

Dioxin and furan contamination from pulp mills: A successful history of source control and regulations

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What's happening with dioxin and furan contamination in Howe Sound?

Historically, two pulp mills have long operated in Howe Sound, the Port Mellon and the Woodfibre mills. The Howe Sound Pulp and Paper (HSPP) mill at Port Mellon began operation in 1908 and is the only mill in operation today in Howe Sound. For decades, effluent from HSPP and the Woodfibre mill, which closed in 2006, created a variety of impacts on receiving waters in Howe Sound. These impacts included high biological oxygen demand causing oxygen depletion, smothering of local seafloors with fine fibre beds, reduced light penetration leading to lower phytoplankton production, and impacts from a variety of chemical contaminants, including dioxins and furans. The chemical contamination resulted in the closure of fisheries in most of Howe Sound in the 1980s.¹ However, effluent regulations introduced in the late 1980s and early 1990s and mill process changes since the mid-1980s have dramatically reduced contamination and related impacts in Howe Sound.

In 1995, harvest restrictions due to dioxin/furan contamination were removed for 40 percent (486 square kilometres) of the previously closed area in Howe Sound,¹ and today permanent fisheries closures remain in effect for crab but not for prawn, shrimp and finfish. Recent sampling reveals that dioxins and furans remain in the sediment in the proximity of HSPP, but levels in sediments are in general decreasing.

Contamination in fish and shellfish has generally declined near HSPP to levels below the Health Canada consumption criteria,^{2,3} but advisories to limit consumption of crab (i.e., specifically the hepatopancreas where dioxins are concentrated) are posted and remain in effect in Howe Sound.⁴ Environment Canada oversees an Environmental Effects Monitoring (EEM) program that continues today at the HSPP mill.



Howe Sound Pulp and Paper mill at Port Mellon. (Photo: Bob Turner)



Crab is a popular food item for fishers in Howe Sound but some areas remain closed to crab fishing due to contamination. (Photo: Gary Fiegehen)

Why is dioxin and furan contamination an important issue?

For many years, the Port Mellon (i.e. HSPP) and Woodfibre pulp mills used liquid chlorine for the bleaching process and, consequently, produced and discharged effluent containing byproducts known as polychlorinated dibenzo-p-dioxins (i.e. dioxins) and dibenzofurans (i.e. furans).⁵ Human intake of dioxins and furans poses potential health risks because these organic pollutants are among the most persistent, toxic, bioaccumulative and carcinogenic hazards to

humans.^{6,7} Because of dioxin and furan contamination in the marine environment and high tissue concentrations in seafood, fisheries (including harvesting of prawn, shrimps and crab) were closed in Howe Sound and other parts of the B.C. coast near pulp mills in 1988.^{5,8,9}

What is the current state?

Monitoring has shown a marked decrease in dioxin and furan contamination in Howe Sound over time (Figure 1). Since initial testing in 1987, concentrations measured in the digestive organs (hepatopancreas) of Dungeness crab at Port Mellon and Woodfibre have decreased by 97 percent and 99 percent, respectively (Figure 1 top panel).^{2,10} However, in 2012, dioxin and furan concentrations in the hepatopancreas of Dungeness crab collected from three of eight sampling sites at the HSPP mill exceeded the Health Canada consumption criteria,² indicating that crabs from these sites are not safe or suitable for human consumption.

Contamination in sediments decreased by 19 percent at Port Mellon and 99 percent at Woodfibre between 1987 and 1995 (Figure 1 bottom panel). The more rapid decrease of dioxins and furans at the Woodfibre mill site relative to Port Mellon likely relates to higher rates of fresh sediment deposition at the Woodfibre site due to its proximity to the mouth of the Squamish River. In 2012, concentrations of dioxins and furans in sediments near the Port Mellon mill were still within the lower end of the historical range, suggesting that the sediments here may act as both sink and source of dioxin and furans.

