NATIONAL/INTERNATIONAL LEGISLATION ON ANTIFOULING

TBT and antifouling strategies: the Italian and European legislation

The detrimental effects on no-target marine organisms, associated with the widespread presence of TBT in the environments, called for international actions. In 2001, IMO adopted the AFS Convention, banning the application of TBT based antifouling paints after 2003 and requiring their absence from ships' hulls since 2008. The EU anticipated the AFS ban, which entered into force only in 2008, by adopting the Regulation (EC) No 782/2003, which made immediately compulsory the restrictions imposed by the AFS Convention. TBT is part of the priority hazardous substances established within the scope of the Water Framework Directive (WFD; Directive 2000/60/EC), for which environmental quality standards (EQS) have been imposed at European level. Since coordination among the existing environmental regulations is a specific requirement of the Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC), the achievement of these EQS in the European seas and the absence of TBT-related effects in the marine biota would be compulsory for attaining the Good Environmental Status

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Introduction

Tributyltin (TBT) based antifouling paints began to be massively used worldwide since the 1970s. Following the assessment of TBT role in inducing a number of detrimental effects on aquatic organisms in the early 1980s (i.e., as immunosuppressive agent and an endocrine disruptor), this biocide underwent ever stricter regulation on the production and applications of such paints.

Organotin compounds (OTC), including TBT, were firstly synthesized in 1853, but they were found to have biocidal properties only 100 years later approximately, when they started to be used in the formulation of several commercial biocide products (i.e., fungicides, miticides, molluscicides, nematocides, ovicides, rodent repellents, wood preservatives). The massive employment of TBT in antifouling coatings was recorded between 1970s-1980s, when it almost completely replaced the most traditional biocides for its unique properties in term of efficiency, versatility and duration. Concern about the hazard generated by the growing presence of TBT in aquatic environments has involved both the scientific and civil communities since 1974, when widespread malformations and developmental abnormalities on aquatic organisms became particularly evident in areas featuring a high density of ships [1]. Among the wide range of biological effects recorded in that period, two had a big resonance because of their significant environmental and economical implications: the shell

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thickening in common oysters (Crassostrea sp.) farmed along the European Atlantic coast, with a consequent decrease in their market value [2; 3]; the incoming of sexual malformation in wild populations of several gastropod species (i.e., superimposition of male sexual organs in females, a phenomenon known as imposex), often leading to sterility and population decline [4]. The regulation of this biocide at the national and international levels became a priority when several research studies reported the existence of a direct relationship between these abnormalities and the presence of TBT in the aquatic compartments. It was ascertained, in fact, that a number of impacts on many marine species were induced by concentrations even lower that 1 ng/L (approximately 2-3 orders of magnitude lower than those usually recorded in hot-spot areas such as ports, dockyards, marina, and 1-2 orders lower than the levels assessed in coastal areas) [5; 6].

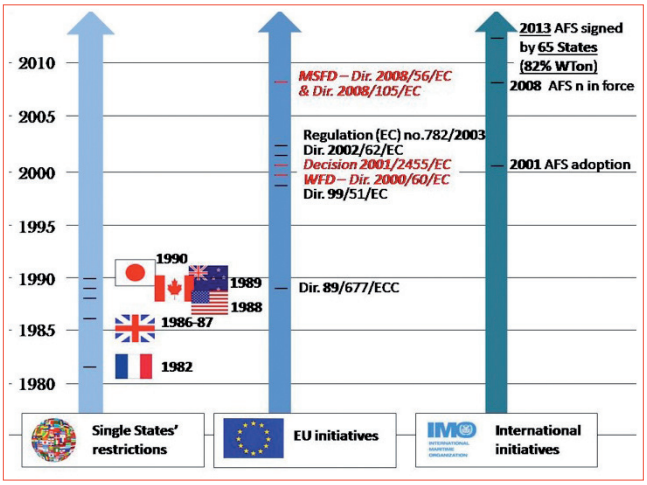

FIGURE 1 Timeline of the main regulatory initiatives taken at level of single States, European Union and international community (IMO International Maritime Organization) since the early 1980s

Initial counteractions toward TBT

The first regulatory initiatives were individually taken by single states, as outlined in Figure 1.

