Friends of Port Mouton Bay
August 2011

Trace Metals in Sediments of Port Mouton Bay - 2009-2010

Summary

A study of sediments in Port Mouton Bay began in October 2009 and was repeated in October 2010. Trace metals have been used as tracers of salmon farm waste in the sediments of coastal waters of southwest New Brunswick and the Broughton Archipelago of British Columbia to qualitatively predict where farm wastes have been deposited in the sediments and the relative depositions at different sites in the same area (Yeats et al., 2005).

In October 2009, 3 months after cessation of fish feeding at the Spectacle Island farm site and after a previous year of stocking at reduced capacity, levels of copper and zinc were highest in sediments within the farm lease site (and above the CCME Sediment Quality Guideline for copper) and elevated at distances 400-2000 m from the farm site relative to levels at a more distant point near Port Mouton Island.

In October 2010, after 15 months of fallowing at the farm site this pattern continues. Levels of copper in sediments were very similar to levels detected in 2009 except for higher levels at 2 of the 3 stations within the farm lease site and at one of the far-field stations. Generally higher Li values suggest migration of finer sediments to the far-field.

A far-field footprint of trace metal enrichment from the salmon farm is indicated in the Li-normalized Cu and Zn data. Based on these results, further accumulation of copper in Port Mouton Bay is unacceptable.

Introduction

A study of sediments in Port Mouton Bay was begun in October 2009 by a team led by Dr. Jon Grant of Dalhousie University's Department of Oceanography. Friends of Port Mouton Bay (FPMB) facilitated the field surveys with the cooperation of Cooke Aquaculture.

Methodology

A grid of 40 stations (Figure 1) encompassed sand, gravel and mud bottom and included the site of a salmon farm near Spectacle Island which had operated continuously for 15 years. The farm site was operating at reduced capacity during 2009 and feeding of fish stopped on July 20, 2009.

Grab samples of sediment were retained at 29 stations on October 7, 2009 and a further 11 stations on November 7-8, 2009 (Figure 1). Sediment cores using the 'Hargrave' wedge corer were photographed at each station on November 7-8. The Dalhousie University Oceanography laboratory analyses include organic matter, grain size, infaunal taxonomy, and interpretation of sediment profile images.

