Salmon Aquaculture Environmental Monitoring Data Report

Results of Sampling Program for Year 2003

by

Cindy Wright[1], Bernie Taekema[2], Brenda Burd[1], and Eric McGreer[2]

[1]Ecostat Research Ltd.
1040 Clayton Rd., RR #1
Sidney, BC
V8L 5P6

[2]Ministry of Environment
Environmental Protection Division,
Environmental Quality Section
2080A Labieux Road
Nanaimo, BC
V9T 6J9

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Executive Summary

This data report contains salmon aquaculture farm site monitoring data collected by the B.C. Ministry of Environment (formerly Ministry of Water, Land and Air Protection) from their audit of the fish farm industry undertaken from April to September, 2003. The sampling program was initiated at the direction of the Regional Waste Manager, Vancouver Island Region to assess compliance with the performance-based *Finfish Aquaculture Waste Control Regulation* that was proclaimed on September 12, 2002. Objectives, instructions and protocols for this program can be found in the ***Protocols for Marine Environmental Monitoring*** document dated September 5, 2002 http://www.env.gov.bc.ca/epd/epdpa/industrial_waste/agriculture/aqua_home.htm.

A total of 13 farms were sampled in 2003. Of these, 4 farms were sampled for benthic invertebrates. In general, the sampling gradient included 30 m stations, 1-2 Reference Stations and 1-3 Tenure Edge stations. A few farms were sampled near the edge of the net pen array. Table 1 summarizes sediment geochemistry measurements and basic biology factors measured.

All sites had measurements of free sulphides as well as redox measurements. The inclusion of both types of measurement tended to best predict biotic effects. Biotic and geochemical effects were noted at varying distances from the farm. Table 1 summarizes sediment geochemistry measurements and basic biology. Substrates were primarily silt or silty sand, with a few sites containing some gravel, wood debris or terrigenous material, shell debris and rock/cobble. The presence of wood fibre debris was a confounding factor. If thick enough, this could cause redox decline and biotic compromise outside the influence of the farm wastes.

Table 1 shows that mild to strong anoxia (redox value <0) was found at 8 of the 13 farms at varying distances, with strong anoxia evident at three farm sites. Sulphide levels at or below what might be considered background levels (determined as <250 to 350 µM) occurred at 5 sites, with moderate levels (>500 to 1000 µM) noted at 4 sites and high levels (>1000 to 1700 uM) noted at 4 sites. Levels for total volatile solids (TVS) were found to be less informative indicators of organic accumulation than redox or sulphide measurements, but tended to correlate with the two. Of note is that anoxia and sulphide levels were very high at all stations for Jane Bay, except Reference station 3 (presumably outside the area). This is suggestive of some strong confounding influence, such as wood fibre beds from log-handling or booming, or a natural depositional area with very little flushing.)

In a number of farm locations, sediment geochemistry (redox and free sulphides) appeared to be within a range expected to support “normal” benthic communities. However, a number of near-field samples, particularly within 30 m of the edge of net pens, had redox levels below zero (suggesting anoxic sediments or patches) and/or sulphide levels well above background levels (<250 to 350 µM) for natural sediments which do not experience any unusual enrichment sources. Those sample locations which had an impoverished biota also tended to have unusual sediment geochemical conditions, suggesting a cause/effect relationship.

However, there are a few exceptions to this pattern. The samples with redox values below 0 did not always have an impoverished biota. Such conditions can occur frequently in natural

sediments where there is limited bottom current and/or natural organic deposition. Under fish farms, negative redox values may occur only in the near-surface layer where rapid organic deposition is occurring. Thus, the sub-surface sediments may be oxygenated and allow reasonable biotic growth. However this condition is expected to be uncommon. More likely, spatial and temporal patchiness of fish farm depositions make on-the-spot redox measurements highly variable. Thus, there may be patches of anoxia with are not extensive enough to inhibit biological growth, but may cause variability in geochemical sampling results.