France – whose oyster farms located along the Atlantic coast experienced high economic damage due to reduced oyster spatfall, larval development abnormalities and shell deformations between 1975-1982 – was the first to take actions to limit TBT release in the environment by regulating the use, the formulation and the public sale of TBT-containing paints. On 19th January 1982, the French Ministry of the Environment imposed limitations on the application of these coatings on boats less than 25m long. Initially, the prohibition referred to products containing over 3% of biocide and was limited to areas with intensive oyster culture along the English Channel and the Atlantic coast. On 14th September 1982, the ban was extended to the whole French coast. These provisions, which included waivers for paints containing less than 3%, boats longer than 25m and all kinds of submerged structures (light alloys, nets, traps, etc), remained in force almost through the 1980s, when the problem started to be addressed at community level. A few years later, on the other side of the English Channel, the UK Government forbade the application of TBT-coatings on the hulls of small vessels (1985), and established the threshold level at 20 ng TBT^+/L (1986), which was reduced to 2 ng TBT^+/L on the following year. Similar restrictions (i.e., ban for boats less than 25m long, maximum leaching rate, percentage of TBT content) were also set outside Europe, as in USA (US Antifouling Paint Control Act of 1988), Canada (under the Canadian Pest Control Act, 1989), Australia (1989), Japan (1990), New Zealand (1993) [7; 1; 8].

The first initiative taken by the European Authorities was adopting the Directive 89/677/EEC, which modified the communitarian framework on dangerous substances and preparations (Directive 76/769/EEC) by introducing organostannic compounds within the list of dangerous substances subjected to restrictions (Annex I) (Figure 2).

The Directive 89/677/EEC unified the regulation of TBT-based antifouling paints at European level by banning their use on ships less than 25m long, submerged facilities for fish and shellfish farming and immersed structures; furthermore the sale was reserved to professional users. In the 1999, with Directive 1999/51/EC, this discipline was further restricted by banning all TBT based-free association -paints and by prohibiting the use of TBT in inland waters.

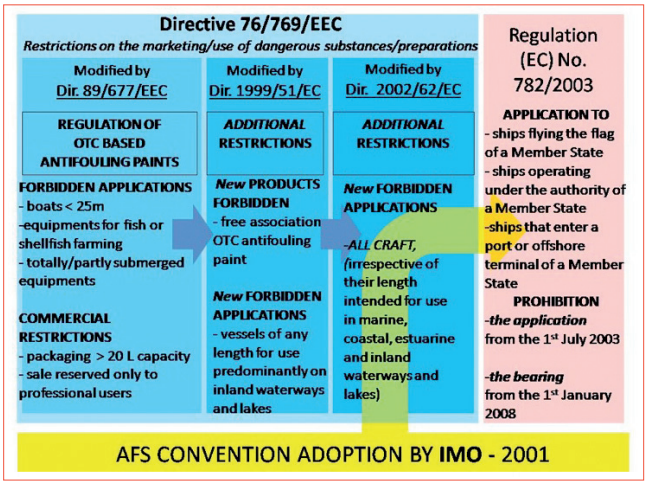

FIGURE 1 Timeline of the EU regulation of OTC based-antifouling paints

Thanks to the adoption of these Directives by France as well as by the other EU members (in Italy with the D.M. 29/07/1994 and D.M. 13/12/1999), during the 1990s the release of TBT into European marine waters was restrained but not arrested. In fact, the adopted resolutions allowed the application of TBT-based antifouling products, having mean leaching rate lower than 4 μg $cm^{-2}d^{-1}$, on the largest ships (> 25 m long).

