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WHITE PAPER

Is the Writing on the Wall for Copper-based Antifouling Paint?

A close look at restrictions and legislation on copper and co-biocide based anti-fouling paints and a comparison with the cycle which led to the eventual ban of TBT

The Hydrex Group
www.hydrex.be

Part I. Introduction and overview

Antifouling paint based on Tributyltin (TBT) was developed in the 1960s, was widely available in the USA and Canada towards the end of that decade, and was in general use around the world in the 1970s, 1980s and 1990s and into the first decade of the 21st century.

Already by the late 1960s scientists were aware of the negative impact of TBT on non-target organisms, and its dangers to the marine environment and the food chain. These early warning signs were ignored and by the late 1970s TBT was in common use on the hulls of commercial and pleasure vessels globally.

In 1986 the US Navy filed a study showing that its proposed use of TBT antifouling paints on its entire fleet of some 600 ships would have no adverse environmental effects. Happily the EPA began a review of TBT which led to the US Congress barring the move.

Edward D. Goldberg of the Scripps Institution of Oceanography described TBT as "perhaps the most toxic substance deliberately introduced to the marine environment." Scientific evidence of this already abounded in the 1970s.

In the late 1970s the oyster crops in Arcachon Bay in France failed severely and the problem was traced back immediately to TBT on the hulls of the fishing boats in that area. In 1982, as a result of this, the French government banned the use of TBT on recreational vessels less than 25 meters in length.

By the early 1990s many countries had introduced legislation partially banning the use of TBT in antifouling paint on a local level.

It was not until 2001 that legislation to ban TBT globally was agreed at the International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS) of the International Marine Organization (IMO).

The eventual ban was to go into effect in January 2003. It mandated that by 2008 ships must either bear no organotin compounds on their hulls or surfaces or must have it sealed in so that it could not leach into the oceans.

The harmful environmental effects were already known in the late 1960s yet the destructive legacy of TBT continues to this day and will do so for some time to come; for example, whole ports and harbors cannot be dredged without bringing the toxic substances back into suspension with a risk to marine life in the area.

How does this parallel the use and restriction of the copper and co-biocide based antifouling paints which replaced TBT-based paints?

The same instrument by which the IMO banned TBT-based AF paint left the door open for the banning of any other harmful substances used for the same purpose.

Copper and many of the so-called "booster biocides" have come under increasing scrutiny and local legislation and restriction in much the same way and to the same degree that TBT did. Copper-based antifouling paints were banned in the Netherlands for pleasure craft in 1999. Copper-based bottom paints have been banned for pleasure craft on the Swedish Baltic coast, as well as in Denmark. Shortly before this White Paper was prepared, Washington State has placed a ban on copper-based antifouling paint on recreational craft and California is in the process of enacting similar legislation. The stated intent is to phase out biocidal antifouling paint completely. Many ports and states around the world forbid underwater hull cleaning on hulls coated with copper-based antifouling paint.

The steadily increasing restrictions and regulations follow much the same pattern as that which eventually resulted in the IMO's complete ban on TBT in antifouling paint.

This White Paper examines existing legislation and restrictions and compares the cycle which led to the banning of TBT with the current scrutiny and restriction which copper-based biocidal hull paint is undergoing. The aim is to help shipowners and operators predict the future for copper-based AF paints and act accordingly when it comes to painting or repainting the underwater hulls of their ships now and in the near future.

Part II. The progress of TBT in AF paint, from introduction to eventual ban

In order to help predict the fate of copper and co-biocide based antifouling paints, it is useful to understand what happened with organotin and TBT-based paints.

The term organotin refers to a chemical compound containing tin and carbon. Organotins include tributyltin (TBT), triphenyltin (TPT), dibutyltin, trimethyltin, triethyltin, and so on. The common denominators are tin and carbon. Organotin is used to encompass all these compounds. TBT is the best known organotin in the realm of antifouling paints although TPT was also used extensively. The chemistry is not important here. What is important is that these compounds, and particularly TBT, are extremely toxic to marine life and to the food chain.[1] This property made them highly effective as active ingredients in antifouling paint systems. The same property led to widespread harmful consequences to other marine life than those which attach themselves to ship hulls as fouling, and a risk to humans. Long after its use was regulated and banned internationally, the effects of its introduction into the marine environment has continued to be felt.[2] TBT is listed by the EU and the US EPA as an endocrine disruptor to humans.[3]

Organotin was first synthesized around the middle of the 19th century.[4] Its pesticidal properties began to be exploited in the 1950s. It was first used in antifouling paints between 1959 and 1961 in Europe.[5]

By the 1970s most of the world's ships and boats bore TBT-based antifouling paint on their hulls.[6]

In a 2002 bulletin, *Focus on IMO*, an article entitled "Anti-fouling systems" briefly traces the progress of TBT: [7]

> During the 1960s the chemicals industry developed efficacious and cost-effective anti-fouling paints using metallic compounds, in particular the organotin compound tributylin (TBT). By the 1970s, most seagoing vessels had TBT painted on their hulls.
>
> However , it soon became clear there was a price to pay for the efficient anti-fouling paints containing TBT. Environmental studies provided evidence that organotin compounds persist in the water and in sediments, killing sealife other than that attached to the hulls of ships and possibly entering the food chain. Specifically, TBT was shown to cause shell deformations in oysters; sex changes (imposex) in whelks, and immune response, neurotoxic and genetic affects in other marine species.
>
> In the 1970s-1980s, high concentrations of TBT in shellfish on the coast of France caused the collapse of commercial shellfisheries in at least one area, and this prompted many States to act and enforce some restrictions on the use of TBT in anti-fouling paints.
>
> In 1988, the problem was brought to the attention of the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO), the United Nations Agency concerned with the safety of shipping and the prevention of marine pollution.
>
> As a result, IMO in 1990 adopted a resolution recommending governments to adopt measures to eliminate anti-fouling paints containing TBT. In the 1990s, the MEPC continued to review the environmental issues surrounding anti-fouling systems, and in November 1999, IMO adopted an Assembly resolution that called on the MEPC to develop an instrument, legally binding throughout the

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[1] Ronald Eisler, "Tin Hazards to Fish, Wildlife, and Invertebrates: a Synoptic Review, US Fish and Wildlife Service Biological Report 85 (1.15) (January 1989.

[2] J. W. Farrington & T. L. Wade "Biochemistry of organic contaminants in aquatic ecosystems: honoring Dr. James G. Quinn," Symposia papers presented before the Division of Environmental Chemistry, America Chemical Society (2002).

[3] F. Grún et al., "Endocrine-Disrupting Organotin Compounds Are Potent Inducers of Adipogenesis in Vertebrates," Molecular Endocrinology, September 1, 2006 vol. 20 No 9, 2141-2155.

[4] Alwyn George Davies, *Organotin chemistry, Volume 1,* Wiley-VCH, (2004), p2.

[5] Tom Beer, *Environmental Oceanography,* p138 (1997)

[6] IMO, "Anti-fouling systems," *Focus on IMO*, (2002).

[7] Ibid.

