A Primer on the Impacts of TBT in the Nearshore Marine Environment

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Background

Tributyltin, or TBT, is a family of organotin compounds that is based on a tin-hydrocarbon substituents link. The compounds are well-known for their toxicity to several marine species and for their persistence in the marine environment. They are extremely effective biocides, and have been used since the 1960s in paints that coat the bottom of boats and on aquaculture cages to keep species from fouling the hulls and cages.[1,2]

One of the first indictors of unintended exposure to TBT was imposex—the phenomenon in which female gastropods develop male genitalia. In extreme cases, the phenomenon has been known to cause death to the females in a population, as they cannot pass their eggs through the abnormally growing vas deferens and penis, and their oviducts rupture.

Imposex in snails was first observed in the 1970s, on both sides of the Atlantic Ocean, and in different species. By the 1980s, it had become a widespread phenomenon, with scientists studying snail populations in marinas and bays recording the greatest number of mortalities and deformities. The phenomenon became linked to TBT, and in the 1990s, it became clear that the only known cause for imposex in the environment was TBT.[3] All told, 45 different snail species around the world have developed imposex characteristics in response to TBT in their environment.[4]

Other indicators of TBT toxicity include failure to settle and develop (most invertebrate larvae, since this impact was what the biocide was intended to do), abnormal shell growth (oysters),[5] bioaccumulation[6] and possible immunosuppression (marine mammals and

[1] Balls, P. W. 1987. Tributyltin (TBT) in the waters of a Scottish sea loch arising from the use of antifoulant treated netting by salmon farms. Aquaculture 65: 227–237.
[2] ten Hallers-Tjabbes, C. C. 1997. Tributyltin and policies for antifouling. Environmental Technology 18: 1265-1268.
[3] Ruiz, J. M, M. Quintela, and R. Barreiro. 1998. Tributyltin and imposex: No uncertainty shown. Marine Ecology Progress Series 170: 293–294. p. 294.
[4] Ellis, D. V. & L. A. Pottisina. 1990. Widespread neogastropod imposex: A biological indicator of global TBT contamination. Marine Pollution Bulletin 21: 248-253.
[5] Alzieu C. 1991. Environmental problems caused by TBT in France: Assessment, regulations, prospects. Marine Environmental Research 32: 7–17.
[6] Guruge, K. S, H. Iwata, H. Tanaka, and S. Tanabe. 1996. Bioaccumulation in the liver and kidney of seabirds. Marine Environmental Research 44: 191–199.

seabirds),[7,8,9] and stunted growth (micro and macroalgae).[10,11] TBT has even entered the human food chain via salmon farmed in treated pens.[12]

Europe banned TBT on small vessels (< 25 m) in 1987 but it would take another 11 years before the International Maritime Organization of the United Nations would impose a ban for most ships. The ban came into effect in 2003 for new ships, and finally—as a result of the overwhelming evidence that continued to be observed and published into the 2000s[13,14]—the use of TBT as a biocide for ship hulls was banned worldwide. In 2008, the global ban was complete.

By some counts, the ban has had a positive effect. In 2014, a series of articles in the popular press reported that snail populations were recovering; mortalities and deformities were lessening.[15] Still, there is disagreement over these claims of recovery.[16] And it is incontrovertible that the legacy of TBT remains in the sediment, where it can have a half-life of many years because it adsorbs onto particles and does not wash away or degrade.[17]

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[12] Ellis, D. V. 1991. New dangerous chemicals in the environment: Lessons from TBT. Marine Pollution Bulletin 22: 8–10.

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[14] Sousa, A., C. Matsudaira, S. Takahashi, S. Tanabe, & C. Barroso. 2007. Integrative assessment of organotin contamination in a southern European estuarine system (Ria de Aveiro, NW Portugal): Tracking temporal trends in order to evaluate the effectiveness of the EU ban. Marine Pollution Bulletin 54: 1645-1653.

[15] Doyle, C. 2014. Gender bending snails recover as toxic paint TBT is banned. 14 Jan 2014. Australian Broadcasting Corporation. http://www.abc.net.au/environment/articles/2014/01/13/3916477.htm

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Why TBT remains a substance of concern

TBT, like all toxic substances, carries greater risk with greater exposure. Exposure is a combined factor of intensity (concentration), duration (length of time), and manner of contact (*e.g.*, breathed, ingested, absorbed through the skin). Intensity has generally decreased because of the international ban. There are very few new sources of TBT in the marine environment, unless dredging or underwater construction causes the re-suspension of sediments in which TBT has been trapped.

However, the persistence of TBT in the environment has resulted in a legacy that has not yet been properly addressed. Many agencies and governments now acknowledge the critical need to impose standards[18] for TBT to ensure the safety of aquaculture and swimming areas[19,20,21] but in many cases the testing has not been done and the public remains vulnerable and unaware of possible risks. All marinas, bays, and areas surrounding aquaculture facilities should be tested for legacy TBT contamination and proper remediation should be carried out to ensure that this exceptionally toxic substance is not just banned, but truly gone, from the marine environment.

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