analyses of the results have been assessed against current consent conditions, which set out the maximum level of enrichment permitted in different depositional zones. These zones commence under the pen out to 50m, then generally extend 50-150 m in low flow sites and 50-200m or greater in high flow sites.

Note: that current consent conditions at most sites do not mirror the Enrichment Stage (ES) model in the Methodology Paper. This is because the consents pre-date the ES model (which is a quantitative model but has subjective interpretation at very high and excessive enrichment states). The enrichment stage permitted in the consents is primarily descriptive and more qualitative in its assessment of the state of benthic conditions.

The monitoring reports therefore evaluate the data with the respect to the ES model in the Methodology Paper. The science provider then attempts to translate the equivalent ES stage to the descriptive enrichment stage in the consent conditions to determine compliance.

This is an important point for the peer-reviewer to be cognisant. Essentially, Council views the permitted maximum enrichment scale as being 5 or less (high enrichment) under the pen as reflecting current consent conditions. However, Council accepts the current consent conditions can plausibly be interpreted differently. This has now been resolved in the recently published best practice guidelines for salmon farm management in the Marlborough Sounds: http://www.marlborough.govt.nz/Environment/Coastal/Best-Practice-Guidelines-for-Salmon-Farming.aspx. The ES has been set at ≤ 5.0. However, these guidelines have yet to be implemented.

The format that follows deals with each farm individually. Current consent conditions for each farm are set out, along with an assessment of farm conditions from the monitoring reports, along with questions for peer-review.

[1] Keeley, N. 2014. New Zealand King Salmon Company Limited annual monitoring programme and methods: 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No. 2613. [Note: This is enclosed].

Therefore, the peer-review report should follow a similar format and thoroughly address the questions in each section. The report should clearly identify where it agrees with Council's preliminary findings, and where it departs and why. Additional comments of relevance are welcomed.

Note: The Waihinau Bay consent is a first generation consent (2000). As such, it does not have prescriptive enrichment stage standards beyond avoiding adverse effects.

Ruakaka, Otanerau, and Ruakaka are second generation consents (2002-2006). They have a simple enrichment effects model. This is accompanied by a descriptive set of permitted conditions.

Te Pangu is a third generation consent (2009). It has a more sophisticated enrichment stage model, broken into six stages. Clay Point (modified in 2013) is the only consent with the seven stage enrichment model (as set out in the annual monitoring programme methods – Keeley 2014).

Individual Monitoring Reports

1. **Monitoring Report for Forsyth Bay salmon farm 2012** [2]

Consent U040412 To extend the existing salmon and snapper farming structures (currently occupying 1.2 ha) to a total area of 2 ha within the existing permit area (6.0 ha) within the coastal marine zone. To discharge up to 4000 metric tonnes of salmon feed per annum.

Condition 14. The environmental quality standards (ES) that shall be applied for seabed effects follow the model as presented in the application i.e. seabed effects are 'zoned' around the cages to allow for a mixing or transition zone. Outside this zone no adverse effect on the seabed is allowed. Three 'zones' under an around the marine farm shall be established as follows:

a. Referred to as 'Zone 1' – Beneath the cages and out to 50 m from the cages.

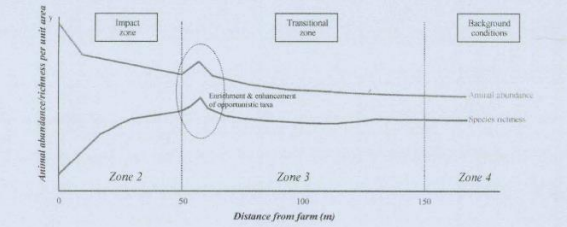
b. Referred to as 'Zone 2' – From 50 m to 150 m from the outside edge of the cages.

c. Referred to as 'Zone 3' – Beyond 150 m from the outside edges of the cages.

Existing Condition 15. The zones may be distorted to allow for the action of tidal currents such that the total area of each zone remains the same as if concentric zones were around the marine farm.