IMO's (International Maritime Organization) Initiative

However it was soon clear that the high toxicological potential of TBT–inducing toxicological effects on the most sensitive aquatic organisms at concentrations less than 1ng/L, [5] made the national individual actions insufficient, to the extent that more severe restrictions, crossing the national boundaries, were indispensable. In 2001, IMO (International Maritime Organization) developed the *Convention on the Control of Harmful Anti-fouling System on Ships*, noted as AFS Convention, banning: 1) new applications of TBT-based antifouling paints from 1st January 2003, and 2) the presence of these coatings on ship surfaces and submerged structures from 1st January 2008. These prescriptions, addressed toward all size-boats flagged or working within the boundaries of signatory countries, couldn't get immediately into force, having to be ratified by at least 25 States covering the 25% of the world gross tonnage.

At first, the EU reacted to the IMO directions with the Directive 2002/62/EC, which introduced as a novelty the prohibition of using antifouling preparations based on organostannic compounds on all kinds of crafts, regardless of their length. One year later, the EU decided to definitively solve the problem in its area of jurisdiction and to adopt an anticipatory action of the AFS prescriptions within the community boundaries: Regulation (EC) No. 782/2003 was adopted, which imposed the immediate respect of the AFS prescription to EU-flagged vessels as well as to all ships approaching the ports and offshore structures of Member States.

Outside the EU boundaries, the global ban of TBT antifouling paints was achieved on 17th September 2008, when the AFS Convention was signed by 25 States, overall representing the 38.11% of the world merchant tonnage. From that date on, the number of countries adopting the AFS prescription has continuously increased and to date 65 States, covering 82.25% of the world tonnage, have banned these products in their territorial waters by signing the international convention[1].

EU directives on TBT

The progressive adoption of even stricter regulations on TBT antifouling systems has led to the progressive decline of TBT concentrations in aquatic environments since the end of the 1980s. According to the literature, TBT levels have diminished in all marine compartments, especially in water and biota [9, and references therein). Similarly, a progressively ecological recovery worldwide has been recorded at different levels of biological organization (e.g., oyster cultures in France and Southern England, dogwhelks population recovery, decline of imposex, macro-infaunal and epifaunal communities recovery) [10; 11; 7; 8].

Despite the achievement of an almost complete ban on TBT used as biocide, there is scientific agreement about the need to keep monitoring OTC levels in aquatic

environments. This is because OTC are persistent environmental pollutants tending to biomagnificate along the food chain [6;12], and concentrations able to induce harm for ecosystem and human health are still found. In particular, high OTC concentrations are still present in sediments, especially in hot spots areas such as ship channels, ports, harbours and marinas [13;14], and it is ascertained that they are acting as secondary source of pollution for the surrounding area [15].

In the EU, TBT is one of the aquatic pollutant considered within the European Water Framework Directive (WFD; Directive 2000/60/EC;). This Directive is aimed at achieving, by 2015, the *good environmental status of waters* by the attainment of both ecological and chemical quality objectives. Pursuant art. 16, the good chemical status is met when concentrations of specific substances, considered priority because presenting significant risk to or via the aquatic environment, do not exceed the EQS established in Annex IX and under Article 16 [7]. TBT is part of a subset of this group, priority hazardous substances, the discharging, emissions and losses of which have to cease or phase-out; hence, stricter objectives have been established. The complete list of *priority* and *priority hazardous* substances is provided for within the Decision n. 2455/2001/EC, whereas Directive 2008/105/EC (EQS Directive) sets Environmental Quality Standards (EQS) in the water matrix. Annex I fixes the limit of 0.0002 μg TBT^+/L as annual average concentration, whereas 0.0015 μg TBT^+/L as maximum permitted concentration. Whilst the WFD is focused on water concentrations for tracing the chemical status and the quality improvements – given thanks to the undertaken measures – the European Authorities allow Member States to establish EQS for sediment and/or biota at the national level and to apply those EQS instead of the EQS for water (art. 16 [7] of the WFD; art. 3 of the Directive 2008/105/EC). In Italy, the Ministerial Decree 260/2010 defines national quality standards in sediments of marine and transitional water for several priority substances including TBT establishing the EQS value of 5μg TBT^+/kg.

