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Dear Dan

ASSESSMENT OF ENVIRONMENTAL EFFECTS OF UNDERWATER LIGHTING FOR SALMON FARM RELOCATION SITES

The Marlborough District Council and central government are working with the salmon industry on options to implement the Best Management Practice Guidelines for Salmon Farming in the Marlborough Sounds. Options for meeting guidelines in future include the potential relocation of six farms currently positioned in sites not ideally suited to modern salmon farming to more environmentally appropriate locations (see Figure 1 appended). Nine potentially suitable sites have been identified and these now require an Assessment of Environmental Effects (AEE) to determine if they are suitable. The Ministry for Primary Industries (under a Heads of Agreement with New Zealand King Salmon Company Limited) has contracted the Cawthron Institute to undertake the underwater lighting component of the AEEs.

An initial stage in this process was a gap analysis of the existing information regarding the potential farm relocations. This gap analysis was undertaken by MWH (NZ) Ltd 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 effort or 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 the effects of underwater lighting associated with the relocation proposal, the gap analysis recommended that all that was required was a minor update or addendum letter confirming the previous conclusions, and whether or not the information and/or recommendations remain relevant. This letter addresses these aspects.

The purpose of this letter is to assess the potential ecological effects of underwater lighting for the potential relocation of the farms; it summarises and builds on a number of previous assessments, including an AEE completed as part of the New Zealand King Salmon EPA Board of Inquiry process for expansion of salmon farming in the Sounds.

I have carried out three previous assessments of effects for underwater lighting at two salmon farm locations, Clay Point and Te Pangu in Tory Channel, Queen Charlotte Sound. These assessments have involved site surveys, the results of which are provided in the following reports:

- Effects on artificial lighting on the marine farm environment at Clay Point and Te Pangu Salmon Farms (Cawthron Report 1851, October 2010)
- New Zealand King Salmon Company Limited: assessment of environmental effects – submerged artificial lighting (Cawthron Report 1982, August 2011)
- Effects of artificial lighting on the marine environment at the Te Pangu Bay salmon farm (Cawthron Report 2374, July 2013).

Information from these assessments contributed to my evidence on the effects of underwater lighting for the EPA Board of Inquiry hearing in 2012 for the New Zealand King Salmon application for new farm sites. Most recently I provided a letter to inform the underwater lighting consent at the New Zealand King Salmon farm located in Otanerau Bay, East Bay, Queen Charlotte Sound (Cawthron Advice Letter 0026 dated 18 January 2016). As part of the preparation of this letter, I have also reviewed the wider literature and to my knowledge, can confirm no significant new findings have emerged with regard to the effects of underwater lighting since my most recent assessment.

New Zealand King Salmon currently has underwater lighting in place at a number of their farms, where it is used during the shorter daylight months of April through October to reduce the risk of early maturation of fish prior to harvest.

The potential ecological effects of artificial underwater lighting include the following:

- Phototaxic organisms such as zooplankton and larval fish may be attracted to the lights and accumulate near and/or within the farm structures.
- Vertical migration in the water column by some phytoplankton and zooplankton species may be influenced by light (moving towards or avoiding it). There may also be enhanced settlement of organisms attracted by the light onto the seabed near farm structures.
- Baitfish may be attracted to the lights and aggregate near and/or within illuminated cages. Visibility of prey during night-time hours will increase. Increased aggregation and visibility of prey could in turn increase rates of predation by the farmed salmon as well as fish and marine mammals (e.g. seals) outside the cages.
- Submerged artificial lighting influences the depth distribution of salmon. Increased densities of salmon at a given depth could increase risk of parasitism.
- Birds flying overhead may be attracted to the lights and as a result could collide or become entangled within the farm structures.