Existing Condition 17. The EQS in each zone is:

Zone	Spatial Extent	Description and Bottom Line
1	Beneath the cages and out to 50 m from their outside edge	Sediments become highly impacted and contain low species diversity, dominated by opportunistic taxa (e.g. polychaetes, nematodes). It is expected that a gradient will exist within this zone, with higher impacts present directly beneath the cages.
2	From 50 m to 150 m from the outside edge of the cages	A transitional zone between zones 2 and 4. Within this zone, some enrichment and enhancement of opportunistic species may occur, however species diversity remains high with no displacement of functional groups. It is expected that a gradient will also exist within this zone.
3	Beyond 150 m from the outside edge of the cages	Normal conditions (i.e. background or control conditions).
All Zones	These conditions are not permitted beneath any NZKS farm	Sediments that are anoxic and azoic (i.e. no life present) will not be permitted.



a) Forsyth has been fallowed since 2013. The site was monitored in November 2014. It is also the subject of a separate scientific remediation study. Environmental data from that remediation study, collected in March 2014, are presented in the monitoring report alongside the November monitoring data.

[2] Elvines, D; Newcombe, E; Keeley, N; Taylor, D. 2014. Environmental Impacts of the Forsyth Bay Salmon Farm: Annual Monitoring 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No 2631.

b) Collectively those data show that the site is still heavily impacted from the previous farm occupation. Enrichment Score (ES) levels ranged from 3.8 to 6.3 (mostly >6.1) within the pen area in March, and in November ES scores were 5.6 under the pens. The impacts are characterised by extremely high organic matter, elevated sulphides, negative redox, and low abundance and diversity of macrofauna. These data suggest the site has little ability to cope with the short-term reintroduction of the farm.

I think this is a reasonable suggestion.

c) A recent study by Keeley, Forrest and Macleod (2014)[3] in Forsyth Bay demonstrated that when the farm was reintroduced to Forsyth after 8 years fallowing, it overwhelmed the benthos with 3 months with anoxic and near-azoic conditions developing. A companion study by Keeley et al. (2014)[4] examined when recovery at Forsyth Bay could be considered complete during the 8 year fallowing period. They found that functional recovery took approximately 5 years after evaluating changes in biological composition and organic matter levels.

i. Based on these studies, would it be reasonable for the farm not to be reintroduced until 2018 (5 years from fallowing)? NZKS have advised that they may reintroduce the farm in 2015.

If the farm was reintroduced without modification in 2015, I would expect that benthic results from a survey a few months later would likely yield poorer outcomes than the survey in 2014 (i.e. ES>5.6 at Pen stations). It is my opinion that the site should be used in future with an appropriate stocking and fallowing cycle that allows it to remain compliant at all stations over all time. It would be best if such a regime was tailored to allow the implementation of Best Practice Guidelines in the near future i.e. ES <5. This could best be realised by a combination of reduced stocking densities/m^2 and/or increased cage spacing and/or lower overall feed inputs.

ii. Alternatively, should the amount of feed discharge be tightly constrained if the farm was reintroduced in 2015 provided the benthos was capable of assimilating the depositional inputs?[5] The aim would be to prevent azoic conditions from occurring. This is in line with the recent best practice management guidelines, where ES pen scores greater than 5.6 require immediate fallowing.[6]

I prefer this option, as per my response above. It should be borne in mind that this is a large farm by the standards of the industry (in Scotland but not perhaps Norway) and it should be possible to run this site successfully at a lower biomass.

d) The preliminary findings of the seabed remediation study at Forsyth do not hold out immediate hope of restoring the seabed by intervention (Keeley, Taylor, Macleod in prep)[7]. These authors applied three different treatments to the seabed to reduce the enrichment. Ploughing and removal of enriched sediments proved the most effective, but this still only represented a reduction of ES by ~1.5 on the ES scale. Currently there is no consent for disturbance of the seabed or deposition of the enriched material, so remediation is not an option in the short term.