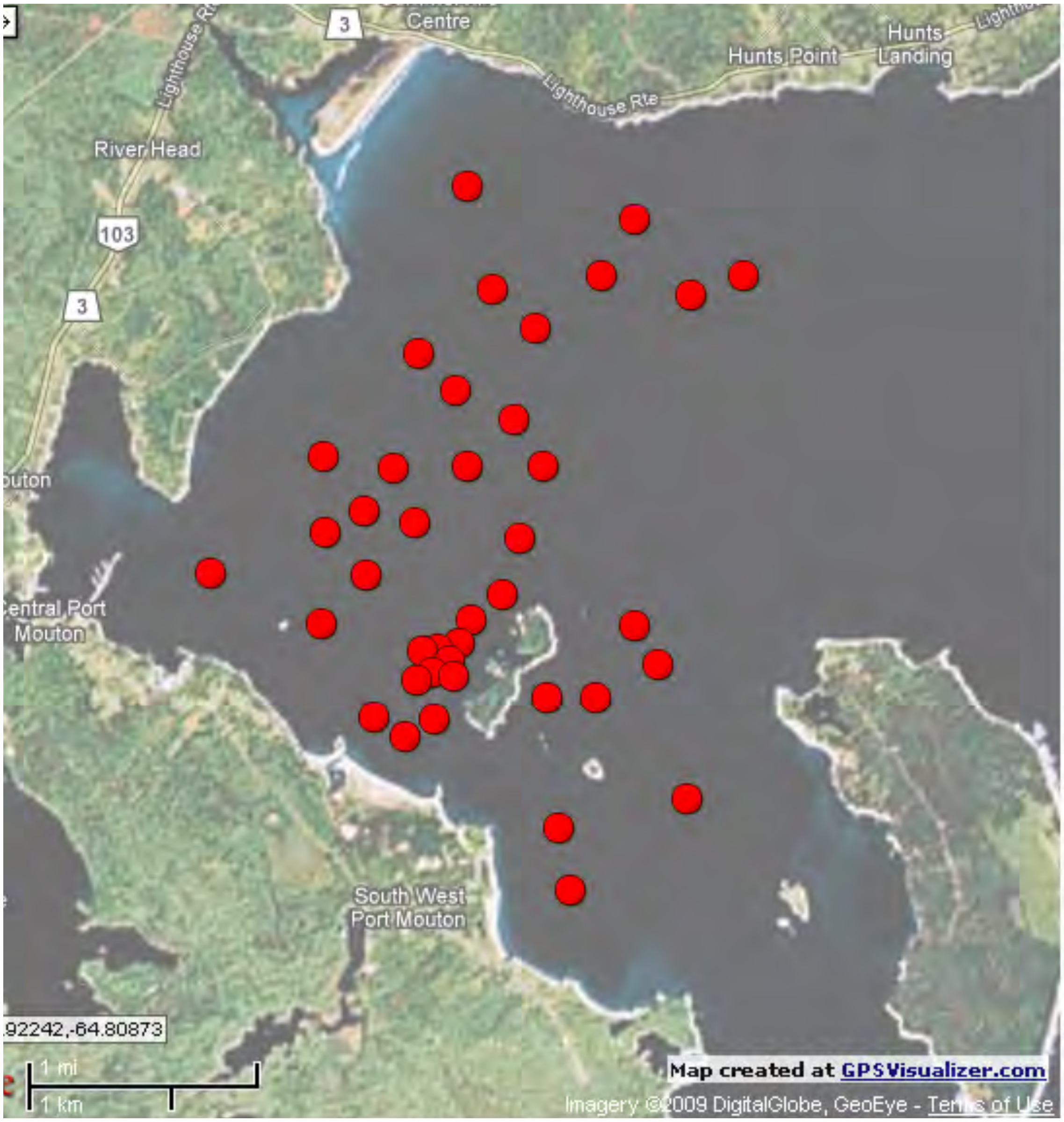


Figure 1. Chart showing the grid of stations sampled for sediments in Port Mouton Bay, October-November, 2009

23 stations were re-visited on October 14, 2010 and sediment samples were subjected to the above analyses with the addition of sulphide/redox and porosity.

FPMB undertook requisition of trace metal analysis in 2009 for samples of sediment from 10 stations selected to include locations of fine sediment mud and elevated levels of organic matter (Figure 2). Two stations – 28 and 43 are most distant from the farm site, exhibited low levels of organic matter (2%) and possibly represent background levels. Stations 20, 21 and 23 were within the farm lease site. Station 14 is ~400 m N of the farm site. Station 24 is ~ 500 m SSW of the farm site, Station 44 is near Carter's Beach ~ 500m SW of the farm site, and Station 34 is ~2000 m SSE of the farm site. Trace metal analysis was repeated in 2010 for 9 stations. Station 44 was omitted.

