Trace Metals in Sediments and Sea-surface Microlayer of Port Mouton Bay

2009-2013

Friends of Port Mouton Bay

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Summary

Friends of Port Mouton Bay (FPMB) have updated earlier studies of trace metals in marine sediments, the coastal water column and in the sea surface microlayer of Port Mouton Bay. The earlier studies took place during a period of fallow at the Port Mouton Bay finfish aquaculture lease site; the updates refer to samples taken in a recent period when the site was re-stocked .

Air-photo of Spectacle Island salmon aquaculture farm in Port Mouton Bay and an associated slick, July 2009, under conditions of light winds and reduced stocking. Photo credit, Linda Ross.

The Port Mouton Bay farm site was stocked with rainbow trout in June 2012 after almost three years in fallow and 15 previous years of salmon aquaculture. In June 2013, copper levels in the sediments at the farm site and at 500m distance were similar to earlier levels during the period of fallow. Locations sampled at the farm site in 2013 were near stocked cages and approximately 100 m distant from locations sampled earlier. Sediment copper levels at the farm site as high as 42 mg/kg exceed Canadian Sediment Quality Guidelines for Protection of Marine Life (18.7 mg/kg). Copper levels in the water column were consistently < 5 µg Cu/L from 2009 to 2013.

Copper molecules also accumulate in the sea surface microlayer, often at concentrations higher than in the water column below. Buoyant fish eggs and crustacean larvae such as lobster and crab can also be found in this microlayer. Measurement of copper in the sea surface microlayer in Port Mouton Bay in 2010-11 during the period of fallow revealed concentrations as much as 10 times higher than a

British Columbia guideline for protection of marine life. Levels decreased with distance from the fish cages and with duration of fallow but remained above guideline at 2500m and 27 months fallow. In October 2013, 16 months after the farm site was re-stocked with rainbow trout, levels of copper were extremely high – 10 to 145 times higher than guideline at 200–700m from the farm site.

Further releases of copper are unacceptable based on the current accumulation of copper in the sediments where they are persistent and in the sea surface microlayer in the near- and far-field of Port Mouton Bay.

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Introduction

Copper is associated with open net pen finfish aquaculture both as a trace element in the feed and as an antifoulant treatment for the nets.

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 aquacultural wastes have been deposited in the sediments and the relative depositions at different sites in the same area (Yeats et al., 2005).

This updated study by FPMB sampled copper in the sediments, the water column, and the sea surface microlayer for the purpose of monitoring persistence above guideline levels. Lithium concentrations were used to provide normalization for grain size and mineralogical differences in Port Mouton Bay sediments.

Copper in Sediments

The Port Mouton Bay farm site was stocked with rainbow trout in June 2012 after three years of fallow (July, 2009 - May 2012) and 15 previous years of salmon aquaculture. In June 2013 sediment samples at two locations (Stations 1 and 2) next to stocked cages on the farm site were analyzed for copper and lithium. These locations were approximately 100m west from earlier cage locations sampled in 2009-11. A third station (#24) was 500m southwest of the farm site and previously sampled in 2009-11 (Figure 1).

Figure 1. Map showing the stations analyzed for trace metal concentrations centred around Spectacle Island (2009-2011 and 2013).

In June 2013, sediment copper levels at the farm site and 500 m distant were similar to earlier levels sampled between 2009-2011: 33-40 mg/kg (2013), 29-42 mg/kg (2011), 35-38 (2010) and 26-32 mg/kg(2009) (Figure 2, Table 1) . All copper values within the farm site (2009-13) – Stations 1, 2, 20, 21, and 23 - exceed the Canadian Sediment Quality Guidelines for Protection of Marine Life (18.7 mg/kg). Copper concentrations above this guideline are lethal to amphipods (e.g. sand-burrowing crustaceans) and echinoids (e.g. sea urchins) in marine sediments. (Burridge et al, 2013).