More recently, the protection of European marine ecosystems from the detrimental effects of the most harmful chemical contaminants, including TBT, has been added within the scopes of the Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC). MSFD establishes a framework for community action in the field of marine environmental policy, having the final aim of promoting sustainable use of EU seas and conserving marine ecosystems. The overall goal is the achievement or maintenance of the *Good Environmental Status* (GES) of the Community's marine environments by 2020, by applying an ecosystem-based approach to the management of human activities, marine goods and services. With the MSFD, the EU asked to each Member State to concretely develop a marine strategy of its own for its marine waters and undertake a program of measures to achieve GES considering both the specificities to its own waters as well as the overall perspective of the marine region/subregion it belongs to. To ensure consistency and allow for comparison within/between marine regions/subregions, the European Commission stated a set of eleven Descriptors of the extent to which GES is being achieved. The issue of marine pollution is specifically faced in Descriptor 8, stating that *"Concentrations of contaminants must be at levels not giving rise to pollution effects".* As for all other Descriptors, within Decision 2010/477/EU distinctive technical features (*criteria*) are tagged together with a list of related *indicators*, which make the criteria operational and allow subsequent progress. Basically, Member States have to trace the progress status towards contamination levels not compromising the achievement GES, by focusing on: Criteria 8.1) concentration of contaminants, ensuring the comparability with the assessments under Directive 2000/60/EC (Indicator 8.1.1), and Criteria 8.2) effects of contaminants for which the cause/effect relationship has been established and needs to be monitored (Indicator 8.2.1), and physical impact of acute pollution events on biota (Indicator 8.2.2).

TBT fate in marine environments, already considered within the WFD and daughter Directives, is among the objectives which have to be considered for the achievement of Descriptor 8-GES of MSFD. In particular, as regards the monitoring of pollutants effects (indicator 8.2.1), the measurement of imposex development in wild gastropod populations is an effective candidate as bio-tool to be included within the monitoring programs. In fact, even if it is likely that

other toxicants might be able to induce imposex in marine snails by disrupting the hormonal system [16], it was largely demonstrated that TBT is the primary pollutant responsible for this effect, and is therefore a mature and valuable technique for assessing the environmental significance of TBT contamination. The analysis of imposex in marine gastropods species is already part of the monitoring protocols in use within some regional convention areas. In particular, since 2003 the evaluation of imposex in common whelks (Nucella, Littorina, Buccinum, Neptunea) is a mandatory commitment of OSPAR Contracting Parties (Convention for the Protection of the marine Environment of the North-East Atlantic) under the CEMP (Co-ordinated Environmental Monitoring Programme). In fact, OSPAR defined imposex in whelks as an Ecological Quality Element and, in collaboration with ICES, established the associated Ecological Quality Objective (EcoQO) as a reference for assessing the achievement of the desired level of marine quality (JAMP Guidelines for contaminant specific biological effects monitoring - OSPAR Agreement 2008-9; Provisional JAMP Assessment Criteria for TBT - Specific Biological Effects - *Reference Number 2004-15*). Also within the Baltic area (HELCOM - Helsinki Commission), during the recent CORESET expert workshop (CORESET HS 5/2013; <http://meeting.helcom.fi/web/guest/home>) the monitoring relevance of imposex was stated as a core indicator of TBT within the Baltic Sea Action Plan, at least for the next decade. By considering that the MSFD wishes for coordination among the existing Sea Conventions, whenever practical and appropriate, it is likely that this already developed bio-tool will be taken into account.

notes

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