Other exceptions to the common pattern can be seen in the sulphide measurements. In addition, high sulphide levels in the data did not necessarily coincide with negative redox levels measured in sediments. The production of hydrogen sulphide by bacteria such as *Beggiatoa* spp. is dependent upon the presence of low levels of oxygen as well as elemental sulfur. Thus the oxic/anoxic interface may be sub-surface, so that a surface redox sample may be positive, with high sulphide production below the surface allowing diffusion of hydrogen sulphide into the near-surface layer. Such conditions are ideal for the proliferation of opportunists such as *Capitella capitata* complex, or where sulphide is more moderate, a more functionally diverse assemblage which is physiologically adapted to tolerate the sulfidic conditions. In addition, patchiness of sampling probe deployment may also cause highly variable results in sediment geochemistry samples.

In cases where sulphide levels were high and redox levels below zero, some biotic compromise is expected. There was no indication of biotic compromise at 2 of the 4 farm sites sampled for biota which did not experience anoxia or elevated sulphides. The presence of a high proportion of *C. capitata complex* was evident at only 1 farm (Saranac), and moderate at a second farm (Sir Edmund Bay) of the 4 farm sites. Species richness values were within reasonable levels for all samples (mean taxa >20). One TE location for Jervis Cove and a 30 m site for Saranac has mean taxa numbers somewhat reduced other sites related to the farms. A notably low value for species richness was evident for one 30 m station at Sir Edmund Bay. Both Saranac and Sir Edmund Bay farms experienced moderate anoxia and sulphide levels at the most affected station (30 m) described above. The biotic diversity indices (Shannon-Weiner and Simpson's 1-D) tended to follow the pattern of species richness.

The sediment particulate copper levels tended to be below the provincial guidelines (PEL = 108 μg/g copper) for all but 3 farm sites (Midsummer, Shelter, Sir Edmund Bay), where it was just over the limit. Zinc was near or over the provincial guidelines (PEL = 271 ug/g) at 5 of the 13 farm sites where it was sampled (Centre Cove, Jervis, Power, Sir Edmund Bay and Young's Pass). Of note is that zinc levels were extreme at 10-30 NE for Sir Edmund Bay, and at the edge of net cages at Power Bay and Jervis Cove.

Table 1. Summary of farm site characteristics for 2003.

Farm Site	Anoxia	sulphides	substrate	*Capitella capitata*	Species Richness	Zinc/Copper
Arrow Passage	Mod 0 m, mild 30 m E	Ext 0 m	Mud to sand	n/a	n/a	Below guidelines
Bell Island	None	Low	Sand	Low	High	Below guidelines
Centre Cove	mod 0-30m SE, mild 30 m -TE NW	Ext 0-30 m SE	Sandy mud	n/a	n/a	Zn >guidelines 0-30 m SE, 30 m-TE NW; Cu>guidelines 0 m SE, 30 m NW
Jane Bay	Ext all but R3	Ext all but R3	mud	n/a	n/a	Zn>guidelines TE; Cu below guidelines
Jervis Cove	None	Low	Muddy sand/gravel	Low 30 m NW	Mod TE NW	Zn>guidelines 0-30 m; Cu below guidelines
Midsummer Isl.	Mild TE-E	Mod-low 0-30 m	Sand/gravel	n/a	n/a	Cu>guidelines 30 m W
Penny Creek	None	Mild 30 m SE	Muddy sand	n/a	n/a	Below guidelines
Power Bay	None	Low	Muddy sand	n/a	n/a	Below guidelines
Ross Passage	None	Low	Mud/sand/gravel	n/a	n/a	Below guidelines
Saranac	Mod 30 m W	Mod 30 m-TE W	Sand	High 30 m W	Mod 30 m W	Below guidelines
Shelter Passage	None	Low	Sand	n/a	n/a	Cu>guidelines 0
Sir Edmund Bay	Ext -10 m, mod 30 m -TE NE	Ext 0 m NE, mod 30 m NE	Muddy sand	Mod 30 m NE	Low 30 m NE	Zn>guidelines 10-30 m N; Cu>guidelines 10 m NE
Young Passage	Mod 0 m NW	Mod 0 m NW	Sand	n/a	n/a	Zn>guidelines 0 m NW; Cu below guidelines

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