I am sceptical of after-the-fact benthic restoration measures which will likely cause as many environmental problems as they solve.

e) Sampling at the outer zone (zone 4, 150 m from the pen sites) only involved sulphide levels. This was by agreement as the site had been fallowed. Therefore an overall ES score was not calculated. The sulphide enrichment scores were assessed as 3.0 (+ 0.1. s.e.). No further action is needed at this time.

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[3] Keeley, NB; Forrest, BM; Macleod, CK. 2015. Benthic recovery and re-impact response from salmon farm enrichment: implications for farm management. *Aquaculture* 435: 412-423.

[4] Keeley NB; Macleod, CK; Hopkins, CA; Forrest, BM 2014. Spatial and temporal dynamics in macrobenthos during recovery from salmon farm induced organic enrichment: when is recovery complete. *Marine Pollution Bulletin* 80: 250-262.

[5] Monitoring results from 2013 showed that ES scores were 5.5 and 5.6 under the pens following a discharge of ~1500 MT.

[6] Keeley N; Gillard M; Broekhuizen N; Ford R; Schuckard R, Urlich S. Best management practice guidelines for salmon farms in the Marlborough Sounds: benthic environmental quality standard and monitoring protocol. Marlborough District Council and New Zealand King Salmon Co. Ltd. http://www.marlborough.govt.nz/Environment/Coastal/Best-Practice-Guidelines-for-Salmon-Farming.aspx

[7] Keeley, N; Taylor, D; Macleod, C. In Prep. Accelerating seabed remediation beneath salmon farms: a comparison of the effectiveness and environmental impacts of three potential treatments.

f) The 2014 monitoring report identifies that Zinc levels are also the highest ever recorded at NZKS sites in the Sounds. Levels at Forsyth are above the ISQG-High[8] threshold for probability of a biological effect(s). Although the report says that the "anomalous samples" could be due to Zinc from paint flakes (p14), the more likely cause is failure of the fish to absorb Zinc as a dietary supplement. We understand that it is more likely that copper-based paints are used for anti-fouling treatment on nets, and not Zinc.

g) Lastly, the bars in Figure 3 representing the annual tonnage discharged do not correspond with the text in section 1.1. Para 3 of section 1.1 states that feed levels have historically ranged from 1,987 to 3.267 tonnes since 2001. However, the graph shows 2012 levels to be <500 MT and 2014 levels are absent.

2. Monitoring Report for Waihinau Bay salmon farm 2014 [9]

Consent MFL456: This is a deemed coastal permit to occupy space the coastal marine area. There are no discharge standards associated with the marine farm licence, other than preventing the deposit of dead salmon, salmon offal or blood water within the farm area or the sea. There are however, requirements for record-keeping, such as for the number of mortalities, and notification provisions to the Ministry for Primary Industries in the event of certain diseases. Notwithstanding that, section 17 of the Resource Management Act imposes a duty on consent holders to avoid, remedy or mitigate adverse effects on the environment arising from their activities.

The consent holder has voluntarily monitored the state of the seabed and water column on an annual basis. The monitoring has been done consistent with the methods used for other farms. Monitoring results have been submitted to Council.

a) Feed discharged exceeded 2400MT in the 12 months preceding the monitoring. Anecdotal reports of spontaneous outgassing occurred over several weeks from early January. The consent holder verbally advised this occurred following the shifting of the farm within the consented area.

b) Sediment chemistry enrichment scores (ES) under Pen 1a, which is "adjacent to a highly used and highly stocked area of the farm" (p15), were at 6.1 $\pm$ 0.1 s.e. in November (p16). Two of the replicates at this Pen site were assessed as ES 7 for sulphides (Appendix 5, p25), which reflects the statement on p9 that "the physico-chemical condition of the sediments…had deteriorated [since 2013]".

i. Given that environmental effects from the farm are likely to be most severe in the summer period, is it reasonable to suppose that sediment chemistry deteriorated further over the hottest months of the year? Would this have meant near-azoic conditions were likely to have developed over this period?