In B.C., the monitoring of effluents from pulp and paper mills, as well as nearby sediments, water and benthic invertebrates, has routinely been conducted since the 1970s.¹³ In October 1976, the Environmental Protection Service (EPS) initiated a program to assess the environmental impact at the Port Mellon pulp and paper mill.¹⁰ The EPS collated relevant data and

environmental monitoring information, which led to additional monitoring studies and environmental impacts assessments and the installation of treatment plant facilities at the Port Mellon mill.¹⁰ To meet effluent quality standards/guidelines, treatment facilities at pulp mills were required to reduce the amount of suspended solids and toxic substances released to the receiving marine environment.¹⁴ Primary and secondary effluent treatments plants were installed in September 1990.¹⁴

At the Woodfibre pulp mill, effluents were treated with an oxygen-activated sludge system starting in December 1992, resulting in a 95 percent reduction in biochemical oxygen demand, meaning that the effluent no longer used up oxygen that plants and animals need to survive in the receiving marine water. Monitoring of fish tissue at Woodfibre up until the time of mill closure in 2006 indicates decreasing concentrations of dioxins and furans.¹⁵ However, dioxin and furan concentrations in 2006 in crab hepatopancreas and dogfish liver near Woodfibre remained above the Health Canada consumption advisory threshold.¹⁵

While the level of dioxin and furan contamination has decreased in the region, ongoing monitoring is still required as the most recent data showed that Dungeness crabs still have elevated levels of dioxins in some locations at the HSPP mill.² Seafloor sediments can function as a contaminant source or sink because exposure pathways for crabs may have changed since the mills ceased producing dioxins and furans; sediment contamination may have improved faster at some sites than others.¹¹