My previous assessments concluded that the *effects of submerged artificial lighting on the surrounding marine environment are small and likely to be highly localised, both in terms of the physical effects on the underwater light environment and subsequent biological and ecological (e.g. food web) effects.* More specifically, the surveys carried out at Clay Point and Te Pangu farms in Tory Channel revealed no measureable effect on larval fish. Any potential effects on zooplankton were likely overshadowed by factors other than light, such as the high tidal currents and the time of night. I also did not observe any adverse effect on animals such as seabirds and seals, which were seen in relatively low numbers and often found resting around both illuminated and dark pens. Observations during the surveys indicated some organisms such as baitfish and squid enter the pens, perhaps initially due to light attraction, and apparently become trapped over time once they become too large to exit the pens. The level of predation on these organisms will be limited due to the fact that the salmon are fed an artificial diet and any organisms trapped within the pens will be released during harvest (New Zealand King Salmon, pers. comm.).

An important consideration is that each farm represents a very small surface area and total water volume compared to the surrounding water body. The physical 'footprint' of the artificial lights on the farms is primarily confined to the net pens and mid-water depths; hence organisms along the bottom or further than about 10–20 m from the structures are unlikely to be affected. The extent to which light 'spills' outside the pens is further minimised due to the central location of the lighting in the pens, and the presence of both the pen nets and the surrounding predator netting that works to shade the lighting (see Figure 2 appended).

I extend the general conclusion above to the relocation of farms from low-flow areas to new locations that are exposed to high currents. The effects of underwater lighting will likely vary between their present and future locations. For instance, in their present location, higher concentrations of some zooplankton species within an illuminated pen compared to a dark pen may be observed as the water has less movement and organisms are able to maintain their position for a longer period of time. If farms are relocated to areas with higher currents, the effects of lighting on the farms will be similar to those summarised above for the Clay Point and Te Pangu farms. Observations during surveys at these farms indicated the effects of underwater lighting on attracting and concentrating organisms within the pens were likely mitigated by high current speeds. In other words, small organisms such as zooplankton will have difficulty maintaining their position near lights during flooding / ebbing tides. Therefore the level of impact is likely to be very small and limited to enhanced attraction and aggregation of some organisms, such as baitfish, during night hours within the pens.

Additional considerations to those outlined above relate to biosecurity and the possibility of enhanced risk of disease transmission and spread due to underwater lighting. Because some wild fish species may be attracted to lighting, there may be an increased risk of exposure to, transmission and spread of diseases from farmed salmon to wild fish within and around illuminated pens compared to unlit pens. Any level of increased risk due to underwater lighting is likely to be very low and difficult to delineate from the existing risk associated with increased densities of wild fish known to occur around salmon pens as a consequence of factors such as lost feed (see for example Dempster et al. 2009[1]). As indicated in the September 2016 report by Dr Ben Diggles, the placement of farms in high-flow environments (combined with biosecurity management best practices) will mitigate risk factors for the emergence of infectious diseases like NZ-RLO.

[1] Dempster T, I Uglem, P Sanchez-Jarez, D Fernandez-Jover, J Bayle-Sempere, R Nilsen, P Bjorn. 2009. Coastal salmon farms attract large and persistent aggregations of wild fish: an ecosystem effect. Marine Ecology Progress Series. 385:1-14.

Some species of phototaxic zooplankton can be fish parasites, such as some copepod species commonly known as sea lice. Although sea lice have not been observed to affect Chinook salmon in New Zealand, the use of artificial underwater lighting adds risk (albeit low) to host switching for sea lice and infection of the non-native salmon (see report by Ben Diggles, Sept 2016). If farmed salmon were to become a new host, they in turn would present a moderate risk to spreading infections to wild fish. I consider the added risk of artificial lighting on host switching and initial infection of the farmed salmon by sea lice to be low due to: (a) the factors outlined above that minimise effects on zooplankton (i.e. the surrounding currents will play a larger role in driving zooplankton distribution than artificial lighting), (b) an apparent low susceptibility of Chinook salmon to sea lice, and (c) the absence of observed occurrences of sea lice associated with farmed Chinook salmon in New Zealand. The last includes a number of years with underwater lighting at some farms such as Te Pangu and Clay Point.

