APPENDIX 2: AN ASSESSMENT OF THE VUOSAARI TBT PROBLEM

Basic information about tributyltin

Tributyltin (TBT) was widely used earlier as a biocide additive to ship paints to prevent the formation of barnacles and other sea life on the hulls of ships. This kind of antifouling paint maintains a smooth layer over the surface of the hull. This decreases friction allowing the ship to move more efficiently through the water, and thereby reducing CO_2 emissions.

Finland abolished TBT use for small boats and large trade vessels years ago. However, the elimination of TBT has been problematic with ships that move in tropical waters. Due to the lack of effective substitutes, TBT use continued in ocean going vessels. International Maritime Organization members in 2003 agreed to ban TBT, and the TBT paints have been removed from ship hulls or painted over by the start of 2008.

When organotins are released from the paint on the ship's hull, they bond with suspended particles in the water. In the Netherlands, researchers found that TBT released from ship hull and attached to sediment particle had diminished bioactivity. The measured toxicity was two orders of magnitude lower than TBT in solution.

The half-life for TBT to degrade typically varies between two weeks in a normal water environment to six months in sediments. In an anaerobic sediment layer, however, the half-life rate of TBT degradation can slow to 5–20 years/59/.

Discussions on assessing bottom sediment quality typically concerns limits on hazardous substance content or levels at which hazardous substances become problematic for the environment. One common threshold is 5 %, that is, the level at which the hazardous substance impacts 5 % of a given ecosystem. Thus, if a lake's sediment is contaminated at this level, 95 % of the lake's ecosystem is still safe. In the Netherlands, the 2002 permitted limit value for total content of organotin compounds was 250 µg /kg dry weight (d.w.). TBT is usually the dominant organotin component in marine sediments. Thus the limit corresponds to about 600 µg/kg d.w of TBT.

TBT in Vuosaari sediments

Organotin levels exceeding the German and Dutch limits were found in Vuosaari surface sediments (top 10 cm layer) in 2003 measurements over an approximately 20-hectare area. This area had been occupied by a stationary dock and a floating dock in the 1970s and 1980. Later the facilities had been used as a repair dock yard.

Further away from the floating dock the surface sediments had TBT levels around 50 µg /kg d.w., in other words 10 % of the limit value.

Most of the TBT was found in a two hectare area that had been deepened for the floating dock. The sedimentation in this kind of a depression is faster than in the surroundings. Here high TBT concentrations were found also in deeper sediments. Maximum TBT-concentrations exceeded limit value by more that one order of magnitude.

Sand blasting of ship hulls had piled paint particles on the dock and these had been released to water from both ends of the floating dock during dockings.

The TBT levels found in Vuosaari were, in fact, typical for such areas. TBT levels in harbors globally have a range of 10–2,000 µg /kg d.w. /59/. In dock areas and small boat harbors, the TBT levels may have been locally distinctly higher. TBT content in sediments under busy channels are also elevated. For example, the typical TBT levels found in surface sediments in the North Airisto channel are in the range of 50–100 µg TBT/kg d.w. /10/.

The Helsinki harbor's own estimate for the total TBT content of Vuosaari sediments was about 100 kg. For purposes of comparison, estimates from the 1990 suggest that Dutch docks released about 5,600 kg of TBT a year and the maritime TBT emissions into Dutch waters at that time were about 17,800 kg a year /14/. In the Rotterdam harbor alone the TBT emissions were estimated at 1,097 kg/year and the amount of TBT stirred up by dredging was put at 451 kg a year/59/.

Based on the above description, it is clear that the TBT content of the sediments was essentially a localized problem near the dock area. The problem was apparently not very serious as it was not noticed during the time the dock was in more intense operation and when the environmental effects of TBT in the Vuosaari dock area were much greater than in 2003.

What does standard dredging and dumping do to the sea bottom?

Dredging is underwater earthworks. If the seabed is locally contaminated, good dredging practices call for dredging away the surface layer first and then covering it later with virgin seabed material dredged from below. The dredging mass is normally placed on a sea bottom subject to natural sedimentation area or used as fill material in the harbor construction works. Heavily contaminated sediments are usually encapsulated, sometimes brought ashore and transported to special landfills and sometimes stabilized in harbor fills.

The end result for areas of dredging and dumping activity is always the same, however – a cleaner seabed. The biologically active surface layer is replaced with a clean new surface layer in the dumping area. TBT degrades undisturbed below the dumping area. Thus, a standard dredging procedure already would have largely eliminated the environmental problems in the vicinity of the Vuosaari dock.

Dredging and dumping operations inevitably generate a certain amount of suspended solids. The press, chose to describe the dredging disturbance in the Vuosaari harbor as a "poisonous cloud". The suspended particles stirred up by dredging and dumping activity typically linger for about a day or less moving with currents before they settle out on the seabed. Particles getting suspended near the bottom settle out quickly. Thus a large part of the suspended material settles in the immediate vicinity of the dredging or dumping activity.