> world, to address the harmful effects of anti- fouling systems used on ships. The resolution called for a global prohibition on the application of organotin compounds which act as biocides in anti-fouling systems on ships by 1 January 2003, and a complete prohibition by1 January 2008.
>
> In October 2001, IMO adopted a new International Convention on the Control of Harmful Anti-fouling Systems on Ships, which will prohibit the use of harmful organotins in antifouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti- fouling systems.
>
> The convention will enter into force 12 months after 25 States representing 25% of the world's merchant shipping tonnage have ratified it.

In 1985, despite a growing body of scientific data showing the dangers of TBT, the US Navy dismissed the findings as a strictly European problem and decided to implement TBT fleet wide. In 1986 the EPA began a special review on the subject. In 1988 the US Congress enacted the Organotin Paint Control Act (OPACA) which limited the use of TBT and prevented the US Navy's planned implementation. In 2003 its use on all ship hulls was banned.[8]

In 2001 the International Maritime Organization (IMO) adopted the International Convention on the Control of Harmful Antifouling Systems on Ships (ICAFS Convention). This Convention prohibited the use of harmful organotins in anti-fouling paints used on ships and established a mechanism to prevent the potential future use of other harmful substances in antifouling systems.[9] The Convention was adopted on 5 October, 2001 and entered into force on 17 September, 2008.

It is worth quoting the IMO's description of the Convention. It is often regarded simply as an international ban on TBT. However, its scope is much wider and lays a foundation for further restriction and prohibition of any substances used in AF paints which are harmful to the environment or human health:

> Under the terms of the new Convention, Parties to the Convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party.
>
> Ships of above 400 gross tonnage and above engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) are required to undergo an initial survey before the ship is put into service or before the International Anti-fouling System Certificate is issued for the first time; and a survey when the anti-fouling systems are changed or replaced.
>
> Ships of 24 metres or more in length but less than 400 gross tonnage engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) have to must carry a Declaration on Anti-fouling Systems signed by the owner or authorized agent. The Declaration must be accompanied by appropriate documentation such as a paint receipt or contractor invoice.
>
> Anti-fouling systems to be prohibited or controlled will be are listed in an annex (Annex 1) to the Convention, which will be updated as and when necessary.
>
> Annex I states that all ships shall not apply or re-apply organotins compounds which act as biocides in anti-fouling systems. By 1 January 2008 (effective date), ships either: (a) shall not bear such compounds on their hulls or external parts or surfaces; or (b) shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems.
>
> This applies to all ships (including fixed and floating platforms, floating storage units (FSUs), and Floating Production Storage and Offtake units (FPSOs).
>
> The Convention includes a clause in Article 12 which states that a ship shall be entitled to compensation if it is unduly detained or delayed while undergoing inspection for possible violations of the Convention.
>
> The Convention provides for the establishment of a "technical group", to include people with relevant expertise, to review proposals for other substances used in anti-fouling systems to be prohib-

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[8] J. W. Farrington & T. L. Wade "Biochemistry of organic contaminants in aquatic ecosystems: honoring Dr. James G. Quinn," Symposia papers presented before the Division of Environmental Chemistry, America Chemical Society (2002).

[9] IMO, "International Convention on the Control of Harmful Anti-fouling Systems on Ships," adoption: 5 October 2001; Entry into force: 17 September 2008.

ited or restricted. Article 6 on Process for Proposing Amendments to controls on Anti-fouling systems sets out how the evaluation of an anti-fouling system should be carried out.

Anti-fouling paints are used to coat the bottoms of ships to prevent sealife such as algae and molluscs attaching themselves to the hull – thereby slowing down the ship and increasing fuel consumption.

The Convention defines "anti-fouling systems" as "a coating, paint, surface treatment, surface or device that is used on a ship to control or prevent attachment of unwanted organisms".

In the early days of sailing ships, lime and later arsenic were used to coat ships' hulls, until the modern chemicals industry developed effective anti-fouling paints using metallic compounds.These compounds slowly "leach" into the sea water, killing barnacles and other marine life that have attached to the ship. But the studies have shown that these compounds persist in the water, killing sealife, harming the environment and possibly entering the food chain. One of the most effective anti-fouling paints, developed in the 1960s, contains the organotin tributylin (TBT), which has been proven to cause deformations in oysters and sex changes in whelks.

The harmful environmental effects of organotin compounds were recognized by IMO in 1989. In 1990 IMO's Marine Environment Protection Committee (MEPC) adopted a resolution which recommended that Governments adopt measures to eliminate the use of anti-fouling paint containing TBT on non-aluminium hulled vessels of less than 25 metres in length and eliminate the use of anti-fouling paints with a leaching rate of more than four microgrammes of TBT per day.

In November 1999, IMO adopted an Assembly resolution that called on the MEPC to develop an instrument, legally binding throughout the world, to address the harmful effects of anti-fouling systems used on ships. The resolution called for a global prohibition on the application of organotin compounds which act as biocides in anti-fouling systems on ships by 1 January 2003, and a complete prohibition by 1 January 2008.

The AFS convention was then developed and adopted in 2001. [10]

A timeline of the history of TBT will perhaps help one to visualize the rise, decline and fall of organotin compounds as active ingredients in antifouling systems:

Date	Incident/regulation/legislation
1849	Organotin first synthesized.
1950	Biocidal properties of organotin molecules discovered by a group headed by G. J. M. van der Kerk at the Institute for Organic Chemistry, TNO, Utrecht, Holland under sponsorship of the International Tin Research Institute in Greenford, England.
1952	Metals & Thermit Corp. (later part of Arkema, Inc.) filed patent in US for a process for making organotin halides.
1958	Metals & Thermit Company opened a plant in Carrollton, Kentucky, USA, producing organotin chemicals. (In 1962 Metals & Thermit became M&T Chemicals. In 1977 M&T Chemicals was acquired by Elf Aquitaine. All these companies became part of Arkema Chemicals, Inc.)
1960s	Synthetic organotin compounds first manufactured.
early 1960s	Organotin first used in antifouling (AF) systems.
1970s-1980s	TBT in use as antifoulant on the majority of ships and boats afloat.
1970s-1980s	High concentrations of TBT in shellfish on the coast of France caused the collapse of commercial shellfisheries in at least one area, and this prompted many States to act and enforce some restrictions on the use of TBT in anti-fouling paints.
1980s	High concentrations of TBT were reported in coastal areas around the world.
1982	French Ministry of Environment announced a temporary 2-year ban on TBT paint containing more than 3% organotin by weight for boats of less than 25 tons.

[10] Ibid.