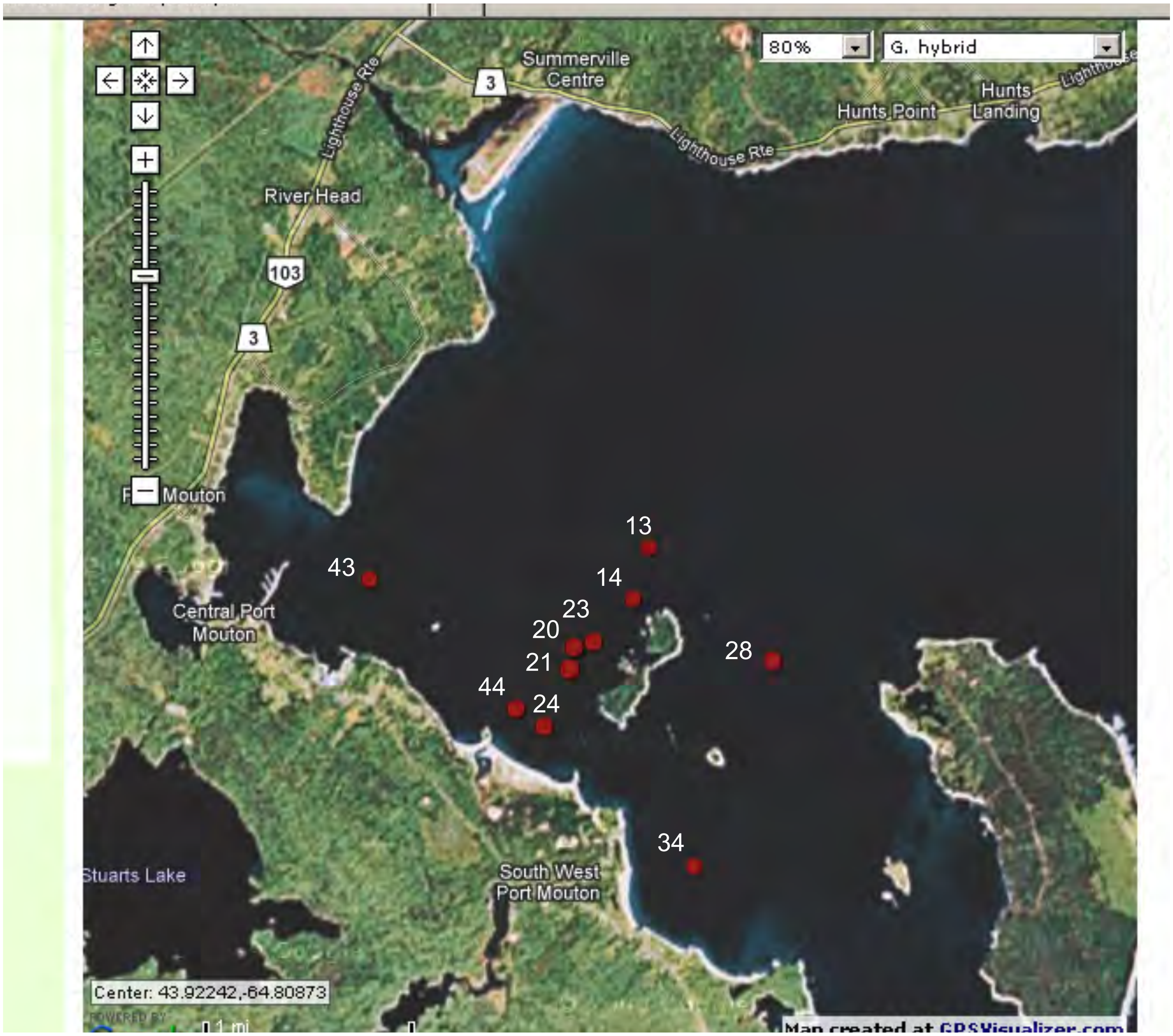


Figure 2. Chart showing the stations analyzed for Lithium and concentrations from Table 1.

The top 2 cm of the grab samples were analyzed for copper (Cu), zinc (Zn), lithium (Li), and tin (Sn) in 2009 and for Cu and Li in 2010 at the Resource Productivity Council lab in Fredericton, New Brunswick. Samples were air-dried and sieved at 2 mm, portions were digested with nitric and hydrofluoric acids and the resulting solutions were analyzed for trace elements using ICP-MS procedures.

Results

The results are shown in Table 1 below and in Figures 3 and 4.

Table 1. Concentrations of zinc, copper, lithium and tin (mg/kg) sampled in Port Mouton Bay sediments, October, 2009 and 2010

Station #	Copper (mg/kg) 2009 2010	Zinc (mg/kg) 2009	Lithium (mg/kg) 2009 2010	Tin (mg/kg) 2009
13	12 12	39	18.7 30.0	1.8
13 (Lab Duplicate)	12 12	39	19.0 30.0	1.8
14	15 16	44	19.4 34.6	2.1
20	26 38	64	24.4 36.0	2.1
21	28 20	64	24.6 36.9	2.5
23	32 35	82	23.7 35.7	2.3
24	17 16	28	23.2 39.1	2.4
28	7 6	27	20.9 25.1	1.4
34	15 15	45	20.4 37.2	2.3
43	8 13	28	19.8 31.9	1.3
44	**16** **-**	**48**	**23.8** **-**	**2.4**

Figure 3. Chart showing the stations analyzed for Copper with relative concentrations from Table 1; 2009 (left), 2010 (right).