Other things (like farm inputs) being equal, it is certain that increased water temperature would lead to a deterioration of sediment biogeochemical conditions. Deterioration in an already poor environment would certainly have negative consequences for the benthos although it is not possible to predict how close to azoia the sediments may have reached.

c) Rising sea surface temperatures from November to March are evident in the data from a Council monitoring site PLS-10 at the entrance to Waitata Bay (see figure below – the NZKS farm is marked as a yellow star) showed an increase in monthly temperatures from November 2014 to March 2015. Surface temperatures recorded ranged from 14.6°C on 20 November to 18.0°C on 18 March 2015. It should be noted that PLS-10 is in the main tidal channel which conveys cooler upwelled water, whereas the NZKS farm is in a less-well flushed and shallow bay, so temperatures are likely to be higher in the bay. NIWA verbally advised that satellite sea surface temperatures in February reached 20°C in the bay.

[8] ISQG = Interim Sediment Quality Guidelines. Australian and NZ Guidelines for Fresh and Marine Water Quality (ANZECC 2000) Ministry for the Environment. http://www.mfe.govt.nz/fresh-water/tools-and-guidelines/anzecc-2000-guidelines

[9] Elvines, D; Newcombe, E; Keeley, N; Taylor, D. 2014. Environmental Impacts of the Waihinau Bay Salmon Farm: Annual Monitoring 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No 2636.

d) Rising temperatures have been suggested by NZKS as a primary cause of another recent mass mortality event at the farm http://www.stuff.co.nz/marlborough-express/news/67314620/Millions-lost-after-warm-seas-kill-salmon. Dissolved oxygen levels recorded by Cawthron on 5 November 2014 at the Pen1a station (p13) show a decrease in dissolved oxygen from 7.7mg/L at the surface to 7mg/L at 13m depth. These dissolved oxygen levels would probably have dropped even lower as the sea warmed over summer.

i. Would it be reasonable to assume dissolved oxygen would have dropped below 6mg/L for long periods within the farm as sea temperatures rose?

At a salinity of 35 PSU, the solubility of oxygen falls from 10.17 mg/L at 14.6 degrees Celsius to 9.09 mg/L at 20.0 C. Thus if the farm had experienced 7 mg/L oxygen concentration at a certain depth in November when the water was at the lower of these temperatures, it would be reasonable to expect that dissolved oxygen concentrations of 6 mg/L would have been likely when the temperature was 20 C. Indeed, as increased temperature generally leads to increased respiration rates, it might be expected that a lower value would have been experienced.

e) A veterinarian report on the mass mortality event at the Forsyth Bay farm in 2013 observed that repeated drops in dissolved oxygen below 6mg/L was not ideal to fish health[10]. The report commented that elevated water temperatures are highly effective at displacing oxygen. Reduced dissolved oxygen levels were also hypothesised to be partly an effect of ichthyotoxic algal species bloom in the bay, which in combination with warmer temperatures were potential contributing causes to the mortality. Fish stocking levels would also be influential as dissolved oxygen levels are drawn down respiration during feeding,

In the face of critically low oxygen levels it would be prudent to reduce or even stop feeding to minimise stress on the animals. I know this to be common practice in the UK industry when faced with low oxygen for whatever reason. Perhaps this was done in this case – it would be interesting to know.

In addition to the benthic outgassing and low dissolved oxygen levels, feed discharge was approximately 240MT for the month of November (and likely maintained or increased over summer given the cohort age of the fish). The newspaper article referred to the dead fish being approximately two years of age. This is the second mass mortality in three years at Waihinau (2012 and 2015) and the third in four years in the outer Pelorus (the other at Forsyth in 2013). It suggests that the management of these two farms is askew and not in harmony with the environment. It is not a recent phenomenon either – anecdotal accounts indicate that there have been three mass mortality events at Waihinau alone in the past decade.

i. Would it be fair to say that these farms have not been managed within the carrying capacity of the local environment?