In my opinion, the low risk and potential for ecological effects does not warrant ongoing monitoring once farms are in place and lighting is implemented. Farm operators are best placed to observe changes around the farm that may be related to underwater lighting: for example, changes in fish health (e.g. any signs of sea lice, feeding) or changes in marine mammal and seabird interactions with the farm. For some of their farm consents, New Zealand King Salmon have volunteered to place a condition to carry out periodic surveys during the first year that lights are operational. As an example, farm operators are to carry out a total of four 2-week long periods of nightly surveys at the Ngamahau farm in Tory Channel during the months that lights are operational (April to October). Figure 3 (appended) shows an example of the information gathered during one of these surveys. Although simple and high level, the surveys assist in identifying potential effects beyond those that could be captured during a one-off survey. For example, are seabirds becoming more abundant over time at farms with lighting in place? Observations at the Ngamahau farm thus far are very similar to those that I made during my visits to the Clay Point and Te Pangu farms.

As recommended in my EPA evidence, it is most important that New Zealand King Salmon ensure lighting is not over-powered and is centralised within the pens as much as possible to minimise spillage of light beyond the structures. It is my understanding that the lighting technology used by New Zealand King Salmon has further advanced since my assessments, and the power and type of light used has been further maximised for efficiency and results in more targeted lighting and less spillage. This will help further minimise any potential for adverse ecological effects.

Please contact me if further clarification or discussion is required with regard to the potential effects of underwater lighting associated with the New Zealand King Salmon farms.

Yours sincerely,

Scientist

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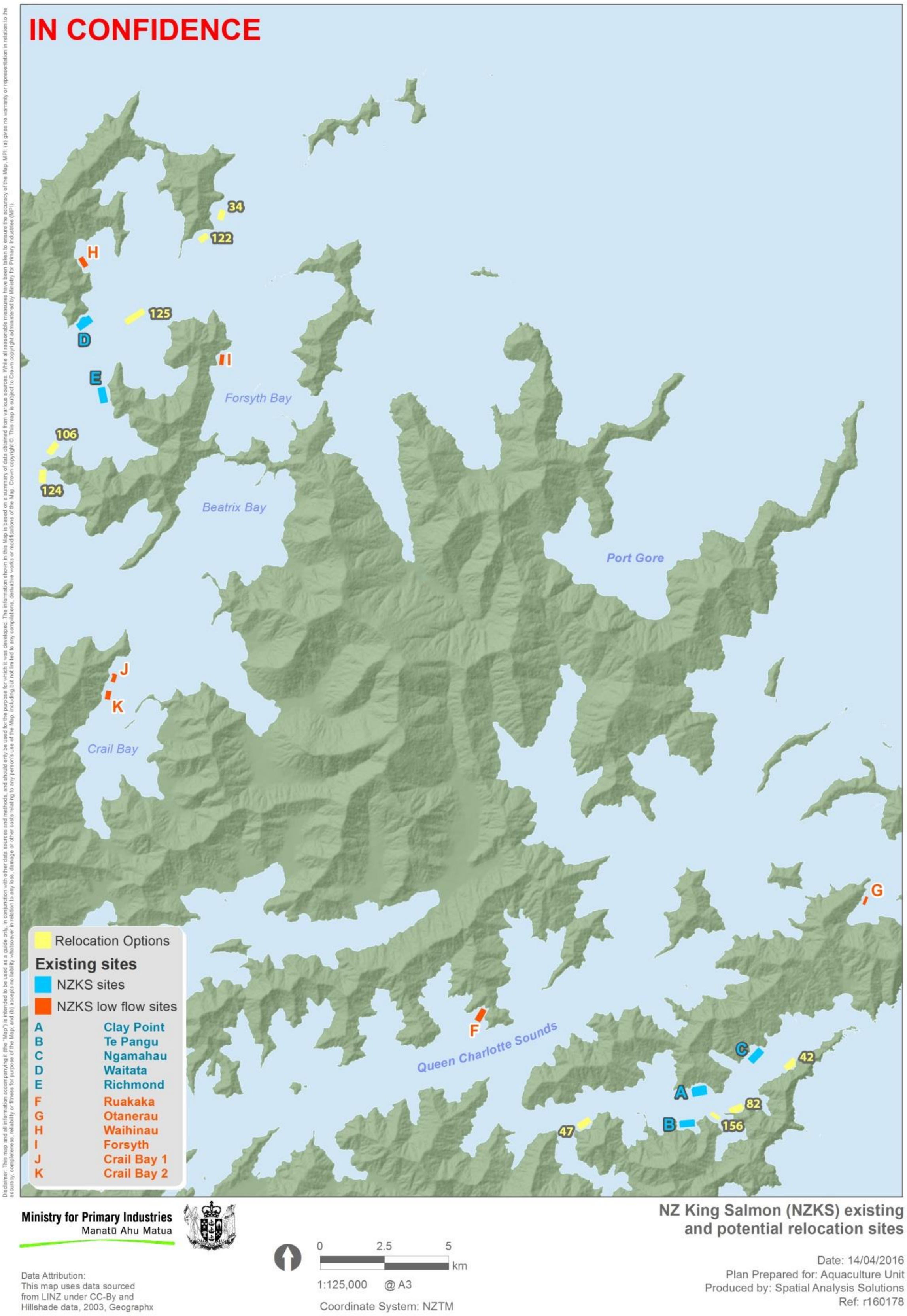

