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Organotin contamination in the Atlantic Ocean off the Iberian Peninsula in relation to shipping

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Abstract

Imposex in female snails, a bioindicator of TBT contamination, and the presence of organotins in snails' tissue and sediments were studied at nine sites off the western Iberian Peninsula. The study was part of a European project (acronym HIC-TBT) co-financed by the EU-LIFE programme, intending to investigate and communicate the impact of organotins from ships in marine ecosystems. Snails and sediments were sampled during two cruises in May/June 1999 and in January 2000 in areas of high, intermediate and low-shipping density. Imposex was found in female snails from several sampling sites, some of which had an imposex incidence of 100%. Differences in sensitivity were found between species; hence comparison of imposex levels between locations where different species were collected was not straightforward. Total organotin concentrations in sediments (sum of butyl and phenyltin compounds) ranged from 21 to 185 ng Sn g^{-1} with higher values for most sites sampled in the vicinity of shipping lanes. Organotin concentration in snails' tissue ranged from <5 to 196 ng Sn g^{-1}, which are similar to those found in snails from other offshore areas contaminated by TBT. Overall, these results give further support to the recent ban on the use of organotin based antifouling paints to all ship size.

Keywords: Imposex; Gastropod; Organotins; Open sea; Sediments

1. Introduction

Antifouling paints are used on ships to maintain a clean hull. Organotins (OT), and tributyltin—TBT, in particular, have been extensively used since the late 1960's as biocides in paints for ships' hulls to prevent settlement of organisms. OTs, however, are extremely toxic to a wide range of non-target organisms (Fent, 1996). In neo- and mesogastropods, TBT is responsible for the development of male sexual characteristics in females, a phenomenon called imposex (Smith, 1971). Advanced stages of imposex can lead to impairment of reproduction due to the blockage of the genital papilla by the development of a vas deferens. In the 1980s imposex was found to be responsible for the decline of several populations of intertidal dogwhelks (Gibbs and Bryan, 1986).

Gastropods are very sensitive to low levels of TBT and effects have been observed at concentrations as low as 0.5 ng TBT Sn l^{-1} (Gibbs and Bryan, 1986), which renders them suitable bioindicators of TBT contamination. Several species from different regions have been used as such (Féral and le Gall, 1983; Axiak et al., 1995; Stroben et al., 1995; Mensink et al., 1996; Horiguchi et al., 1997; Santos et al., 2002).

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Based on the deleterious effects of OTs in non-target organisms, in the 1980s several countries banned the use of OTs from ships smaller than 25 m (Alzieu et al., 1989; Ten Hallers-Tjabbes, 1997). In 1989 the European Union published Directive (89/677/CEE) banning TBT from vessels smaller than 25 m; in 1990 the Marine Environment Protection Committee (MEPC) of the International Maritime Organisation (IMO) adopted a resolution recommending to ban TBT from such small vessels (Resolution MEPC 46(30), MEPC, 1990). More recently, the 2001 IMO convention "International Convention on the Control of Harmful Antifouling Systems on ships", banned the application of this kind of paints from the 1 January 2003, and the presence of OT on ship hulls from the 1 January 2008 (MEPC, 2001).

In 1991 Ten Hallers-Tjabbes et al. (1994) found that imposex was common in the subtidal whelk, *Buccinum undattum*, in areas of dense shipping traffic in the North Sea, while in the early 1970s imposex was not found in *Buccinum undatum* from the same area. Mensink (1999) and Mensink et al. (2002) reported that TBT induced imposex in juvenile whelks bred from imposex-free whelks caught in low-shipping density areas in the North Sea. Swennen et al. (1997) showed that imposex was also found in different species of neo- and mesogastropods in offshore marine areas off South East Asia, in the vicinity of shipping routes. More recently, Solé et al. (1998) reported imposex in the subtidal neogastropod *Bolinus brandaris* offshore in the North-western Mediterranean, and similar results were found off the Italian coast (Chiavarini et al., 2003). Taken together, these results supported the recent ban on the use of OT based antifouling paints to all ship sizes.

In contrast to the extensive body of literature reporting impact of TBT in mainly intertidal snails from coastal and estuarine areas, and its consequences in policy, impact of OT contamination in offshore seas has only been studied in the North Sea, South East Asia and the North-western Mediterranean. The confusion in interpreting scientific data on the impact of TBT, as fuelled by not distinguishing the effects on intertidal snails in relation to small ships from the impact on subtidal offshore snails caused by TBT from larger, mainly merchant ships, has been discussed by Ten Hallers-Tjabbes and Boon (1995).