Date	Incident/regulation/legislation
1986	US Environmental Protection Agency (EPA) initiated a review of TBT antifoulant registrations.
1987	US EPA issued a Preliminary Determination to Cancel Certain Registrations of TBT in which the agency proposed, among other things, to cancel all registrations which exceeded a daily release rate of 4.0 micrograms/cm^2 and prohibit the use of TBT antifouling paints on all nonaluminum vessels under 65 feet LOA.
1987	Switzerland: The use of TBT-based antifouling paints banned in freshwater lakes. All antifoulants must be registered.
1986-1987	UK prohibited the use of TBT-based paints on vessels less than 25 meters length overall (25 m LOA) and on fish-farming equipment. TBT antifoulants available only in 20 liter (L) containers. All antifoulants to be registered as pesticides; Advisory Pesticides Committee must approve sale and use. Washing/blasting slurry treated as hazardous.
1988	State of New York banned the sale and application of quick release tributyltin antifoulant bottom paints as of January 1, 1988.
1988	State of Rhode Island enacted the Tributyltin Antifoulant Paint Control Act. The Act prohibits the distribution, possession, sale, application, or offer for sale, use or application any marine antifoulant paints containing tributyltin compounds.
1988	US Congress enacted a partial ban on TBT antifouling paints, eliminating the need for EPA action. The Organotin Paint Control Act (OPACA) banned the application of antifouling paint containing organotin to vessels less than 25 m LOA.
1988	Problems with TBT brought to the attention of the Marine Environment Protection Committee of the IMO. Paris Commission requested IMO to consider the need for measures under relevant legal instruments to restrict the use of TBT compounds on seagoing vessels.
1989	Canada banned the use of TBT antifouling paints on vessels less than 25 m LOA, with the exception of vessels with aluminum hulls.
1989	Australia prohibited the use of TBT-based paints on vessels less than 25 m LOA. Maximum leaching rate of 5 micrograms per square centimeter per day (µg/cm2/day) for vessels greater than 25 m LOA. All dry-docks must be registered with the Environmental Protection Agency because of discharges. All antifoulants must be registered.
1989	New Zealand: The application of TBT copolymer antifouling paint banned with three exceptions: hulls of aluminum vessels, the aluminum out-drive, or any vessel greater than 25 m LOA.
1989	Norway prohibited the use of TBT-based paints on vessels less than 25 m LOA.
1989	US EPA issued a data call-in (DCI) to C K Witco and Elf Atochem (the only companies manufacturing TBT-based hull coatings in the USA, requiring 10 years of monitoring TBT concentrates in the water column, sediments and tissues of marine organisms at specified locations.
1989	Sweden prohibited the use of TBT-based paints on vessels less than 25 m LOA.
1990	IMO adopted a resolution recommending governments to adopt measures to eliminate antifouling paints containing TBT.
1990	Germany prohibited the use of TBT-based paints on vessels less than 25 m LOA. Ban on retail sale. Ban on its use on structures for mariculture. Regulation for the safe disposal of antifouling paints after removal.
1990	The Netherlands prohibited the use of TBT-based paints on vessels less than 25 m LOA. Washing/blasting slurry used to prepare TBT antifoulants to be treated as hazardous waste. TBT antifoulants available only in 20 L containers. All antifoulants must be registered.
1991	Europe (EC) prohibited the use of TBT-based paints on vessels less than 25 m LOA. TBT antifoulants available only in 20 L containers.

Date	Incident/regulation/legislation
1991	Finland prohibited the use of TBT-based paints on boats less than 25 m LOA.
1991	South Africa prohibited the use of TBT-based paints on vessels less than 25 m LOA. TBT antifoulants available only in 20 L containers. All antifoulants to be registered.
1992	Application of TBT antifoulings in Japan totally forbidden from 1992 on.
1992	By 1992 many individual nations had placed restrictions on the use of TBT. This includes landlocked nations such as Switzerland and Austria, to protect their inland waterways and lakes.
1992	Sweden restricted TBT paint to maximum leaching rate of 4μg/cm^2/day for vessels greater than 25 meters LOA. All antifoulants must be registered.
1993	New Zealand: The application of TBTO free-association paints banned. Maximum leaching rate of 5μg/cm^2/day for vessels greater than 25 meters LOA. All antifoulants must be registered. Use of any organotin containing antifouling paint prohibited.
1997	Japan prohibits the production of paint containing TBT.
1998	MEPC agreed at its 41st session in April 1998 to establish a Working Group at its 42nd session, later the same year, to begin work on drafting mandatory regulations to phase out and eventually prohibit the use of toxic anti-fouling systems containing organotin compounds such as TBT.
1999	Three companies were producing TBT. The world's largest producer was Witco with 75% of the world's market. In the USA Elf Atochem had 20% of the world market. The third company was Korean A. Song Woun which had 5% of the world market share. Six major paint companies manufactured and sold TBT based AF paint. International Paint had 28% of the world market share, 34% of the European market share. Jotun had 18% in both markets. Hempel had 16% world share and 18% European share. Chugoku, Sigma and Ameron had smaller shares. (Source Greenpeace, Amsterdam, "TBT: A Global Problem for the Marine Environment" 1999.)
1999	IMO adopted an Assembly resolution that called on the MEPC to develop an instrument, legally binding throughout the world, to address the harmful effects of anti- fouling systems used on ships. The resolution called for a global prohibition on the application of organotin compounds which act as biocides in antifouling systems on ships by 1 January 2003, and a complete prohibition by 1 January 2008.
2000	The Canadian Pest Management Regulatory Agency (PMRA) stopped accepting or processing applications to register new organotin antifouling paints and began a nationwide phase out of these products.
2000	The Biocidal Products Directive (BPD) entered into force in the EU to regulate the production, marketing and use of non-agricultural products intended for biocidal purposes which included antifouling paints.
2001	Vessels operating in Alaskan waters must not be repainted with TBT anti-foulings (Alaskan state law, 1/1/2001).
2001	IMO adopted a new International Convention on the Control of Harmful Anti-fouling Systems on Ships, which prohibited the use of harmful organotins in antifouling paints used on ships and established a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems. The convention was to enter into force 12 months after 25 States representing 25% of the world's merchant shipping tonnage ratified it.
2002	Canada completely banned the sale and use of TBT antifouling paints.
2003	Annex 1 to the AFS Convention, application of organotin compounds, e.g. TBT-based paints, has been banned since 1 January 2003.

Date	Incident/regulation/legislation
2003	Application of TBT antifoulings to all vessels forbidden in all EU countries under EU law.
2003	New EU law to be brought into force forbidding application of TBT antifoulings to any ship flying the flag of an EU country from April 2003 and banning the presence of TBT on all ships hulls by 1/1/2008. Ships changing flag to that of an EU country, where TBT was applied after 1/1/2003, must remove all TBT from the hull or apply a sealer coat.
2003	All antifoulings applied in Australia require registration with NRA (National Registration Authority) under pesticide laws. Registration of TBT antifoulings forbidden from June 2003.
2004	EPA released its final ambient water quality criteria for TBT in January 2004, pursuant to Section 304(a) of the Clean Water Act (CWA).
2008	Complete ban by IMO on TBT in AF paint. Ships either: (a) shall not bear such compounds on their hulls or external parts or surfaces; or (b) shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems. This applies to all ships (including fixed and floating platforms, floating storage units (FSUs), and Floating Production Storage and Offtake units (FPSOs).
2008	Vessels coated with active TBT paint are prohibited entry into EU ports irrespective of flag.

The effects of TBT continue in sediments in ports and harbors, around shipyards. Assurances about a short half life and no lasting harm to the environment have been shown to be vain.

While TBT has largely gone out of use in antifouling paint, some nations have not subscribed to the IMO regulations. Indeed, there is some possibility that some countries may challenge in court under fair competition law the right of nations to forbid TBT coated ships from entering ports of nations which do forbid TBT bearing hulls in their waters.[11]

The effects of TBT continue in sediments in ports and harbors and around shipyards. Assurances about a short half life and no lasting harm to the environment have been shown to be vain.