I think that would be fair. However, it may be that these sites are particularly susceptible to harmful blooms and so may always be at risk of mortality. On the other hand, it is correct that stressed animals faced with cumulative

[10] Johnston C. 2013. Fish health investigation – technical report. New Zealand King Salmon – Forsyth Bay. Brightwater Consulting Limited. September 2013.

insults are more likely to succumb to a new threat and so, in the interests of fish welfare, the farms should be managed within their carrying capacities to ensure a wholesome environment for the fish, particularly at times of high water temperature.

ii. Given this, would formal adoption (by a change in consent conditions) and implementation of the best practice guidelines prevent future outgassing and/or avoid or, at lease minimise, mass mortality events?

Adoption of the Guidelines would likely mean a large reduction in tonnage. If the reduced biomass of fish was spread over the same area as at present this would result in lower benthic impacts and lower stocking densities both of which would reduce the risk of mass mortality events.

3. **Monitoring Report for Otanerau Bay salmon farm 2014** [11]

Consent U040217 To extend the existing salmon and snapper farming structures (currently occupying 1.289 ha) to a total area of 2 ha within the existing permit area (10.0 ha) within the coastal marine zone. To discharge up to 4000 metric tonnes of salmon feed per annum.

For the other relevant conditions around Zone delineation and enrichment descriptions – these are the same as Forsyth Bay (see above)

a) The discharge of feed in 2014 was the lowest since 2001, with 1000 MT discharged between May-November. NZ King Salmon confirmed that all fish were harvested from the farm in December, and the site destocked over the summer. However, the ES score at one of the pen stations (Pen 2) was 5.7 (± 0.0? s.e.), with sediment chemistry at 5.9. This ES score would trigger fallowing of the site if the best practice guidelines were implemented. Over the last four years the pen site has had ES scores of 5.9 (2011), 6.1 (2012) and 4.8 (2013).

i. Is it a fair interpretation of the report that these ES scores reflect that there is little resilience in the seabed to sustained organic matter loading, and that this site continues to require careful management?

Yes, this is fair to say. I support the point made in the Cawthron Survey report (2633) conclusions regarding the consequence of the method of scaling back production. If left at the same density, the same peak impacts will be experienced, although over a smaller area. To reduce peak impacts, it is much better to occupy the same area but at a lower density, as I mention above.

b) Zinc levels were above the ISQG-Low or High (2 instances) levels of possible or probably biological effects (bio-available fraction). However, these are lower than the peak in 2013. No action is proposed at this stage, and the situation will be reviewed following the next round of monitoring in late 2015.

4. **Monitoring Report for Ruakaka Bay salmon farm 2012** [12]

Consent U021247 To continue the occupation of the seabed by marine farming structures in Ruakaka Bay authorised by MFL1, and previous resource consents U950656 and U980543 and to continue marine farming salmon and snapper in the area illustrated on the plan attached to the consent and confined to the area specified with the schedule with the schedule of New Zealand map grid co-ordinates outlined; and a coastal permit to discharge up to 3200 metric tonnes of salmon feed per annum to seawater.

For the other relevant conditions around Zone delineation and enrichment descriptions – these are the same as Forsyth Bay (see above)

a) The ES score at one of the pen stations (Pen 2) was 5.6 (±0.1 s.e.) with extremely elevated sulphides, very elevated organic matter and peak abundance of invertebrates. The monitoring report comments that "further deterioration of the [invertebrate] communities may occur over the coming [summer] months" (p18). This ES score would trigger a 40% feed reduction in annual feed discharge if the best practice guidelines were implemented.

[11] Elvines D; Newcombe E; Keeley N; Taylor D. 2014. Environmental Impacts of the Otanerau Bay Salmon Farm: Annual Monitoring 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No 2633.

[12] Elvines D; Newcombe E; Keeley N; Taylor D. 2014. Environmental Impacts of the Ruakaka Bay Salmon Farm: Annual Monitoring 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No 2634.

i. Is it a fair interpretation of the report that Pen 2 ES score reflects that there is little resilience in the seabed to sustained organic matter loading, and that this site requires careful management?