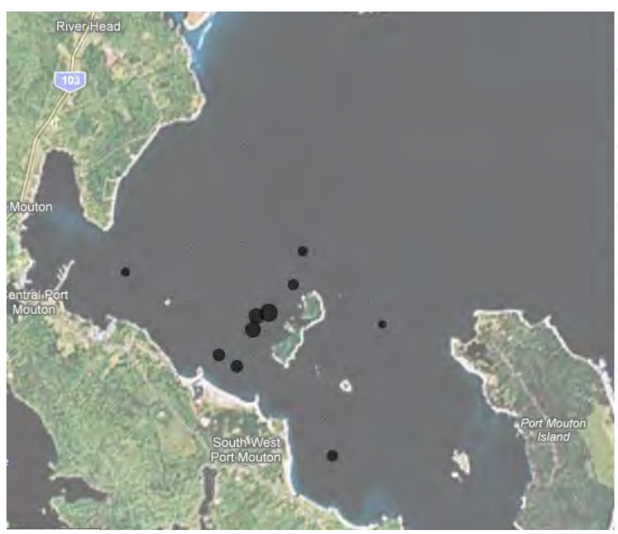


Figure 4. Chart showing the stations analyzed for Zinc with relative concentrations from Table 1.

The natural variability of Cu and Zn concentrations in sediments is largely related to grain size and mineralogy of the sediments (Yeats et al. 2005). Li data were used in this study to provide normalization for grain size and mineralogical differences in Port Mouton Bay sediments.

Results in Table 1 for Cu show 7-8 mg/kg in 2009 for the two stations most distant from the farm site; 6 mg/kg in 2010 at the most distant station near Port Mouton Island and a greater than 50% increase to 13 mg/kg in 2010 at the other distant station in the inner harbour; highest levels of 26-32 mg/kg in 2009 and 20-38 mg/kg in 2010 on the lease site; elevated levels of 12-17 mg/kg at points 400 – 2000m distant from the farm site in both 2009 and 2010. 2009 copper data are contrasted with 2010 data in Figure 3. The Canadian Council of Ministers of the Environment (CCME) Interim Sediment Quality Guideline (ISQG) for Cu in marine environments is 18.7 mg/kg.

The results for Zn in 2009 show 27-28 mg/kg at most distant stations; highest levels of 64-82 mg/kg on the lease site and elevated levels of 39-48 mg/kg at points 400 – 2000 m distant from the farm site (Figure 4). Zn and Sn were not measured in 2010. The CCME Interim Sediment Quality Guideline (ISQG) for Zn in marine environments is 124 mg/kg.

In 2010, Li levels are higher than 2009 levels by as much as 50% at all stations except the most distant station (#28) near Port Mouton Island (Table 1)