[11] S. Bray, "The long-term Recovery of the Bioindicator Species Nucella lapillus from Tributyltin Pollution." University of Southampton, Thesis submitted for the degree of Doctor of Philosophy, pp 204-205, (2005)

Part III. Legislation and regulation restricting the use of copper and other biocides in AF paints

As TBT based AF paints were outlawed, they were replaced in the main by AF systems which rely on copper and a variety of other biocides for their efficacy.

Copper and the other biocides were considered a less harmful alternative to TBT and were intended to be used until a better alternative became available, as explained in the following extract from a Greenpeace publication from 1999.

> There are several alternative products on the market. In some alternative anti-fouling systems, TBT has been replaced by another biocide. Examples of other biocides that are used in antifouling paints are Irgarol, which is an atrazine biocide, zineb, ziram and thiram. The TBT problem is replaced by another problem. An alternative that has been on the market for a long time already before TBT was introduced, is copper-based anti-fouling paint. Copper is less harmful to the marine environment compared to TBT and is proposed as intermediate alternative by most IMO-countries.[12]

Principle 15. Precautionary principle. In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Precautionary principle

The IMO's Resolution on early and effective application of the International Convention on the Control of Harmful Anti-fouling Systems on Ships made mention of the precautionary approach, as set out in Principle 15 of the United Nations Rio Declaration on Environment and Development, which states:

> Principle 15. Precautionary principle
>
> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[13]

The precautionary principle or precautionary approach states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking the action.

This principle allows policy makers to make discretionary decisions in situations where there is the possibility of harm from taking a particular course or making a certain decision when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result.

In some legal systems, as in the law of the European Union, the application of the precautionary principle has been made a statutory requirement.[14]

This is highly relevant to the application of biocidal antifouling paint on ship hulls where there is considerable conflict in scientific and pseudo-scientific opinion and reports with regard to the environmental consequences of such application. The differing opinions are not so surprising since industry often funds or commissions the investigations, and profits, values and vested interests can play their part in influencing the results.

The precautionary principle when exactly followed can circumvent the problem. As its title suggests, this approach leans towards an environmentally safe rather than a hazardous stance. It was built into the IMO Convention on the Control of Harmful Antifouling Systems and no doubt is guiding and will guide regulations on the subject of harmful antifouling systems and potentially harmful antifouling systems.

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[12] "TBT: A Global Problem for the Marine Environment," Greenpeace Amsterdam, 1999.

[13] Report of the United Nations Conference on Environment and Development, United Nations General Assembly, 12 August 1992

[14] http://en.wikipedia.org/wiki/Precautionary_principle, accessed 12 September 2011

Timeline of progress of copper and other biocides in AF paint

The following timeline lists some of the findings, restrictions and legislation regarding the use of copper and other biocides in antifouling paints to date. Since part of the purpose of this White Paper is to draw a parallel between the progress and fate of TBT and the progress and anticipated fate of other harmful biocides in AF coatings, it is worth comparing the TBT timeline given above with this timeline.

This timeline includes restrictions on the use of copper and also a number of alternative or co-biocides in use in AF paints. These include Irgarol 1051, Diuron, DCOIT (SeaNine 211), copper and zinc pyrithione, Dichlofluanid, Chlorothalonil, Econea, Medetomidine, Triphenylborane, Capsaicin, DDT and a number of other biocides.

Date	Incident/regulation/legislation
1990s-2000s	USA: Dissolved copper found to exceed levels allowed by state laws in marinas and harbors of the Chesapeake Bay in Maryland, of Port Canaveral and Indian River Lagoon in Florida, and in areas of Washington State.
1990s (early)	Irgarol 1051 and other biocides, introduced as alternatives to TBT, found to be contaminating salt and fresh water in Europe.
1992	Sweden: No antifouling products with Diuron have been approved since the first approval process of antifouling products in 1992. No antifouling products have been approved for use on pleasure boats in freshwater since 1992.
1999	NL: Following an environmental risk assessment, the Netherlands banned the use of copper-containing antifoulant paints for use on personal watercraft in 1999. The Netherlands also banned the cleaning or scrubbing of copper-bearing antifouling coatings.
1999	November 1999, IMO adopted an Assembly resolution that called on the MEPC to develop an instrument, legally binding throughout the world, to address the harmful effects of antifouling systems used on ships. With the phasing out of TBT in AF paints, copper in its various forms and a variety of other biocides became increasingly prevalent as alternative biocides. When TBT was finally banned, copper and other non-tin biocides replaced it in the main.
1999	UK: Professional products based upon RH-287 banned on vessels under 25 meters in length.
1999-2000	UK: It was also recommended that all amateur uses of antifouling products containing Chlorothalonil should be revoked after studies on human toxicology indicated that the risk of skin sensitization was unacceptably high. Amateur and professional use of TCMTB (Thiocyanomethylthiobenzothiazole) was revoked due to failure to supply outstanding data requirements.
2000	UK: Registration of Diuron in antifouling products was revoked in the UK in 2000, in view of its low degradability in seawater and low safety margin for adverse human hematological effects.
2000	UK: The amateur use of Irgarol 1051 was revoked due to environmental concerns and professional use was revoked due to failure to supply data requirements.
2000	The EU Biocidal Products Directive (BPD) entered into force 14 May 2000 intending to regulate the production, marketing and use of non-agricultural products intended for biocidal purposes. This includes antifouling substances and antifouling paints. Producers, importers and marketers of biocides in Europe must have their products registered with the BPD, which requires them to demonstrate that the particular products and the biocides they contain are of low risk to the environment and humans while being effective enough at allowed levels to do what it is supposed to do.

Date	Incident/regulation/legislation
2001	A treaty entitled "The International Convention on the Control of Harmful Antifouling Systems on Ships" (AFS Convention) was adopted in a Diplomatic Conference of the IMO. Article 4 of the AFS Convention requires that those parties acceding to the Convention prohibit or restrict the use of harmful antifouling systems on ships flying their flag or operating under their authority as well as any ship that enters a port, shipyard or offshore terminal of a party. Annex 1 attached to the Convention lists antifouling systems to be prohibited. It specifically mentions organotin compounds acting as biocides. But the Convention also established a mechanism for other harmful systems to be added to Annex 1 in the future. Such systems believed to be harmful can be proposed by any party to be added as an amendment to Annex 1. Proposals to be reviewed by a technical team and added as prohibited systems if found to be harmful.
2002-2003	With US EPA water standards for dissolved copper in marine waters at 3.1 parts per billion (ppb) and EPA considering reduction of this to 1.9 ppb, studies found concentrations as high as 8 ppb in San Diego Bay and 29 ppb in Newport Beach, California. Other studies showed that 90% of dissolved copper in boat basins comes from copper-based antifouling paint.
2003	Denmark: In September 2003 the Ministry of the Environment published Statutory Order No. 792 restricting import, sale and use of biocidal antifouling paint. The order includes: Import, sale and use of antifouling paint containing the biocides Diuron (CAS no. 330-54-1) or Irgarol (CAS no. 28159-98-0) on vessels of a total length of less than 25 m as defined by ISO 8666, shall be prohibited. Import, sale and use of biocidal antifouling paint on pleasure craft which are used predominantly in freshwaters shall be prohibited. Import, sale and use of biocidal antifouling paint, for which the release of copper exceeds 200 mg Cu/cm^2 within the first 14 days and 350 mg Cu/cm^2 within the first 30 days counted from the day it was applied, shall be prohibited on pleasure craft of more than 200 kilograms used primarily in salt waters. Import, sale and use of biocidal antifouling paint on pleasure craft of less than 200 kilograms used primarily in salt waters shall be prohibited. Import, sale and use of biocidal antifouling paint on pleasure craft releasing substances that meet the requirements of classification for environmental impact with the risk phrase, "May cause long-term adverse effects in the aquatic environment," (R53) alone or in combination with other risk phrases concerning harm to the aquatic environment, shall be prohibited after 1 January 2006.
2004	Sweden banned use of copper in AF paint on the East (Baltic) coast. Sweden restricted use of copper in AF paints on the West coast of Sweden.
2005	USA: Use of copper in antifoulings under review by EPA as part of re-registration eligibility decision (RED) process. Review should be complete in 2015. US Department of State and EPA also reviewing environmental inputs of copper from antifoulings used on US Government vessels. Decision (under Uniform National Discharge Standards [UNDS] regulations) expected in 2008/9 which will set maximum copper leaching rate for antifouling products used. All antifoulings applied in the USA require registration both Federally with the Environmental Protection Agency (US EPA) and with each state authority.
2005	Regional Water Quality Control Board San Diego region introduces restrictions on the use of copper-based hull paints.
2008	USA: A re-registration program in progress whereby chemicals registered before 1 Nov 1984 must be re-evaluated and re-registered to comply with contemporary safety standards and data requirements. Cuprous oxide was included in this program and the process was scheduled to be finalized in 2010. Further, a registration review program had been initiated covering all approved pesticides ensuring a periodical re-evaluation to establish that the products were still safe to use.