Yes. The Pen 2 station had sulphide values which were very high indeed. I agree that conditions would likely have deteriorated further as the water warmed in Summer/Autumn. Obviously this site will require careful future management to ensure that the seabed under the cages in the middle of this farm does not become more seriously degraded.

As I have previously said, it would be better if farms were monitored at the time when environmental conditions are likely at their worst (i.e. when water temperatures are highest) to ensure that quality standards are met, rather than to have to extrapolate.

b) Zinc levels were above the ISQG-Low levels of possible biological effects (bio-available fraction) at Pen 2. However, these levels are lower than the peak in 2013. No action is proposed at this stage, and the situation will be reviewed following the next round of monitoring in late 2015.

5. **Monitoring Report for Clay Point salmon farm 2012** [13]

Consent U060926 To establish up to 2 hectares of salmon farming structures (cages and barges), to install underwater lighting, to discharge up to 4000 tonnes (reduced from 6000 tonnes at hearing) of salmon feed per annum within marine farm licence 537 and associated discharge marine fouling from nets cages and other structures and from antifouled seal protection nets.

Condition 34. The discharge of feed shall meet the requirements of conditions 35-36 relating to Environmental Quality Standards (EQS) at all times. Any breach of these requirements shall, as soon as practicable and not later than two (2) working days after the consent holder discovers the breach, be notified to the Marlborough District Council.

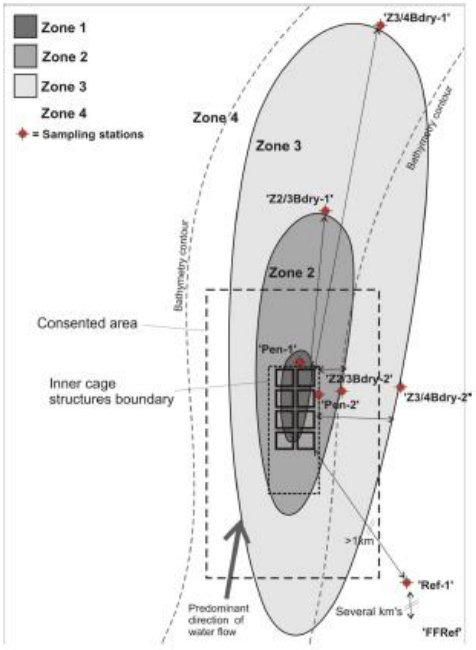
Condition 35. EQS Compliance Zones shall be defined for the farm, in accordance with Figure 1 (attached) and the dimensions and areas contained in Table 1.

Table 1: Maximum distances of EQS Compliance Zone 2/3 and Zone 3/4 boundaries from the nearest edge of the salmon farm net pens; and the maximum total areas of Zones 1, 2 and 3

EQS Compliance Zone Boundary Dimensions (maximum distances)		EQS Compliance Zone Area (Maximum area)
Distance from nearest net pen to Zone 2/3 boundary	Distance from nearest net pen to Zone 3/4 boundary	Total compliance zone area of Zones 1, 2 and 3
Metres (m)	Metres (m)	Hectares (ha)
90	300	31

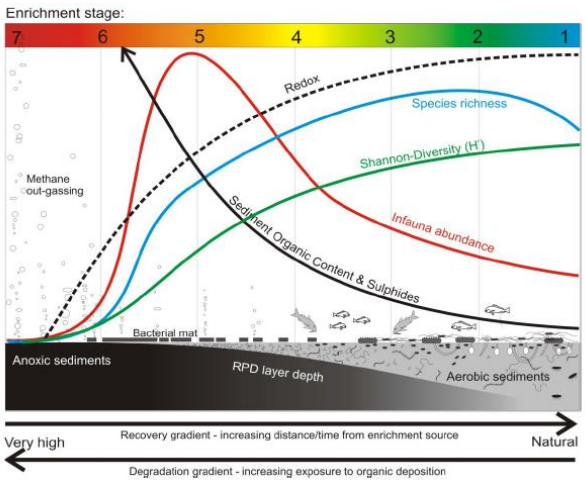
[13] Elvines D; Newcombe E; Keeley N; Taylor D. 2014. Environmental Impacts of the Clay Point Salmon Farm: Annual Monitoring 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No 2632.