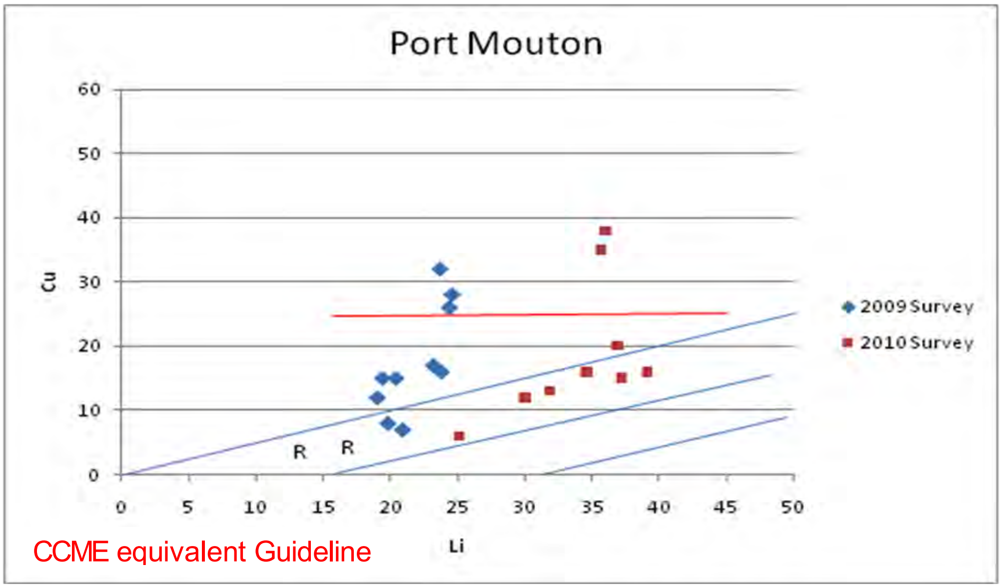
The Canadian Council of Ministers of the Environment (CCME) Interim Sediment Quality Guidelines (ISQG) for Cu and Zn in marine environments are based on a less rigorous laboratory digestion for sediments using only nitric acid which generally produces results about 75% as large as the hydrofluoric and nitric acid digestion in Maritime sediments (P.Yeats, personal communication). Allowing for the difference in laboratory methodology, the levels of Cu on the lease site are above the Threshold of Effects Level (TEL) in marine environments provided by the CCME Sediment Quality Guideline in 2009 and in two of three stations on the lease site in 2010. Figure 5 shows the equivalent CCME Guideline corrected for differences in laboratory procedures. None of the Cu and Zn data reach the toxic effect levels of CCME's Probability of Effects Level (PEL) Guideline.

Discussion

Historical industrial activity in Port Mouton Bay was limited to the traditional fishery and fish processing before finfish aquaculture began in 1992. The sample grid in the 2009-10 Port Mouton Bay sediments study was designed to avoid potential nearshore influences of sewage sources.

Comparison of Port Mouton Bay 2009 data with harbours from the Atlantic south shore not affected by anthropogenic inputs or odd mineralogy (courtesy of Phil Yeats from data published in Loring et al. 1996) is shown in Figures 5, 6 7 and 8.. These figures show Cu and Zn plotted vs. Li. The plots include lines that represent background conditions (the central line is the metal vs Li best-fit relationship for the data from south shore harbours that are not affected by anthropogenic inputs or odd mineralogy, and the two outer lines are 95% confidence bands). The Port Mouton Bay Cu and Zn data show levels above the background conditions from reference harbours as represented by the Cu or Zn vs. Li regression line.

The higher Li levels in 2010 by as much as 50% at all stations except the most distant station (#28) near Port Mouton Island in Figure 5 suggest that finer sediments have migrated from the farm site. 2009 copper data is also contrasted with 2010 data in Figure 5.