DIOXIN AND FURAN CONCENTRATIONS MEASURED IN DUNGENESS CRAB AND MARINE SEDIMENTS

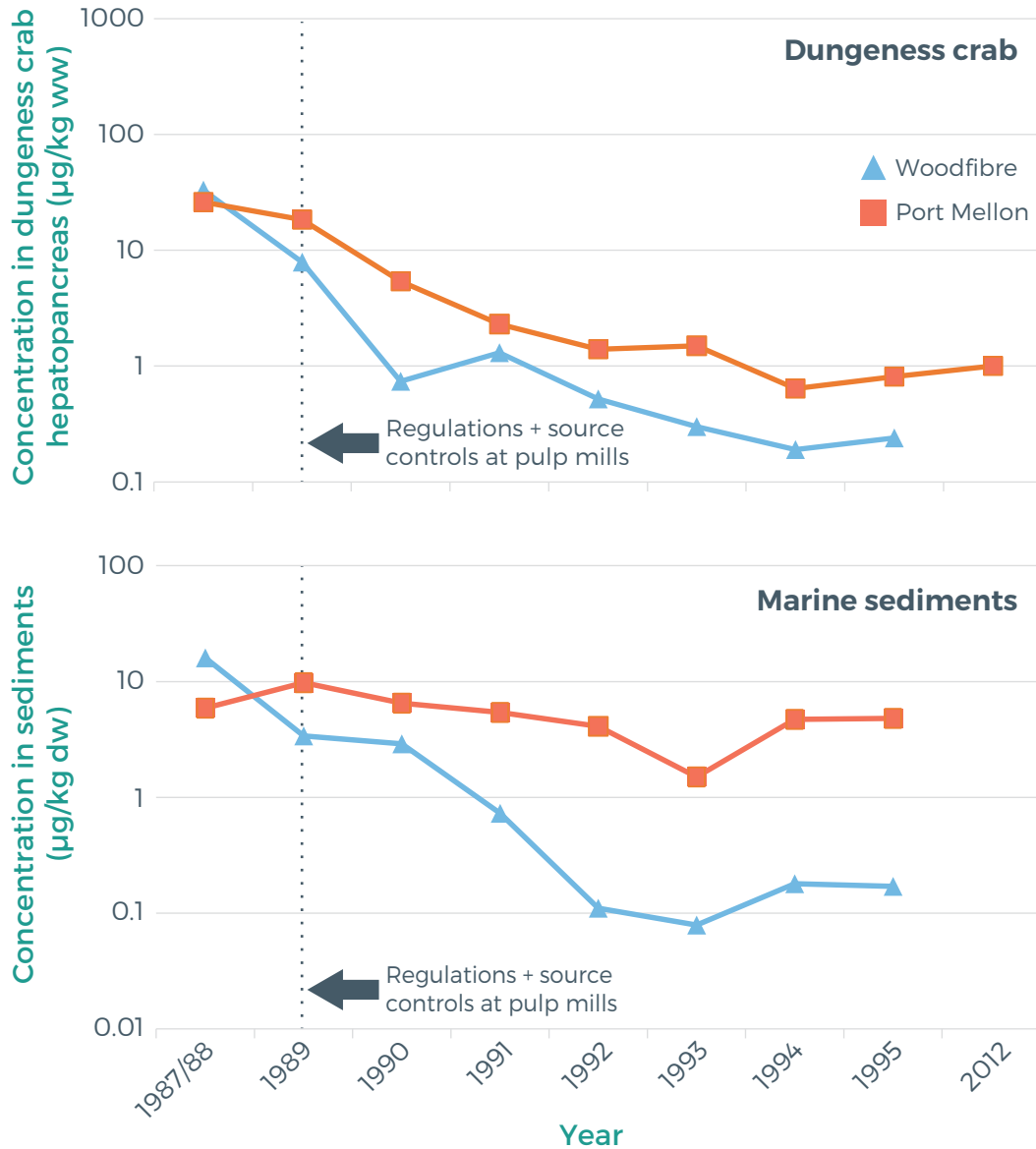


Figure 1. Trends of total dioxin and furan concentrations measured in (top) Dungeness crab hepatopancreas (µg/kg wet weight) and (bottom) marine sediments (µg/kg dry weight) collected at Woodfibre and Port Mellon (i.e. HSPP) from 1987 to 1995.¹¹ The dashed line represents the timing of implementation of regulations and source control in pulp and paper mills to address and reduce dioxin and furan emissions. The concentration in 2012 for Port Mellon (top) is the average of total concentrations of dioxin and furans measured (≈ 1.0 µg/kg wet weight) in Dungeness crab hepatopancreas at eight sample sites.¹²

What is being done?

Federal regulations passed in 1992 improved pulp and paper mill effluents. The amended Pulp and Paper Effluent Regulations (PPER) under the Fisheries Act significantly reduced load limits and two new Canadian Environmental Protection Act (CEPA) regulations curtailed dioxins and furans releases.¹⁶ To meet these stricter regulations, pulp mills upgraded their processes and installed secondary treatment so significant improvements occurred over the past 20 years. HSPP conducts biological monitoring as part of their Environmental Effects Monitoring (EEM) program under the PPER. The mill had a coordinated program with the Western Pulp Mill until the latter closed permanently in 2006.¹⁶ Thus, EEM studies are on-going and directly assess the effects of mill effluent on fish, fish habitat, and use of fisheries resources in the vicinity of the effluent discharge as commanded by Environment Canada.¹⁶ For example, the EEM Cycle Six program for HSPP at Port Mellon ran between April 2010 and April 2013 to conduct studies of the potential negative and lethal effects of mill effluents on bottom dwelling organisms to support sediment quality assessment, as well as dioxin/furan monitoring survey of sediment, crab and fin fish in support of the EEM fish tissue survey.²

Health Canada monitors the concentrations of dioxins and furans in foods in its ongoing Total Diet Study surveys. As part of its risk assessment activities, Health Canada continues to assess the concentrations of these compounds in foods as well as monitoring any new research about the health effects of dioxins and furans.¹⁷

In terms of policy and legislation, dioxins and furans are scheduled for virtual elimination under the Canadian Environmental Protection Act (CEPA), the federal Toxic Substances Management Policy (TSMP) and the Canadian Council of the Ministers of Environment (CCME) Policy for the Management of Toxic Substances. Under the federal PPER (SOR/92-269), pulp mills are required to monitor the chemistry and toxicity of mill effluent and its potential effects on the receiving environment.¹⁸ Environment and Climate Change Canada and the Department of Fisheries & Oceans developed the first EEM program for inclusion in the 1992 amendment of the Regulations. The EEM portion of the Regulations were subsequently amended in 2004 and in 2008 as a result of experience with implementation of the program, stakeholder consultations, and feedback from the Smart Regulation Initiative¹⁹ on Improving the Effectiveness and Efficiency of Pulp and Paper Environmental Effects Monitoring.

What can you do?



Individual and Organization Actions:

- Avoid the incineration of organic matter and plastics to prevent the release of dioxins into the air and coastal environment.
- Use and apply “green” or homemade pesticides and organic fertilizers in gardens and agricultural fields to avoid toxic run off (e.g., salmon friendly lawn and/or orca friendly lawn: non-toxic pesticides, non-toxic herbicides, non-toxic fertilizers).



Government Actions and Policy:

- Help to guide and design creative solution-oriented practices to reduce the levels of dioxins and furans in Dungeness crabs which still exhibit concentrations of dioxin/furans of concern for public health.
- Promote and sponsor national programs and solutions for marine pollution to protect ocean life from human made chemicals with research, continued education and engagement, and advocacy to succeed with actions.
- Continue with the implementation of source controls and regulations to hamper dioxin and furan pollution from pulp mills in the coastal marine environment of Howe Sound.
- Regulate and control the usage of pesticides containing potential traces of dioxins and furans as impurities to avoid the accidental release of these byproducts into the coastal marine environment.
- Address the appropriate disposal of old tanks and bins and any material containing dioxin-contaminated fluids and/or oil from former military facilities, old refineries, junk yards and harbours.