Date	Incident/regulation/legislation
2008	Canada established a maximum copper release rate limit for antifouling paints of 40 microgram/cm^2 painted surface per day. All registered antifoulings containing copper must have a release rate of less than 40μg copper/cm^2/day. All antifoulings applied in Canada require registration with the Government.
2008	EU: Antifoulings applied in EU member states must be notified or authorized for use. Products requiring sale in UK, Sweden, Malta, Netherlands, Eire, Belgium, Finland and Austria must be registered under national pesticide laws before supply can begin. The EU Biocidal Products Directive (98/8/EC) now active and a review of all antifouling biocides submitted for approval begun. Decisions on acceptability of these biocides not expected before 2010 at the earliest. If a biocide is deemed "acceptable" under the BPD, EU member states will then re-review antifouling products containing them that exist on the market. If acceptable, a product registration will be issued allowing sale and application of the product. Products deemed "unacceptable" will be removed from the EU market.
2008	US EPA awarded $190,000 in funding for Project NP00946501-4 entitled "Safer Alternatives to Copper Antifouling Paints for Marine Vessels" designed to find viable alternatives to copper hull paints.
2010	Department of Pesticide Regulation in California announces decision to initiate reevaluation of copper based antifouling paint pesticides. The list of products included in the reevaluation includes 179 products from 13 ship hull/boat bottom paint manufacturers. The substances under reevaluation include copper hydroxide and copper oxide.
2011	Estimates place use of copper and other biocide based AF paints at 90% of ship and boat hull coatings currently in use.
2011	USA, California: A legislative analysis prepared for the May 2 hearing before the Environmental Quality Committee reported that approximately 322 acres of San Diego Bay are listed as "impaired" because of dissolved copper. And it quoted the San Diego Regional Water Quality Control Board as reporting that approximately 98 percent of total copper loading in the San Diego Yacht Basin originates from copper-based antifouling paints applied to the hulls of recreational vessels.
2011	California introduces legislation banning the use of copper in AF paint on recreational craft sold or used in California and the application of such paint.
2011	May 3, Washington State Gov. Chris Gregoire signed legislation prohibiting the sale of recreational vessels 65 feet and smaller with copper-based antifouling paint beginning Jan. 1, 2018, and the sale or use of paint with more than 0.5 percent copper beginning Jan. 1, 2020.
2011	Final Report of the US EPA Project Safer Alternatives to Copper Antifouling Paints for Marine Vessels concluded that "viable alternatives to copper do exist and are available for use today." "This project achieved its goal to find viable alternatives that performed similar to copper paints. Moreover, high performing alternatives were identified that are available for use today. Thorough evaluations of cleaning strategies also were conducted and indicated that alternatives can be cleaned effectively and cost consciously. Finally, insights were made in better understanding the coating application procedures used for alternative coatings. All of which are believed to have cost-effective long term benefits that should help increase the use of these products."
2011	The Shelter Island Yacht Basin in the Port of San Diego subsidized the removal of copper antifouling paints from privately owned boats if the owners replace it with a non-biocidal hull paint. Funding from the California State Water Resources Control Board.

Details of legislation

The recent legislation in Washington and California in the USA is particularly interesting since it sets a likely precedent for further restrictions in the USA and internationally.

Washington State

Following is the final report of the bill as enacted:

FINAL BILL REPORT

SSB 5436

C 248 L 11

Synopsis as Enacted

Brief Description: Regarding the use of antifouling paints on recreational water vessels.

Sponsors: Senate Committee on Natural Resources & Marine Waters (originally sponsored by Senators Ranker, Shin, Litzow, Swecker, Tom, Harper, Nelson, Hobbs, Fraser, Rockefeller, White, Kilmer, Conway and Kline).

Senate Committee on Natural Resources & Marine Waters

House Committee on Environment

Background: Aquatic antifouling paints are used on water vessel hulls to prevent the growth of aquatic organisms such as barnacles and algae. Most of these antifouling paints use copper to reduce the growth.

According to a 2007 study, the Department of Ecology (DOE) has conducted research measuring copper concentrations in marinas and found the primary source of copper to be from the antifouling paints found on boat hulls. Research has shown copper to be highly toxic to aquatic life.

According to a 2007 study, the Department of Ecology (DOE) has conducted research measuring copper concentrations in marinas and found the primary source of copper to be from the antifouling paints found on boat hulls. Research has shown copper to be highly toxic to aquatic life. Summary: Recreational water vessels are defined as a vessel that is less than 65 feet in length, and used primarily for pleasure or leased, rented, or chartered to a person for the pleasure of that person. It does not include a vessel that is subject to United States Coast Guard inspection and is engaged in commercial use or carries paying passengers.

After January 1, 2018, new recreational water vessels with antifouling paint containing copper may not be sold in the state. Beginning January 1, 2020, the sale of copper antifouling paint intended for use on recreational water vessels is prohibited.

DOE is required to be responsible for the enforcement of the chapter. The money from the civil penalties collected must be deposited into the state Toxics Control Account.

DOE may establish a state wide advisory committee after January 1, 2016, to assist DOE in the implementation of the Act. DOE is also required to study how antifouling paints affect marine organisms and water quality. The study is in addition to the requirement to survey the manufacturers of antifouling paints to determine the type of paints available and report the findings of the survey to the Legislature by January 1, 2018.

DOE may adopt rules to implement the act.

Votes on Final Passage:

Senate 46 3

House 62 32 (House amended)

Senate 38 10 (Senate concurred)

Effective: July 22, 2011.

This analysis was prepared by non-partisan legislative staff for the use of legislative members in their deliberations. This analysis is not a part of the legislation nor does it constitute a statement of legislative intent.[15]

Following is the original report on the Senate Bill showing the arguments pro and con:

SENATE BILL REPORT

SB 5436

As of February 10, 2011

[15] Final Bill Report SSB 5436, Washington State, 22 July 2011.