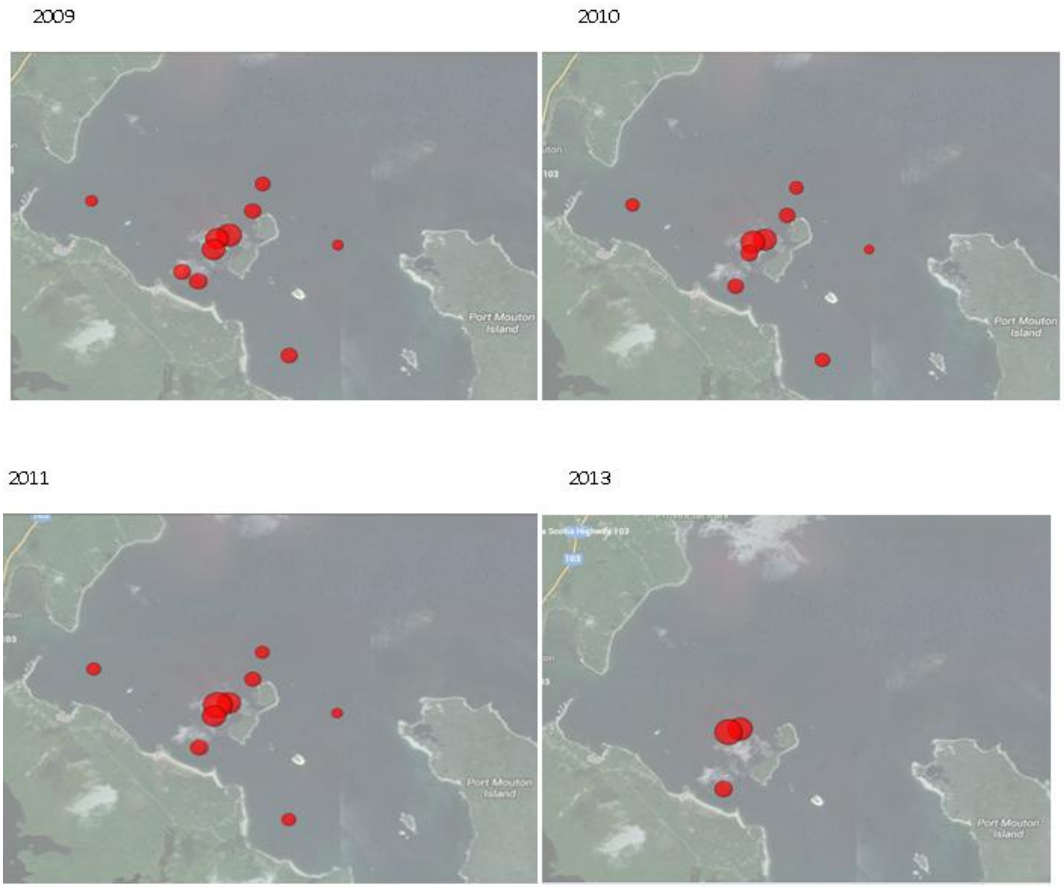

Figure 2. Chart showing concentrations for copper relatively unchanged, 2009-2013, in sediments from Table 1;

Table 1. Concentrations of zinc, copper and lithium (mg/kg) sampled in Port Mouton Bay sediments (October, 2009) and concentration of copper and lithium (October 2010, 2011, June 2013).

Station #	Copper (mg/kg) 2009	2010	2011	2013	Zinc (mg/kg) 2009	Lithium (mg/kg) 2009	2010	2011	2013
1				33					31.1
2				40					32.8
13	12	12	11		39	18.7	30.0	28.8	
13[1]	12	12	11		39	19.0	30.0	28.3	
14	15	16	14		44	19.4	34.6	31.1	
20	26	38	42		64	24.4	36.0	35.3	
21	28	20	29		64	24.6	36.9	36.1	
23	32	35	29		82	23.7	35.7	33.8	
24	17	16	16	16	48	23.2	39.1	35.7	35.2
28	7	6	6		27	20.9	25.1	22.9	
34	15	15	11		45	20.4	37.2	32.1	
43	8	13	11		28	19.8	31.9	28.0	
44	16	-		-	48	23.8		-	-

Copper is a non-degradable element which is a factor in the persistent levels measured on the farm site and at distance in the far-field.

Allowing for a less rigorous method of laboratory copper extraction used in the Canadian Guideline than used at the Resource Productivity Council laboratory where these samples were analyzed, the levels of copper on the lease site remain above the Canadian guideline (Table 1).

