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Using *Nucella lapillus* (L.) as a bioindicator of tributyltin (TBT) pollution in eastern Canada: a historical perspective

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ABSTRACT

Dogwhelks (*Nucella lapillus*), a universal bioindicator of tributyltin (TBT) pollution, were used to determine butyltin distribution in three Atlantic Canada harbours previously surveyed between 1995 and 2006. *N. lapillus* were analysed for the presence of TBT and its degradative products while imposex incidence and severity were compared with previous surveys to assess the efficacy of the Canadian regulations on TBT. Imposex was observed at two harbours that had dogwhelks, but not at surrounding reference sites. When comparing results with previous surveys in the same geographic area, there appears to be some improvement of affected *N. lapillus* populations, suggesting that the 1989 Canadian regulations have been effective in decreasing imposex severity for most sites as measured by the vas deferens sequence index (VDSI), but not the occurrence of imposex. The highest butyltin tissue concentration ($63.75 \text{ ng Sn g}^{-1}$, dry wt) was detected in imposex-affected females from Red Head in Saint John Harbour (New Brunswick), which is adjacent to an area frequented by large oil tankers that, under the 1989 regulations, are legally allowed to use TBT antifouling paint. This study is the first to illustrate a significant correlation between TBT levels and imposex on a spatial scale in Atlantic Canada.

Key words | Atlantic Canada, Bay of Fundy, imposex, *Nucella lapillus*, recovery, tributyltin

INTRODUCTION

Between the 1960s and 1970s, the primary biocide in antifouling paint, cuprous oxide (Cu_2O), was replaced by a more effective one, tributyltin (TBT) (Huggett *et al.* 1992). However, it was soon observed that TBT negatively affected non-target organisms such as bivalves and gastropods. The first evidence that TBT was having an adverse effect on non-target organisms came from France's Atlantic coast in the late 1970s where TBT was linked as the causative agent for 'chambering' and decreasing abundance in the commercially cultivated Pacific oyster, *Crassostrea gigas* (Alzieu 1986). Around the same time, another biological impact was occurring across geographic boundaries in female gastropod molluscs. Female dogwhelks (*Nucella lapillus*) in the United Kingdom (Blaber 1970), sting winkles (*Ocenebra erinacea*) in France (Poli *et al.* 1971), emarginate dogwinkles (*Nucella emarginata*), channel dogwinkles (*Nucella canaliculata*) in California (Houston 1971) and eastern mudsnail (*Nassarius*

obsoletus) in the Connecticut (Smith 1971) were observed growing a 'penis-like' structure. This phenomenon where gonochoristic female gastropods were growing a penis has been named 'imposex' (Smith 1971) or pseudohermaphroditism (Jenner 1979; Fioroni *et al.* 1990). Laboratory exposure experiments and field transplant studies later confirmed TBT as the causative agent (Smith 1981; Féral & LeGall 1982).

Due to the deleterious effects of TBT on non-target organisms, especially the commercially lucrative *C. gigas*, several countries regulated the use of organotin in antifouling paint, and have used bivalves and gastropods as biomarkers and bioindicators of TBT pollution. France was the first country to regulate the use of TBT in 1982 (Alzieu 1991), and other countries followed suit. Canada passed regulations in 1989 to control the use of TBT by banning its use on vessels <25 m in length (Agriculture Canada 1989). Imposex and intersex, another form of feminine masculinization, have been used

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