Title: An act relating to reducing copper in antifouling paints used on recreational water vessels.

Brief Description: Reducing copper in antifouling paints used on recreational water vessels.

Sponsors: Senators Ranker, Shin, Litzow, Swecker, Tom, Harper, Nelson, Hobbs, Fraser, Rockefeller, White, Kilmer, Conway and Kline.

Brief History:

Committee Activity: Natural Resources & Marine Waters: 1/26/11.

SENATE COMMITTEE ON NATURAL RESOURCES & MARINE WATERS

Staff: Sherry McNamara (786-7402)

Background: Aquatic antifouling paints are used on water vessel hulls to prevent the growth of aquatic organisms such as barnacles and algae. Most of these antifouling paints use copper to reduce the growth.

According to a 2007 study, the Department of Ecology has conducted research measuring copper concentrations in marinas and found the primary source of copper to be from the antifouling paints found on boat hulls. Research has shown copper to be highly toxic to aquatic life.

Summary of Bill: Recreational water vessels are defined as watercraft that are operated solely for pleasure and not for monetary gain.

After January 1, 2013, new recreational water vessels with antifouling paint containing copper may not be sold in the state. After January 1, 2018, any recreational water vessel being sold must have been stripped of copper paint or sealed. And after January 1, 2020, no antifouling paint containing more than 0.5 percent copper may be sold in Washington.

The Department of Ecology must monitor and certify compliance with the requirements. A civil fine is set for up to $10,000 per day per violation.

Appropriation: None.

This analysis was prepared by non-partisan legislative staff for the use of legislative members in their deliberations. This analysis is not a part of the legislation nor does it constitute a statement of legislative intent.

Fiscal Note: Available.

Committee/Commission/Task Force Created: No.

Effective Date: Ninety days after adjournment of session in which bill is passed.

The state has a program that will phase out copper in brake pads; it is now time to do the same with copper paint on boats. There are alternative paints and products available now that are effective and affordable.

Staff Summary of Public Testimony: PRO: Copper is a very significant toxicant for many aquatic species, including salmon. The Department of Ecology estimates that copper bottom paint represents about 10 percent of overall loading of copper in Puget Sound, which is concentrated in the marinas. The state has a program that will phase out copper in brake pads; it is now time to do the same with copper paint on boats. There are alternative paints and products available now that are effective and affordable. The timeframe for the phase out should take into account that even after the paint is banned, there will be several years delay before the vast majority of recreational vessels are using nontoxic paint. Boatyards are closing because of copper contamination; this bill is vitally important to our industry.

CON: We understand the need to protect the state's waters; in fact, it is our position that banning effective antifouling coatings containing copper may create a risk by increasing the potential for invasive species in the waters. Currently, there is no evidence that the copper levels resulting from boat hull coatings present any real harm to the fisheries in Washington. The studies to date show there are no high levels of copper found in the waters where salmon travel, as the problem exists in marinas. The greater risk is allowing an invasive species into the waters and spending millions of dollars to eradicate it. It is our recommendation that further studies are conducted before any final decision is made to ban an effective antifouling coating.

OTHER: There are amendments that we would like to offer to change the definition of recreational vessel to be consistent with the federal Clean Boating Act of 2008. The definition should include boats 65 feet or less. A three-year timeframe from January 1, 2012, to January 1, 2015, is sufficient time for the paint industry to adapt. There are already boatyards that are copper free.

Persons Testifying: PRO: George Harris, Northwest Marine Trade Association (NMTA); Michael Grayum, Puget Sound Partnership; Bridget Moran, Department of Natural Resources; Bruce Wishart, People for Puget Sound; Jim Brown, NMTA, YachtCare.

CON: Neal Blossom, American Coatings Association, American Chemet Corporation.

OTHER: Don Seeberger, DOE.[16]

California bill

The proposed California bill which as of 18 August, 2011 was still making its way through the legislative procedure contains the following:

AMENDED IN ASSEMBLY JUNE 21, 2011

AMENDED IN SENATE APRIL 25, 2011

SENATE BILL No. 623

Introduced by Senator Kehoe

February 18, 2011

An act to add Chapter 8 (commencing with Section 117140) to Part 12 of Division 104 of the Health and Safety Code, relating to public health.

LEGISLATIVE COUNSEL'S DIGEST

SB 623, as amended, Kehoe. Vessels: marine antifouling paint.

Under existing law, the Department of Boating and Waterways regulates the operation and equipment of vessels. The Director of Boating and Waterways administers the department. Existing law regulates various substances in products, like lead, copper, and mercury, that can lead to public health issues when introduced into the environment.

This bill would require the Department of Pesticide Regulation, by January 1, 2014, to determine the maximum allowable leach rate for low-leach rate antifouling paints. The bill would prohibit, on and after January 1, 2015, a manufacturer, wholesaler, retailer, or distributor from selling or offering for sale in California a new recreational vessel, as defined, containing antifouling paint that contains copper. The bill also would prohibit, on and after January 1, 2019 2015, the use or application of antifouling paint that contains copper on recreational vessels, except as provided. The bill would require the State Water Resources Control board, by January 1, 2019, and biennially thereafter, to determine whether the use of low-leach rate copper-containing antifouling paints could result in the attainment of water quality objectives in marinas and harbors for dissolved copper. The bill would, on of after January 1, 2019, prohibit the use or application of antifouling paint on recreational vessels one year after a determination by the State Water Resources Control Board that the trend line of measured water quality data does not point toward attainment of the dissolved copper water quality objectives in marinas and harbors.

...

The people of the State of California do enact as follows:

SECTION 1. The Legislature finds and declares all of the following:

Copper is toxic to many aquatic organisms and plants. Its concentration in water and sediments can increase to the point of impacting the food web in the marine environment by eliminating certain species.

(a) Marine antifouling paints are used on vessel hulls to prevent the growth of aquatic organisms, such as barnacles and algae. Most antifouling paints use copper to prevent the growth of aquatic organisms. Copper-containing marine antifouling paints are a source of copper releases in marinas within California estuaries and along shorelines.

(b) Copper is toxic to many aquatic organisms and plants. Its concentration in water and sediments can increase to the point of impacting the food web in the marine environment by eliminating certain species. Copper is one of the metals listed in the federal Clean Water Act (33 U.S.C. Sec. 1251 et seq.) that the state is required to regulate. Numerous bays and harbors throughout California have water quality impairments due to copper, as referenced by the California 2008–2010 303(d)

[16] Senate Bill Report SB 5436, State of Washington, USA, 10 February 2011.

list of impaired water bodies. As such, measures must be taken to reduce impacts on aquatic environments by reducing copper loads in these areas.

(c) Best management practices relative to in-water hull cleaning of recreational vessels can help to minimize biocide input and invasive species transport in state waters.

(d) Boating is an important part of the economic and social fabric of California. California has approximately 800,000 recreational boats and more than three million people who participate in recreational boating annually. These boaters contribute $1.2 billion to the state's Gross State Product and have a direct impact on over 24,000 jobs with labor income of $750 million. Any policy affecting boating must ensure that boating continues to be a vigorous part of California life. Therefore, it is the intent of the Legislature that any policy relating to the application or use of paints on vessel hulls be structured in a manner that protects these values.