Details of the methodology used and discussion of earlier results can be found in the FPMB report, Trace Metals in Sediments (2009-11). http://www.friendsofportmoutonbay.ca/news.html

Copper in the Water Column

Copper in the water column was sampled as part of each survey for copper in the sea surface microlayer. Bulk water concentrations were consistently less than 5 µg Cu/L. This result for water column copper is the basis for the enrichment factor - the concentration of copper in the sea-surface microlayer compared to the concentration in the water column below.

[1] Laboratory duplicate

Copper in the Sea-surface Microlayer (SML)

Metal molecules accumulate in the SML, often at concentrations higher than in the water column. Buoyant fish eggs and crustacean larvae such as lobster and crab can also be found in this microlayer. Harding et al. (1987) report Stage IV lobster larvae caught almost entirely at the sea-surface at all times of day. Other constituents identified in the SML have included pesticides, other trace metals (Wurl and Obbard, 2004), and bacteria and viruses (Aller et al. 2006). Surface slicks from a fin fish aquaculture operation can be wind-driven over several kilometers and interact with shorelines over the rise and fall of the tide (Loucks et al. 2012). British Columbia's Ministry of Environment copper guideline for protection of marine life is 3 µg/L. An European lobster larvae study recommended a copper guideline of <0.45 µg/L for protection of lobster larvae (Marino-Balsa et al., 2000).

Copper levels in the SML in Port Mouton Bay decreased with distance from the fish farm site and time but remained above the BC guideline at 2500 metres/25 months fallow and at 1600 metres/27 months fallow. 12 months after re-stocking the farm site, samples within the visible slick of the sea surface microlayer showed copper concentrations, ~30 and 8 µg/L. 16 months after re-stocking, concentrations were extremely high – 443, 56 and 30 µg/L - 145, 20 and 10 times higher than the BC guideline (Figure 3). These levels were found at >200m east, 400m south and 700m west south west of the farm site, respectively. Four samples outside the visible slick exhibited concentrations ≤ 6 µg/L..

The highest level – 443 µg/L is ~1000 times greater than the European guideline recommendation for protection of lobster larvae. The enrichment factor for this sample compared to the water column concentration below is greater than 88 (443 µg/L/5 µg/L).