Footnotes

- ¹ Hagen, M.E., A.G. Colodey, W.D. Knapp, and S.C. Samis. 1997. Environmental response to decreased dioxin and furan loadings from British Columbia coastal pulp mills. *Chemosphere* 34(5): 1221-1229.
- ² Hatfield. 2013. Howe Sound Pulp and Paper Environmental Effects Monitoring Cycle Six. Final. Prepared for Howe Sound Pulp and Paper Limited Partnership (HSPP), Port Mellon, BC. Hatfield Consultants, North Vancouver, BC, Canada.
- ³ Toxic Equivalent (TEQ) = 24.4 pg/g or 0.024 µg/kg. The toxic equivalency concept is a widely applied method to express the toxicity of complex mixtures of compounds that act via receptor-mediated mechanisms such as induction of the arylhydrocarbon or estrogen receptors. The TEQ methodology is primarily intended for estimating exposure and risks via oral ingestion (e.g., by dietary intake).
- ⁴ <http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s28-eng.htm#shellfish>
- ⁵ Macdonald, R. W., W.J. Cretney, N. Crewe, and D. W. Paton 1992. A history of octachlorodibenzo-p-dioxin, 2,3,7,8-tetrachlorodibenzofuran, and 3,3',4,4'-tetrachlorobiphenyl contamination in Howe Sound, British Columbia. *Environmental Science and Technology* 26: 1544-1550.
- ⁶ Van den Berg, M., L. S. Birnbaum, M. Denison, M. De Vito, W. Farland, M. Feeley, H. Fiedler et al. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. *Toxicological sciences* 93(2): 223-241.
- ⁷ World Health Organization: Dioxins and their effects on human health, Fact sheet N° 225, May 2010.
- ⁸ McLaren, P., W.J. Cretney, and R.I. Powys. 1993. Sediment pathways in a British Columbia fjord and their relationship with particle-associated contaminants. *Journal of Coastal Research*, 9(4):1026-1043.
- ⁹ Yunker, M.B. and W.J. Cretney. 1996. Dioxins and furans in crab hepatopancreas: Use of principal components analysis to classify congener patterns and determine linkages to contamination sources. In: Servos, R. M., Munkittrick, K.R., Carey, J.H., Van der Kraak, G.J. *Environmental Fate and Effects of Pulp and Paper Mill Effluents*. St. Lucie Press, Delray Beach, FL, USA. pp.315-326.
- ¹⁰ Yunker, M.B., W.J. Cretney, and M. G. Ikononou. 2002. Assessment of chlorinated dibenzo-p-dioxin and dibenzofuran trends in sediment and crab hepatopancreas from pulp mill and harbor sites using multivariate-and index-based approaches. *Environmental Science and Technology* 36(9):1869-1878.
- ¹¹ Data adapted from Yunker et al. 2002; see reference 10.
- ¹² Calculated from the data reported in the Howe Sound Pulp and Paper Environmental Effects Monitoring report (Hatfield Consultants 2013; see reference 2).
- ¹³ Young, L.U. 1996. Water Quality Assessment. In: Levy, D.A., Young, L.U., Dwernychuk, L.W.. *Strait of Georgia Fisheries Sustainability Review*. Hatfield Consultants Ltd. West Vancouver, BC, Canada. pp.57-123.
- ¹⁴ Nelson, H. 1979. Pulp mill environmental impact assessment: Canadian Forest Products LTD. Howe Sound Pulp Division. Regional Program Report 79-2. Environmental Protection Branch, Environmental Protection Service, Pacific Region. 35pp.
- ¹⁵ Hatfield. 2007. Howe Sound environmental effects monitoring (EEM) Cycle Four interpretive report. Prepared for Western Pulp Limited Partnership –Squamish Operation. Hatfield Consultants Ltd., West Vancouver, BC.
- ¹⁶ Environment Canada. 2010. Pulp and paper technical guidance for aquatic environmental effects monitoring. Environment Canada, 2010.
- ¹⁷ <http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/dioxin/index-eng.php>
- ¹⁸ <http://laws-lois.justice.gc.ca/eng/regulations/SOR-92-269/?showtoc=&instrumentnumber=SOR-92-269>
- ¹⁹ <https://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=96B3035D-1>