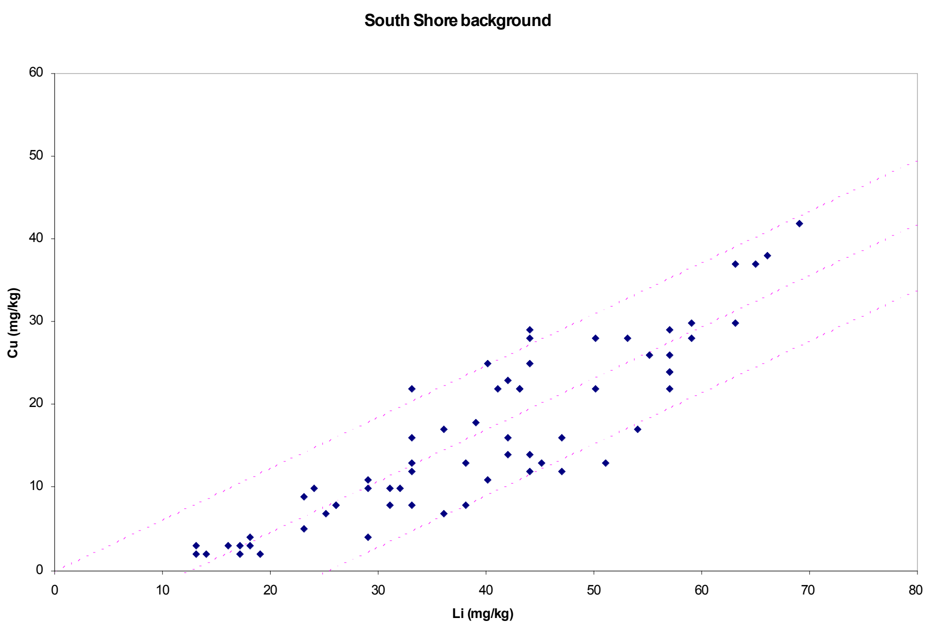
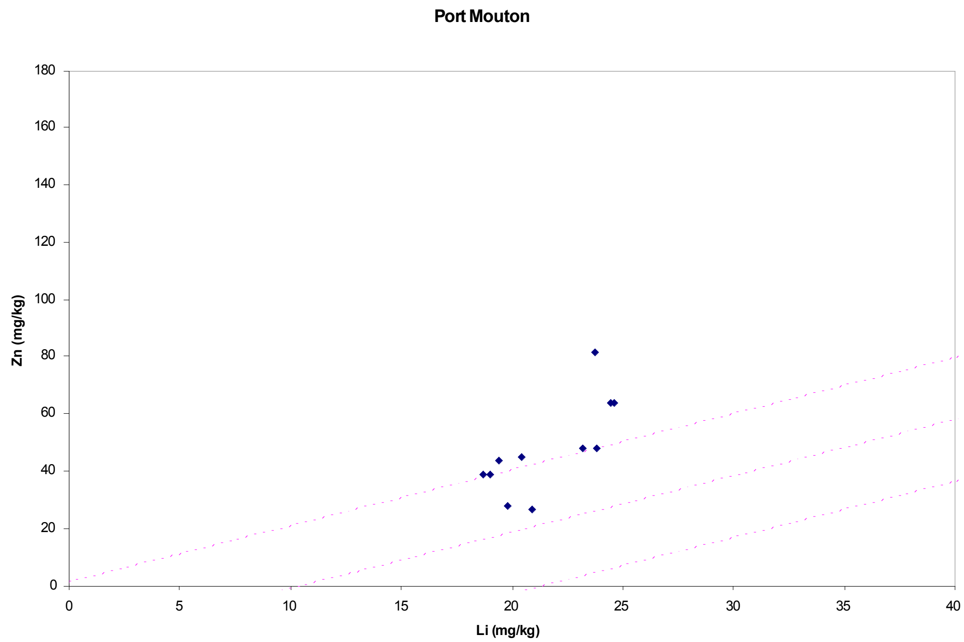


Figure 5 (top) shows Port Mouton Bay levels of Cu, 2009 and 2010, normalized for Li in sediments contrasted with typical South Shore Nova Scotia coastal background levels of Cu not affected by anthropocentric inputs (Figure 6 - bottom).