Figure 1. Map of NZ King Salmon existing and potential relocation sites.

A

B

C

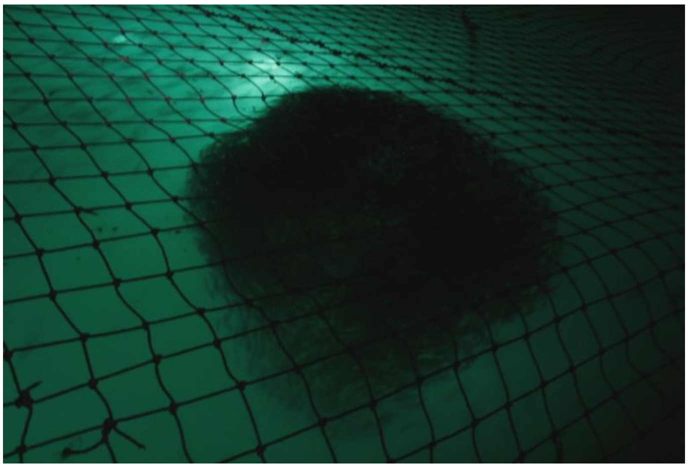

Figure 2. Photograph of the illuminated cages taken from the second floor of the support building at the Clay Point salmon farm during my first visit in September 2010 (A), a photograph taken from a boat located ~10 m away from the edge of an illuminated pen during my second visit in March

2012 (B) and a photo above a pen showing a dense aggregation of baitfish near the surface (C).

Datasheet prepared by Cawthron Institute, 12 April 2016

DATASHEET FOR UNDERWATER LIGHTING OBSERVATIONS

Date: 20 April 2016	Farm: Ngamahau
Time: 1900	Staff member: Aaron Phillips
Conditions: Clear S 0-5K moon 90% increasing	
Tide stage and sea state: calm sea, Neap tide increasing .3m	
Notes on farm operations: (e.g. lighting engaged in all pens?) Lights operational in 1 pen, last feeding at 17:45 Tow pen present.	

OBSERVATIONS

Seabirds

Species / type	No.	Behaviours	Location(s)	Comments
Red-billed gull	8	Resting	On tow pen farm structures	No evidence of birds feeding Birds resting on unlit pens.

Seals

Species / type	No.	Behaviours	Location(s)	Comments
Fur seal	7	6 swimming outside of farm 1 resting on tow cage walkway	around tow cage	No evidence of chasing prey

Dolphins

Species / type	No.	Behaviours	Location(s)	Comments
None observed				

Fish (other than salmon)

Species / type	No.	Behaviours	Location(s)	Comments
garfish	8	Swimming near surface in pens	In illuminated pens	
Baitfish	<200	Schooling and swimming inside pen	In illuminated pens	
Spiny dogfish	10	Swimming in pen near surface	In illuminated pens	

Other observations:

Figure 3. Example datasheet filled out by a NZ King Salmon staff member at the Ngamahau farm.