(e) Due to the inherent conflict between the need for an antifouling paint that effectively controls the growth of aquatic organisms on vessel hulls and the federal requirements under the federal Clean Water Act to protect aquatic environments from pollution, it is the intent of the Legislature to promote the use of nonbiocide paints in order to balance the needs of these conflicting interests.[17]

Due to the inherent conflict between the need for an antifouling paint that effectively controls the growth of aquatic organisms on vessel hulls and the federal requirements under the federal Clean Water Act to protect aquatic environments from pollution, it is the intent of the Legislature to promote the use of nonbiocide paints in order to balance the needs of these conflicting interests.

The American Coatings Association, which represents coating manufacturers, said such legislation could, "serve as a terrible precedent for other U.S., foreign and international authorities to follow."[18]

The Hull Paint Conversion Program was developed after water regulators identified the Shelter Island Yacht Basin as an area where high copper levels exceed federal and state standards. A regulatory order requires the port, marinas, yacht clubs, hull cleaners and boaters to reduce copper pollution in the area by 76% by 2022.[19]

The progress of restrictions on copper and other harmful biocides, even if slow, appears to be accelerating and inexorable.

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[17] California Senate Bill No. 263 amended in Senate April 25, 2011, Amended in Assembly June 21, 2011

[18] PaintSquare, July 13, 2011.

[19] Ibid.

Part IV. Comparing the progress of legislation and restriction regarding copper and other biocides with the TBT cycle

It has been estimated that about 90% of the hulls currently in the water around the world are painted with antifouling paint containing copper and/or other biocides.[20]

Many shipowners/operators have already been through the exercise of making sure their ships were in compliance with the AFS Convention which banned TBT from use. In many cases this consumed valuable time and money with additional time off-hire in drydock and all the expense of recoating the hulls of their ships. While one might protest and try to blame regulatory bodies for bringing this situation about, the responsibility lies squarely on the shoulders of those who marketed, sold and applied a chemical which was hazardous to the environment, the food chain and human health without taking the necessary precautions to make sure that what they were selling was safe and benign to the environment and human health. The regulatory bodies acted to prevent further harm.

If there is one lesson to be learned from the history and fate of TBT it would surely be not to repeat it with another substance.

If there is one lesson to be learned from the history and fate of TBT it would surely be not to repeat it with another substance.

With newbuilds on the way and hulls being completely repainted, shipowners and operators want to make sure that they are not applying a coating which is going to have to be replaced prematurely because some or all of the biocides it contains have been banned.

It is important to be able to plan ahead and avoid a recurrence of a costly and time wasting exercise.

With this in mind it is worth comparing the timelines above for TBT, beginning with its introduction as the key active ingredient in antifouling paints to its final eventual prohibition by the IMO, with the timeline for copper and other biocides.

By the 1970s TBT had gained widespread acceptance and was in general use. Estimates placed this market share at about 75%.[21]

Copper and co-biocide AF paint had been in use before TBT began to be employed, but other biocides were largely phased out and replaced by TBT. When TBT was banned, copper and the various co-biocides were reintroduced and AF paint laden with these biocides became the most widely used underwater ship and boat hull coatings. In 2011 an experienced paint inspector and consultant estimated that 90% of the current world fleet is using tin-free antifouling paint with 10% using fouling release and other coatings.[22]

As TBT came into more widespread use, contrary effects on the marine environment began to be reported.

Similarly with copper and co-biocides, reports of harm to the environment began to appear.

With TBT, the reports were ignored or dismissed for some time.

With copper and the other biocides, industry has attempted to invalidate the reports of the toxicity and harmful effects which concentrations of these heavy metals and poisons cause to non-target species and to the environment in general. Yet the scientific evidence continues to mount.

The reports on TBT began to be acted on, starting in 1982 in France. The initial restrictions were local and gradually spread and increased.

With copper, Irgarol, Diuron and other biocides currently in use, restrictions have so far been imposed locally and these have increased in number and scope. Copper and other biocides currently used in AF paints have been banned in certain areas and for certain types of craft. The

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[20] Interview with Gunnar Ackx, "Ship Hull Coatings – A Paint Inspector/Specialist's Perspective." *Journal of Ship Hull Performance,* Vol 1. Issue 2, p 74 (April, 2011).

[21] Candries, Maxim, "Drag, boundary-layer and roughness characteristics of marine surfaces coated with antifoulings," Newcastle University, Doctorate Thesis, p 1, 15: (2001)

[22] Interview with Gunnar Ackx, "Ship Hull Coatings – A Paint Inspector/Specialist's Perspective." *Journal of Ship Hull Performance,* Vol 1. Issue 2, p 74 (April, 2011).

Netherlands, Sweden, Denmark, the UK, the USA, have all placed restrictions on biocides currently in use. This follows the pattern that was adopted with TBT.

In the USA, the State of Washington is the first state to ban the use of copper in AF paints for certain vessels. California is rapidly following suit.

Comparing the progress of regulation and legislation on copper and co-biocide based antifouling paints and the history of TBT, one finds many similarities. While copper and some of the co-biocides in use appear to be less harmful than TBT, there are other biocides and combinations of biocides in use which appear to have the same types of unwanted environmental effects as TBT (and which resulted in the ban of TBT).[23]

Concerns about the effects of TBT led to the first attention placed by the IMO on the subject of harmful antifouling systems. In fact the concerns about TBT had been growing for over 20 years before the situation escalated to IMO level. Quicker action on an international basis would have curtailed and reduced the long term harmful effects of TBT which are still being felt. These effects will continue to be felt for some time, despite the fact that the ban came into effect in 2008, 20 years after the IMO's attention was first drawn to the problem.

The same IMO treaty which banned TBT also created a mechanism for future restrictions or banning of other antifouling systems which might prove to be harmful to the environment. Because the methods and organization are now in place, faster action can be expected in the future. Articles 4, 6, 8 and 9 of the text adopted by the IMO Conference reads as follows:[24]

ARTICLE 4

Controls on Anti-Fouling Systems

(1) In accordance with the requirements specified in Annex 1, each Party shall prohibit and/or restrict:

(a) the application, re-application, installation, or use of harmful anti-fouling systems on ships referred to in article 3(1)(a) or (b); and

(b) the application, re-application, installation or use of such systems, whilst in a Party's port, shipyard, or offshore terminal, on ships referred to in article 3(1)(c),

and shall take effective measures to ensure that such ships comply with those requirements.

(2) Ships bearing an anti-fouling system which is controlled through an amendment to

Annex1 following entry into force of this Convention may retain that system until the next scheduled renewal of that system, but in no event for a period exceeding 60 months following application, unless the Committee decides that exceptional circumstances exist to warrant earlier implementation of the control.

ARTICLE 6

Process for Proposing Amendments to Controls on Anti-Fouling Systems

(1) Any Party may propose an amendment to Annex 1 in accordance with this article.

(2) An initial proposal shall contain the information required in Annex 2, and shall be

submitted to the Organization. When the Organization receives a proposal, it shall bring the proposal to the attention of the Parties, Members of the Organization, the United Nations and its Specialized Agencies, intergovernmental organizations having agreements with the Organization and non-governmental organizations in consultative status with the Organization and shall make it available to them.