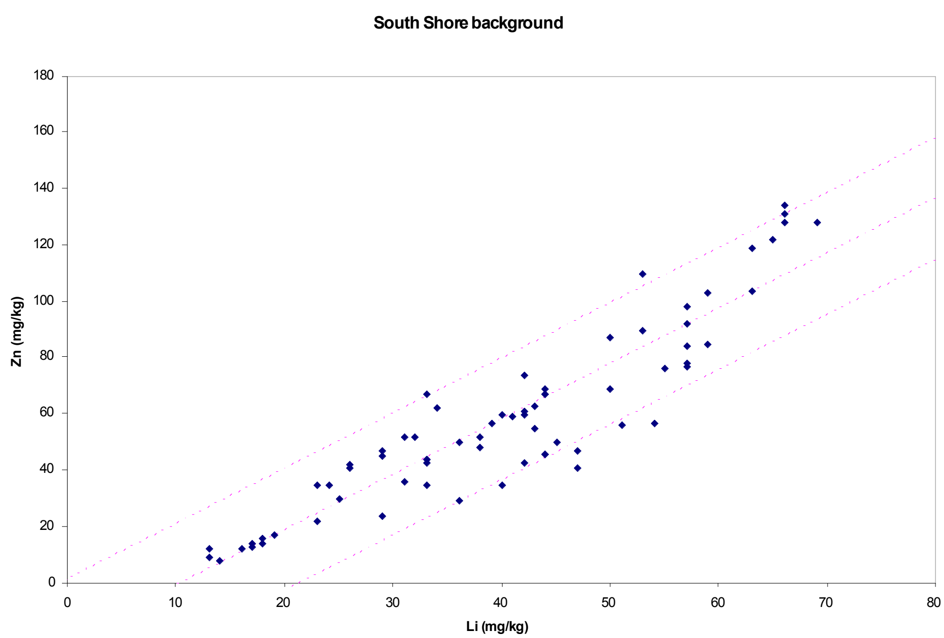


Figure 7 (top) shows Port Mouton Bay levels of Zn normalized for Li in sediments contrasted with typical South Shore Nova Scotia coastal background levels of Zn not affected by anthropocentric inputs (Figure 8 - bottom).

Copper sulphate and zinc sulphate are ingredients in fish feed and copper is the active ingredient in antifoulant paints that are routinely applied to nets used in finfish aquaculture. They are present in waste feed and fish feces; Cu leaches from treated nets and both Cu and Zn are bound in sediments. Lethal and sub-lethal effects of sediment copper on marine organisms have been established. Effects of copper and zinc in sediments at aquaculture sites are dependent on bioavailability and exposure. (Pathways of Effects for Finfish and Shellfish Aquaculture, Canadian Scientific Advisory Secretariat Scientific Advisory Report 2009/071, DFO, http://www.dfo-mpo.gc.ca/CSAS/Csas/Publications/SAR-AS/2009/2009_071_e.htm). Factors such as recovering oxic conditions can increase bioavailability to marine organisms.

Heavy metals have been used as tracers of salmon farm waste in the coastal waters of southwest New Brunswick and the Broughton Archipelago of British Columbia to qualitatively predict where farm wastes have been deposited in the sediments and the relative depositions at different sites in the same area (Yeats et al., 2005).

Figures 9 and 10 show the relationship between concentrations of Cu and Zn and % organic matter in Port Mouton Bay. Highest concentrations of Cu and Zn generally occurred where organic matter content was highest. In 2010 the concentration of Cu for one of the stations on the farm site was very high (35 mg/kg) but the corresponding % organic matter analysis was lost in the laboratory analysis..

