Salmon Aquaculture Environmental Monitoring Data Report

Results of Sampling Program for Year 2001

by

Cindy Wright[1], Bernie Taekema[2], Brenda Burd[1], James Dalby, Jr[3]., 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

[3]Ministry of Agriculture & Lands
Aquaculture Development Branch
1st Floor, 808 Douglas Street
Victoria, BC
V8W 2Z7

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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) to provide the necessary background scientific data to support the development of a new fish farm waste control regulation. The data were collected June through September, 2001. One of the recommendations of the provincial Salmon Aquaculture Review (SAR, 1997) was the development of a performance-based waste management regulation to protect the marine environment. The sampling program undertaken by the ministry and the B.C. aquaculture industry was initiated at the direction of the Regional Waste Manager, Vancouver Island Region. Objectives, instructions and protocols for this program can be found in the ***Aquaculture Information Request and Interim Monitoring Program*** document dated May 29.

A total of 11 farms were sampled in 2001. Of these, 10 farms were sampled for benthic invertebrates. In general, the sampling gradient included 0, 30, 100 m distant and two reference sites. Table 1 summarizes sediment geochemistry measurements and basic biology factors measured.

All sites had measurements of free sulfides 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. 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 10 of the 11 farms at varying distances, with strong anoxia evident at five farm sites. Sulfide levels at or below what might be considered low levels (determined to be > ~250-350 μM) occurred at 2 sites, with moderate levels (~500-1000 μM) noted at 9 sites and high levels (>1000 to 1700 uM) noted at 6 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.

In a number of farm locations, sediment geochemistry (redox and free sulfides) 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 sulfide 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 sulfide measurements. In addition, high sulphide levels in the data did not necessarily coincide with negative redox levels measured in sediments. The production of hydrogen sulfide 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 sulfide production below the surface allowing diffusion of hydrogen sulfide into the near-surface layer. Such conditions are ideal for the proliferation of opportunists such as *Capitella capitata* complex, or where sulfide 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.

Indian Bay was unusual, in that species richness and abundance was low at all stations, including the reference. Sediment sulphides and anoxia were only moderate or low at the stations with biological samples, suggesting some natural or confounding influence affecting faunal composition.

The biotic diversity indices (Shannon-Weiner) tended to follow the pattern of species richness in extreme cases, but were indiscriminate where more subtle biotic effects were evident.

The sediment particulate copper levels tended to be below the provincial guidelines (PEL = 108 µg/g copper) for all but 1 farm site, where it was near the limit. Zinc was near or over the provincial guidelines (PEL = 271 µg/g) at only 2 of the 10 farm sites where it was sampled.

Table 1. Summary of farm site characteristics for 2001.

Farm Site	Anoxia	sulfides	substrate	*Capitella capitata*	Species Richness	zinc/copper
Arrow Passage	Mod-strong 0 m, slight 100 m	High 0 m, mod 30 m	Silty sand	No	Normal	Below PEL
Bedwell Sound	Mod 0-100 m	Mod 0-30 m, High 100 m	Sandy silt	High 0 m	Low 0 m	Below PEL
Cecil Island	Mild 0-30 m	Mod 0 m	Sand	Mod 30-100 m	Normal	n/s
Centre Cove	Severe 0-100 m SE	Severe 0-100 m	Sandy silt	No	Low 0-100 m	Zn>PEL 0-100 m SE, Cu @PEL 0 m SE
Cyrus Rocks	Mod 0-30, mild 100 m	Mild-mod 0-30 m	Sandy	Some 30 m	Mod 30 m	Below PEL
Deep Harbour	Extreme 0 m T2	Mild 0 m T1, T2	Silt	n/s	n/s	Below PEL
Indian Bay	Mod 0-100 m	Mod 0, 30 m low 100 m	Sandy silt	High 30 m	Low all stations	Below PEL
Midsummer Island	Mod 0,100 m high 30 m	High 0-30 m, mod 100 m	Sand	High 0 m, mod 30 m	Low 30 m mod 100 m	Below PEL
Shaw Point	High 0-100 m mod R1	High 0-100 m	Mud, esp. R1	High 30 m	Low 30 m mod 100 m	Zn>PEL 30 m, Cu below PEL
Upper Retreat	Mod 0 m, high 30-10 0m	High 0, 30 m mod 100 m	Silty sand	Mod 30 m	Low 30 m	Below PEL
Westside	None	Low 0-100 m	Silt	No	Mod 30 m	Below PEL