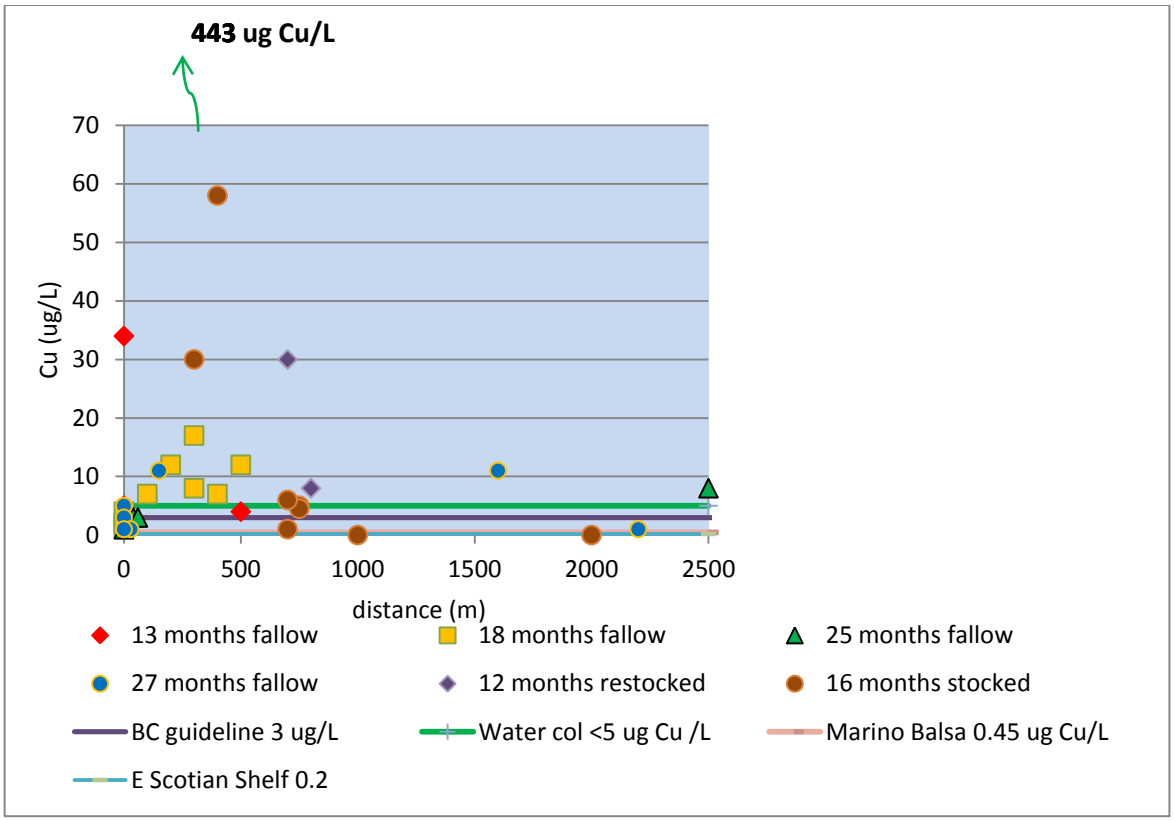

Figure 3. Chart of copper concentrations at the sea surface with distance from the fish cages in fallow and restocked conditions.

Details of the methodology and discussion of earlier results for the SML in Port Mouton Bay can be found in the research paper published in the Marine Pollution Bulletin, Loucks, R. H., R. E. Smith, C. V. Fisher, and E. B. Fisher (2012), ***Copper in the sediment and sea surface microlayer near a fallowed, open-net fish farm.*** **This paper concluded that "Elevated and enriched concentrations in the sea surface microlayer over distance from the farm site led, as a result of wind-drift, to an enlarged farm footprint."** http://www.sciencedirect.com/science/article/pii/S0025326X12002457 http://www.friendsofportmoutonbay.ca/news.html, June 12, 2012.

Conclusions

Further releases of copper are unacceptable based on the current accumulation of copper above guidelines, both in the sediments where they are persistent, and in the sea surface microlayer, where concentrations can be very high in the near- and far-field.

References

Aller, J.Y., Kuznetsova, M.R., Jahns, C.J., Kemp, P.F., 2005. The sea surface microlayer as a source of viral and bacterial enrichment in marine aerosols. Journal of Aerosol Science 36 (5/6), 801–812.

Burridge, L.E. 2013. Chemical Use in Marine Finfish Aquaculture in Canada: A Review of Current Practices and Possible Environmental Effects.

http://www.dfo-mpo.gc.ca/science/enviro/aquaculture/sok-edc/volume1/burridge-eng.htm

Harding, G.C., J.D. Pringle, W. P. Vass, S. Pearre, Jr.,S. J. Smith. 1987. Vertical distribution and daily movements of larval lobsters *Homarus americanus* over Browns Bank, Nova Scotia. Marine Ecology - Progress Series Vol. 41:29-41.

Loucks, R. H., R. E. Smith, C. V. Fisher, and E. B. Fisher. 2012. Copper in the sediment and sea surface microlayer near a fallowed, open-net fish farm. Marine Pollution Bulletin 64, 1970-1973.

Mariño-Balsa, J.C., Poza, E., Vázquez, E, Beiras, R., 2000. Comparative toxicity of dissolved metals to early larval stages of Palaemon serratus, Maja squinado, and Homarus gammarus (Crustacea:Decapoda). Archives of Environment Contamination and Toxicology 39, 345–351

Wurl, O., Abbord, J.P., 2004. A review of pollutants in the sea surface microlayer(SML): a unique habitat for marine organisms. Marine Pollution Bulletin 48, 1016–1030

Yeats, P.A., Milligan, T.G., Sutherland, T.F., Robinson, S.M.C., Smith, J.A., Lawton, P., Levings, C.D., 2005. Lithium -normalized zinc and copper concentrations in sediments as measures of trace metal enrichment due to salmon aquaculture. In: Hargrave, Barry (Ed.), Environmental Effects of Marine Finfish Aquaculture, The Handbook of Environmental Chemistry, 5 M.Springer, pp. 207–220.