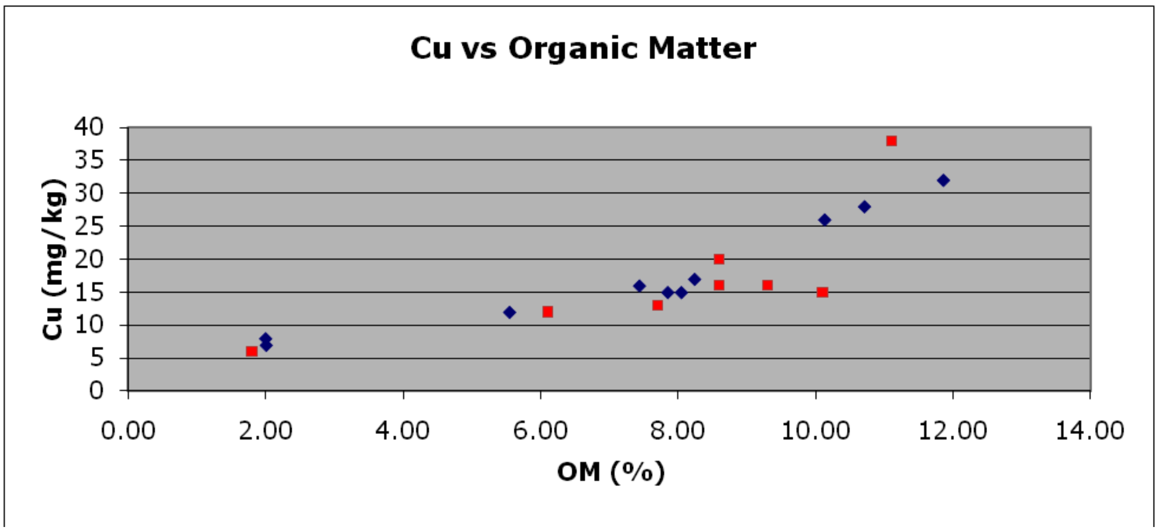


Figure 9. Copper levels in relation to % Organic Matter in Port Mouton Bay, 2009

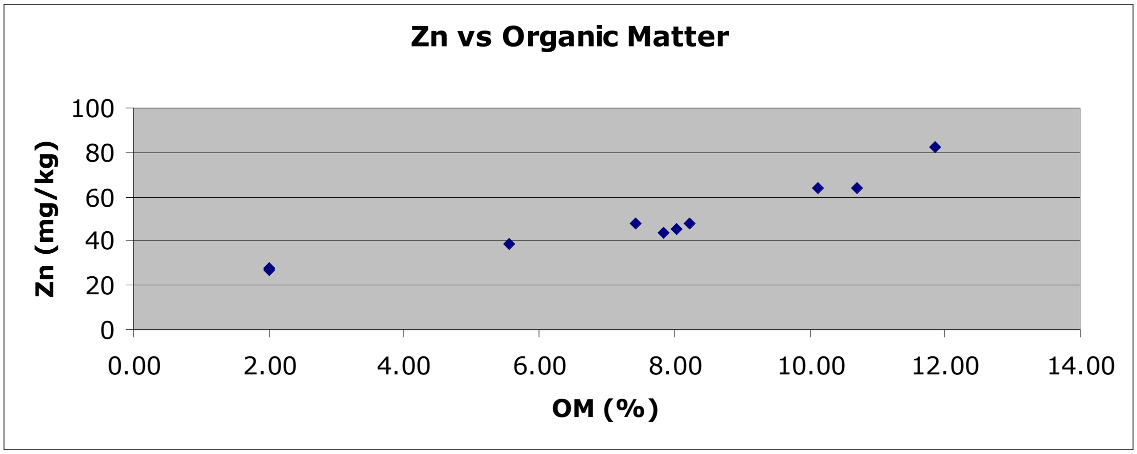


Figure 10. Zinc levels in relation to % Organic Matter in Port Mouton Bay, 2009

Conclusions

Concentrations of Cu and Zn are highest in 2009 within the lease site and are elevated at distances of 400 m to 2000 m from the site. A far-field footprint of trace metal enrichment from the salmon farm is indicated in these Li-normalized Cu and Zn data.

In 2010 this pattern continues. Levels of Cu in sediments were very similar to levels detected in 2009 except for higher levels at 2 of the 3 stations within the farm lease site and one of the far-field stations. Higher Li values suggest migration of finer sediments to the far-field.

Based on these results, further accumulation of copper in Port Mouton Bay is unacceptable.

References

Loring, D.H., Rantala, R.T.T., Milligan, T.G. (1996). Metallic Contaminants in the Sediments of Coastal Embayments in Nova Scotia , Canadian Technical Report Fisheries and Aquaculture Science 2111.

Yeats, P.A., T.G. Milligan, T.F. Sutherland, S.M.C. Robinson., J.A. Smith, P. Lawton and C.D. Levings. 2005 . Lithium–Normalized Zinc and Copper Concentrations in Sediments as Measures of Trace Metal Enrichment due to Salmon Aquaculture Fundy *in* Barry Hargrave (ed) Environmental Effects of Marine Finfish Aquaculture, The Handbook of Environmental Chemistry, Vol.5, Water Pollution, Part M. Springer.