In normal backhoe or grab dredging, up to 5 % of the mass is suspended in the water column. When the dredging mass is dumped down at the dumping site from a barge, the amount of solids suspended in the water is about 5 % of the total mass in the case of soft, fine sediments.

In a standard dredging operation, about 10 kg of the 100 kg of TBT in the Vuosaari sediments would have gone into suspension. Most of this would have been eventually buried in the dumping area.

Because the total mass to be dredged was about 5 million m^3, the average TBT content of suspended solids that would have settled elsewhere would have been low, about 2 µg /kg d.w. i.e. well below the background TBT content. Furthermore, as the surface sediments would have been dredged first, the TBT containing sediment particles would have been covered with clean material.

The environmental impact of suspended solids compared to emissions from maritime traffic

In the following, we first attempt to put the dimensions of the suspended-solids issue in perspective. We take direct comparison points from the figures for Dutch sea traffic.

Reference /59/ assumes TBT emissions of 0.04 g per day for each square meter of tin-painted ship hull. This means that the emissions for a typical ocean freighter would be about 200 grams a day. The 1990 maritime TBT emissions in Dutch waters were estimated at 17.8 tons/14/. In that year, Dutch harbors had 45,000 calls. This works out to an average TBT emission of 0.4 kg per call.

Assume sediments containing TBT are dredged and dumped using standard methods for six months. The operation releases an average of 0.4 kg of TBT a week into the water mass (mostly attached to suspended solids). This amount corresponds to the emissions from 25 harbor calls of sea freighters, i.e. about one harbor call a week during the dredging operation.

In recent decades, Finland’s harbors averaged 300–400 calls from foreign traffic ships every week, with the Helsinki harbor alone having 60–70 calls. Most of the calling ships had hulls coated with TBT-antifouling paints. In the last ten years, while ship traffic has increased, TBT use on ships hulls in the Baltic has declined.

The poisonous cloud

Most of the Vuosaari TBT was located in and around the sides of the repair dock excavation. How much of a poisonous cloud was actually stirred up during dredging of Vuosaari sediments? We consider here the worst case of removing 10 kg of TBT a week using normal dredging and dumping methods.

As a point of comparison, consider the Elbe River delta in the Hamburg area and downriver. This is an approximately 400 km^2 area, where the suspended solids in the water mass average 50 mg/l. Due to higher turbulence in the Freiburg-Gluckstadt area, the suspended solids level in the water can be an order of magnitude higher /36/. The average organotin content in Elbe River delta suspended solids has averaged 600 µg/kg for many decades /10/.

In the case of the Vuosaari dredging mass, the average organotin levels in the area of the repair dock were an order of magnitude higher than this. The organotin content in suspended solids in the dredging and dumping areas, however, drops to under 50 mg/l within a few hundred meters of the repair dock area. In other words, at its worst the water quality corresponds to water in the Freiburg-Gluckstadt area during the few weeks of floating dockyard depression dredging in an area of approximately 10-hectares.

No particular health problems or eco-catastrophes have been reported from the Elbe River delta, where TBT has long been present.

The poisonous cloud in the Vuosaari case was comparable to the emissions of an ocean-going vessel. At the most intense phase of the operation, the amount of TBT in suspension added to the local waters from the dredging and dumping operation would have amounted to about 1 kg of TBT a week. At the time of the project execution a similar level of emissions would have been given off by a moderate sized RO-RO freighter legally anchored at the Vuosaari harbor.

TBT's effects on human health

The average organotin content in Vuosaari fish averages 20–50 µg/kg. The European Food Safety Authority (EFSA) estimates that a person can safely consume an average of 0.25 µg of organotins per kilo every day. In other words, a 60-kg individual could eat without risk about 400 grams of Vuosaari fish every day. Finnish per capita fish consumption is about 30 grams a day. Moreover, the EFSA recommendation includes a 100-fold safety factor /51/.

The maximum amount of alcohol a 60-kg person can consume daily without risks to health works out to an average of two12-cl glasses of wine a day. This figure does not include any safety factor. If, for example, the fisherman's wife consumes an average of 400 g of Vuosaari fish every day of her life, the impact, considering the safety factor, would still be smaller than if she enjoys a glass of wine once a month.

The TBT levels in fish can be assumed to decline rapidly with the elimination of ship hull emissions. If there is a need to immediately lower the TBT levels in fish, the fastest way to achieve this is to make extensive dredging of shipyard and sea traffic areas. In this respect, the Vuosaari dredging operation was quite effective.

Helsinki harbor solution

Guided by the demands of the environmental administration, the harbor officials decided to dredge the sediments containing TBT inside an extensive curtain that contained the suspended solids. The most problematic masses were temporarily placed in a rock excavation. The final dumping site of these sediments was a contained bay. The sediments were covered by granular fill and became part of the harbor field.

The solution completely eliminated the dispersion of TBT in the harbor area. Helsinki harbor officials report that these special measures added about €10 million to the construction costs. The damage caused by changes in the project execution and schedule are hard to quantify.