Figure 1: Environmental Quality Standard (EQS) - Definition of EQS Compliance Zones



Note – Figure 1 is diagrammatic only

Figure 2: Schematic Diagram of Enrichment Stages



Condition 36. At all times, the seabed beneath and in the vicinity of the farm shall comply with the EQS specified in Table 2. Zone dimensions and area for compliance purposes shall be defined in accordance with condition 35. Enriched Stages (ES) shall be defined in accordance with Figure 2 (attached) and Table 3 (attached). For the avoidance of doubt, the ES shall be calculated for compliance with purposes as the mean of all sample replicates taken at a single sampling station (refer to Figure 1). Standard errors or confidence limits of the mean ES at each sampling station shall be reported in the monitoring report (refer to condition 41).

Table 2: Environmental Quality Standards (EQS)

Compliance Zone	Compliance Monitoring Location	EQS
Zones 1 & 2 – beside and beneath the net pens	Measured beneath the edge of the net pens	ES≤5.0 No more than on replicate core with no taxa (azoic) No obvious spontaneous out- gassing (H_2S/methane) Bacteria mat (*Beggiatoa)* coverage not greater than localized/patchy in distribution
Zone 3 – near to the net pens	Measured at the Zone 2/3 Boundary	ES≤ 4.0 Infauna abundance is not significantly higher than at corresponding "Pen" Station Number of taxa >75% of number at relevant/appropriate reference Station(s)
Zone 4 – outside the compliance zone area of Zones 1, 2, and 3	Measured at the Zone 3/4 Boundary	ES≤3.0. *

a) The ES score for the Zone 2-3 boundary (sample site 90m E) is 4.7 (± 0.1 s.e.) which exceeds the permitted ES of <4.0 (condition 36), and is therefore non-compliant. The physico-chemical and biological data characterised this sampling station as having: "redox negative (marginally), and sulphides strongly elevated. Total [species] abundance strongly elevated…taxa richness low."

Agreed.

b) It is worth noting that the best practice guidelines have not been implemented at this farm. The guidelines have a different, and simpler, zonal system compared to the three zone system at Clay Point. The guidelines have a Zone of Maximal Effect (ZME), equivalent to Zones 1 & 2 and an Outer Limit of Effect (OLE) which is equivalent to Zone 4.

c) The guidelines recognised the two key regulatory parameters are the intensity (ZME) and spatial extent (OLE) of effects. There was also a recognition by the group developing the guidelines that enrichment varies between Zones 2 and 4, and that there can be depositional hollows or 'pockets' which exceed the Zone 3 level. The benthic working group assessed that there can be enrichment levels recorded in these pockets which are not reflective of the wider pattern of enrichment (as in nature). The working group also thought that these were unlikely to be biologically significant unless ES scores were above 5.

i. Therefore, in considering the conditions at the 90m E site, how would you characterise the significance of local and wider biological effects from the non-compliant enrichment score at 90m E?

The 90E station at ES 4.7 nearly reaches the Zone 1/2 limit and clearly breaches the Zone 3 limit. If it is an isolated pocket, I do not see any great environmental risk. More importantly, the EQSs are met at the Zone 3-4 boundaries showing that the impact level is small to negligible at the 300m range.

PS there is a typo in Table 3 of report 2632 where the 90W station is said to be on the 3-4 boundary when it should be the 2-3 boundary.