Most snails of the reported studies were sampled in shelf seas of less than 100 m of depth, while gastropods from deeper locations have not been investigated for the presence of imposex, nor have OTs concentrations in tissue and sediments been measured.

The present study is part of an European project co-financed by the LIFE programme, aimed to investigate OT contamination in offshore seas in relation to the proximity of shipping routes, in a co-operation between scientists from the Netherlands, Italy, Spain, Portugal and UK. For this purpose, imposex in marine snails, and levels of OTs in biota (snails) and sediments were investigated in the North Sea, the Mediterranean and the North East Atlantic off the Iberian Peninsula (Fig. 1). This paper reports on the investigations in the Atlantic off the Iberian Peninsula.

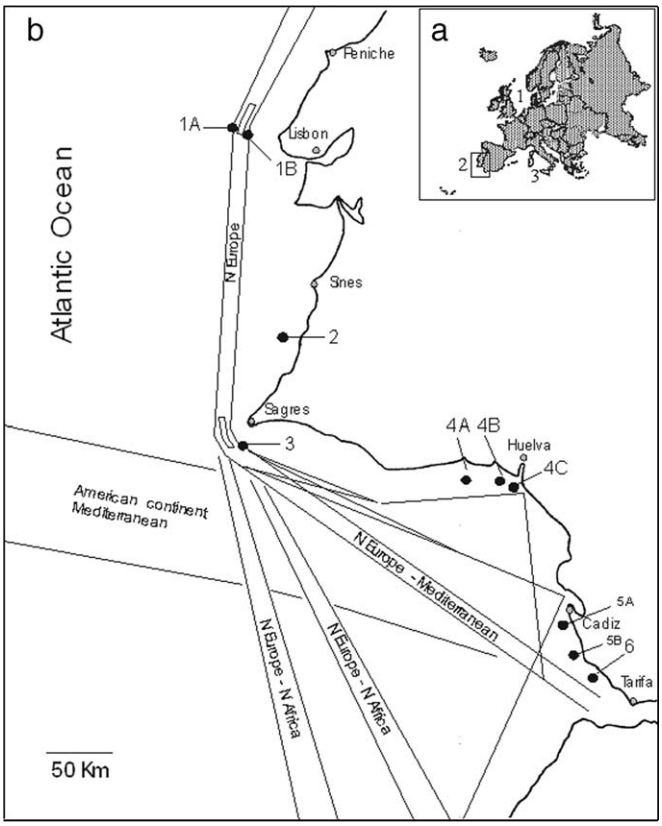

Fig. 1. Area of study. (a) Coastal areas considered under the present study (European Project, acronym HIC-TBT): 1. North Sea coast; 2. Iberian Atlantic coast; 3. Mediterranean coast. (b) Sampling sites location in the Atlantic Iberian Coast and gastropod species collected per location: 1A—*Ranella olearia*, *Charonia lampas*; 1B—*Cassidaria tyrrhena*, *Collus gracilis*, *Aporrhais pespelicani*; 2—*Ranella olearia*, *Aporrhais pespelicani*, *Bussinum humphreysianum*; 3—*Ranella olearia*, *Cassidaria tyrrhena*; 4A—*Cymbium olla*, *Cassidaria tyrrhena*, *Cymatium corrugatum*, *Hexaplex trunculus*, *Bolinus brandaris*; 4B—*Bolinus brandaris*; 4C—*Bolinus brandaris*; 5A—*Bolinus brandaris*; 5B—*Turritella monterosatoy*; 6—*Cymatium corrugatum*, *Cymbium olla*. Lines represent the main shipping routes in the study area.

2. Materials and methods

2.1. Sample collection

Snails and sediments were sampled during two different periods: May/June 1999 and January 2000. The selected sampling sites reflected different shipping densities: (a) low-shipping density (LSD)—less than 5 ships passing per day within a distance of 15 nautical miles (NM) from the sampling locations; (b) intermediate shipping density (ISD)—between 5 and 10 ships per day; (c) high shipping density (HSD)—more than 10 ships per day. The estimates for shipping density are based on information from different international sources (Ten Hallers-Tjabbes et al., 1994, 2003) and completed by regional data from the Finisterre Maritime Safety Centre. Sampling sites of the first