3.1 Introduction

Organotin compounds were first developed as moth-proofing agents in the 1920s, and were only later used more widely as bactericides and fungicides (WHO 1980). Organotin compounds produced for commercial applications include methyltins, butyltins, phenyltins, octyltins, and cyclohexyltins. The major uses of organotins are as polyvinyl chloride (PVC) heat stabilizers, catalysts (for silicone and polyurethane production), biocides, agrochemicals, and glass coatings. The use of tributyltin (TBT) in marine antifouling paints dates from the 1960s, initially as a booster biocide in copper-based formulations. As a result of TBT’s efficacy over copper, the use of TBT-based paints accelerated greatly in the 1970s. Annual production of organotin compounds increased from <5,000 t in 1955 to >50,000 t in 1995 (Fent 1996; OECD 2001), with 15–20% of the production accounted for by triorganotins (Bennett 1996). The global annual production of TBT alone was estimated to be 4,000 t in the late 1990s (OECD 2001). In addition to antifouling uses, TBT was used in wood and material preservatives, and slimicides. The use of TBT in antifouling paints applied to hulls of ships and boats, fish-nets, crab pots, docks, and water cooling towers contributed to the direct release of organotins into the aquatic environment. These antifouling usages have caused the greatest environmental concern, because of TBT’s high aquatic toxicity. Since the widespread use of TBT-based paints began in the early 1970s, several researchers have reported the harmful effects of TBT on economically important marine food species such as...
One of the first documented instances of TBT toxicity was in Pacific oysters, *Crassostrea gigas*, in France’s Arcachon Bay. Abnormal spatfall, decrease in larval survival rates, and shell malformations were observed as early as 1974. By the early 1980s, effects on oysters in Arcachon Bay had been linked to TBT, and in 1982 France banned the use of TBT-containing antifouling paints on vessels less than 25 m in length (Alzieu 1991). Many other countries adopted similar regulations from the late 1980s, e.g., the UK, the USA, Australia, Canada, The Netherlands, Switzerland, Japan, Denmark, and Hong Kong. The toxic effect of butyltins was also recognized in other bivalves, especially mussels, and in gastropods. Several studies in the 1980s established a link between TBT exposure and ‘imposex’ (the imposition of male sexual characteristics on females) in certain neogastropods, and the decline of populations in the waters off southwestern England (Smith 1981; Bryan et al. 1986). Imposex can be initiated in mollusks at water TBT concentrations in the low nanogram per liter range (i.e., <10 ng/l) (Bryan et al. 1986), also the concentration range at which shell deformities and larval mortalities occur (Alzieu 1991). In the mid 1980s, bioaccumulation of TBT in farmed salmon held in net-pens that had been treated with TBT-based antifouling paints was reported (Short and Thrower 1986; Davis and McKie 1987).

Butyltin pollution is not limited to the coastal marine environment; it also extends to the freshwater environment. Austria and Switzerland banned the use of TBT, even though these two countries are land-locked. Nevertheless, as stated earlier, the regulations on TBT-based antifouling paints are only partial in most of the countries that limit usage applying to recreational boats and vessels <25 m in length. The International Maritime Organization (IMO) adopted a global treaty to ban the application of TBT-based paints from January 2003, and total prohibition by January 2008 (IMO 2001). Details of the worldwide regulatory strategies for organotin compounds have been reviewed by Champ (2000).

In general, the regulations have resulted in reduced TBT contamination in water and some organisms, and recovery of mollusc populations, particularly those close to marinas. However, researchers have noted that there has been little or no reduction in TBT concentrations in sediments, even several years after the regulations were enacted (e.g. Quevauviller et al. 1994; Fent and Hunn 1995; Chau et al. 1997). Persistence of TBT in sediments is indicated by a half-life of between 2 and 30 years in temperate regions (Dowson et al. 1996; Maguire 2000; WHO 2006), whilst continued occurrence of imposex at sites near shipping activities (e.g. Fent 2004; Santos et al. 2004), indicates that the legacy of TBT is likely to be long-lasting: appropriate management of potential impacts is an important consideration. In addition, unregulated use of TBT on vessels >25 m in length and on aluminum-hulled boats will continue to be sources of release in large harbors, anchorages, and shipping lanes. Although the IMO’s global treaty on the use of TBT is applicable to member countries of the organization, TBT will continue to be produced and used as biocides, especially in developing countries and those countries that do not join the organization. In addition, TBT continues to be used in other applications such as material and wood preservatives and in slimicides.