NZKS have advised that they have engaged Cawthron to undertake further monitoring of the middle and outer zone. They indicate that results of that will inform the proposed management response. However, it would be preferable for the best practice guidelines to be adopted.

d) Zinc levels were above the ISQG-Low for Pen 2 for possible biological effects. This is the total recoverable and not the bio-available fraction which is likely to be below the threshold. Although the report notes that total recoverable Zinc levels are at the highest recorded levels, they are still comparatively low compared to the low flow sites. No action is proposed at this stage, and the situation will be reviewed following the next round of monitoring in late 2015.

6. Monitoring Report for Te Pangu Bay salmon farm 2012 [14]

Consent U090841 To increase the discharge from 4,000 tonnes (as authorised under previous consent U040813) to 6,000 tonnes of fish feed per year. Site No 8408.

Condition 22. The environmental quality standards (EQS) that shall be applied for seabed effects follow the model as presented in the application i.e. seabed effects are 'zoned' around the cages to allow for a mixing or transition zone. Outside this zone no adverse effect on the seabed is allowed. Three 'zones' under and around the marine farm shall be established as follows:

a) Referred to as 'Zone 2' - Beneath the cages and out to 50 metres from the cages.

b) Referred to as 'Zone 3' - From 50 metres to 200 metres from the outside edge of the cages.

c) Referred to as 'Zone 4' - Beyond 200 metres from the outside edge of the cages.

Condition 25. The EQS in each zone will be managed with reference to permitted 'impact stages', as depicted and defined in Figure 1. In relation to Figure 1, the effects within the zones specified in condition 22 will not exceed (i.e. be higher than) the following permitted impact stages.

Zone 2 shall not be more that the transition between stages IV and V.

Zone 3 shall not be more than the transition between stages III and IV.

Zone 4 shall not be more that the transition between stages I and II

Figure 1. Stylised diagram indicating how environmental variables change over an enrichment gradient in relation to impact stages I-VI.

[14] Elvines D; Newcombe E; Keeley N; Taylor D. 2014. Environmental Impacts of the Te Pangu Bay Salmon Farm: Annual Monitoring 2014. Prepared for New Zealand King Salmon Company Limited. Cawthron Institute Report No 2635.

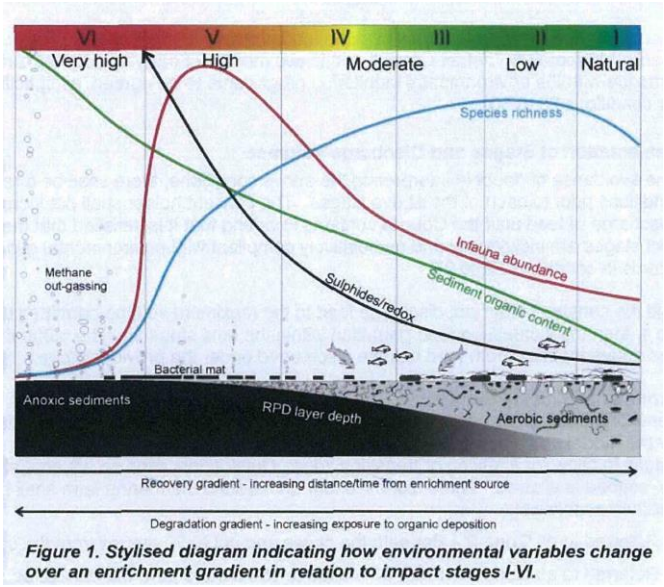


Figure 1. Stylised diagram indicating how environmental variables change over an enrichment gradient in relation to impact stages I-VI.

Note: This is an earlier version of the ES Model in the Methodology Paper

a) Benthic, water column and heavy metal monitoring results generally reflected that the site was being managed to the assimilative capacity of the environment. There was a relatively high enrichment score at the Zone 3-4 boundary of ES 3 (± 0.2 s.e.). This consent is up for renewal and an application is currently being considered. NZKS advise that: *Investigations undertaken as part of that process have confirmed the eddy is likely to have an impact on the depositional footprint*. The best practice guidelines are also proposed to be implemented at this site. In light of this, no further action seems warranted.

Steve Urlich
Council coastal scientist
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