(3) The Committee shall decide whether the anti-fouling system in question warrants a more in-depth review based on the initial proposal. If the Committee decides that further review is warranted, it shall require the proposing Party to submit to the Committee a comprehensive proposal

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[23] Stefan Nehring, "After the TBT Era: Alternative Anti-fouling Paints and their Ecological Risks," Senckenbergiana maritima, (2001)

[24] IMO, Adoption of the Final Act of the Conference and any Instruments, Recommendations and Resolutions Resulting from the Work of the Conference – International Convention of the Control of Harmful Anti-fouling Systems on Ships, 2001" Text adopted by the Conference.

containing the information required in Annex 3, except where the initial proposal also includes all the information required in Annex 3. Where the Committee is of the view that there is a threat of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason to prevent a decision to proceed with the evaluation of the proposal. The Committee shall establish a technical group in accordance with article 7.

(4) The technical group shall review the comprehensive proposal along with any additional data submitted by any interested entity and shall evaluate and report to the Committee whether the proposal has demonstrated a potential for unreasonable risk of adverse effects on non-target organisms or human health such that the amendment of Annex 1 is warranted. In this regard:

(a) The technical group's review shall include:

(i) an evaluation of the association between the anti-fouling system in question and the related adverse effects observed either in the environment or on human health, including, but not limited to, the consumption of affected seafood, or through controlled studies based on the data described in Annex 3 and any other relevant data which come to light;

(ii) an evaluation of the potential risk reduction attributable to the proposed control measures and any other control measures that may be considered by the technical group;

(iii) consideration of available information on the technical feasibility of control measures and the cost-effectiveness of the proposal;

(iv) consideration of available information on other effects from the introduction of such control measures relating to:

- the environment (including, but not limited to, the cost of inaction and the impact on air quality);
- shipyard health and safety concerns (i.e. effects on shipyard workers);
- the cost to international shipping and other relevant sectors; and

(v) consideration of the availability of suitable alternatives, including a consideration of the potential risks of alternatives.

(b) The technical group's report shall be in writing and shall take into account each of the evaluations and considerations referred to in subparagraph (a), except that the technical group may decide not to proceed with the evaluations and considerations described in subparagraph (a)(ii) through (a)(v) if it determines after the evaluation in subparagraph (a)(i) that the proposal does not warrant further consideration.

(c) The technical group's report shall include, inter alia, a recommendation on whether international controls pursuant to this Convention are warranted on the anti-fouling system in question, on the suitability of the specific control measures suggested in the comprehensive proposal, or on other control measures which it believes to be more suitable.

(5) The technical group's report shall be circulated to the Parties, Members of the Organization, the United Nations and its Specialized Agencies, intergovernmental organizations having agreements with the Organization and non-governmental organizations in consultative status with the Organization, prior to its consideration by the Committee. The Committee shall decide whether to approve any proposal to amend Annex 1, and any modifications thereto, if appropriate, taking into account the technical group's report. If the report finds a threat of serious or irreversible damage, lack of full scientific certainty shall not, itself, be used as a reason to prevent a decision from being taken to list an anti-fouling system in Annex 1. The proposed amendments to Annex 1, if approved by the Committee, shall be circulated in accordance with article 16(2)(a). A decision not to approve the proposal shall not preclude future submission of a new proposal with respect to a particular anti-fouling system if new information comes to light.

(6) Only Parties may participate in decisions taken by the Committee described in paragraphs (3) and (5).

ARTICLE 8

Scientific and Technical Research and Monitoring

(1) The Parties shall take appropriate measures to promote and facilitate scientific and technical research on the effects of anti-fouling systems as well as monitoring of such effects. In particular, such research should include observation, measurement, sampling, evaluation and analysis of the effects of anti-fouling systems.

(2) Each Party shall, to further the objectives of this Convention, promote the availability of relevant information to other Parties who request it on:

(a) scientific and technical activities undertaken in accordance with this Convention;

(b) marine scientific and technological programmes and their objectives; and

the effects observed from any monitoring and assessment programmes relating to anti-fouling systems.

ARTICLE 9

Communication and Exchange of Information

(1) Each Party undertakes to communicate to the Organization:

(b) on an annual basis, information regarding any anti-fouling systems approved, restricted, or prohibited under its domestic law.

(2) The Organization shall make available, through any appropriate means, information communicated to it under paragraph (1).

(3) For those anti-fouling systems approved, registered or licensed by a Party, such Party shall either provide, or require the manufacturers of such anti-fouling systems to provide, to those Parties which request it, relevant information on which its decision was based, including information provided for in Annex 3, or other information suitable for making an appropriate evaluation of the anti-fouling system. No information shall be provided that is protected by law.

Invocation of the precautionary principle will help shorten the time between the discovery of harmful effects of biocides and their withdrawal from use.

Now one can expect that other biocides including copper, Irgarol, Diuron and so on will be proposed as additions to Annex 1 and will go through studies at IMO level which eventually lead to their prohibition.

Invocation of the precautionary principle should help shorten the time between the discovery of harmful effects of biocides and their withdrawal from use.

Part V. Conclusions and recommendations

Even if slow to appear and even if not yet fully formed and clear, the writing is indeed on the wall for the current widely used copper and co-biocide based antifouling systems.

Comparing the history of TBT in AF paints with the progress of copper and other biocides currently in use, the likelihood is that alternative, nonbiocidal, environmentally-benign antifouling systems will replace the existing copper and co-biocide based antifouling paints. The length of time this will take to occur can also be predicted to some degree.

Fortunately, there are extant alternatives to biocidal AF systems, tested and in use today, which

1. Are completely non-toxic
2. Are much more economical (especially when the total cost of ownership for the vessel is considered)
3. Help reduce fuel consumption by 20% or more when compared to conventional AF systems and result in a similar percentage reduction in greenhouse gases, NOx, SOx and particulate matter emissions
4. Are a more effective approach than biocidal AF systems to preventing the spread of alien invasive species.[25]

What should shipowners/operators, boat owners, ship builders, naval architects do?

When it comes time to build a new boat or ship or to reblast and recoat an existing hull, those responsible should consider the options carefully, look to the future of that boat or ship, compare the hull coating systems available and "crunch the numbers" carefully, not necessarily for the day or the week but for the rest of the life of the ship.

They should take into account the marine environment not only for the present but as it will be for their children and their grandchildren and future generations who will want to enjoy seafood, clean oceans and waterways, safe ports and harbors.

On this subject, there is an interesting and very human note at the end of the highly scientific volume, *Ecotoxicology of Antifouling Biocides,* edited by T. Arai, H. Harino, M. Ohji and W.J. Langston, published by Springer in 2009. The note tends to put in very clear perspective all the scientific data amassed on the subject as delineated in the earlier chapters of the book. It reads:

> Without wishing to sound emotive, but on a more personal note, Dr. Ohji, one of the editors of this volume, became a parent in March, 2008. The eyes of the baby are clear and innocent. We guess from baby's eyes that there is anticipation to experience a new world and hopefully a safe and comfortable world. This expectation applies to all animals on the earth. Our job as parents and guardians is to help fulfill these expectations. We hope that this book will make a useful contribution towards understanding and managing the specific issue of antifouling and would like to appeal to all for "continuous efforts to help restore and sustain a clean marine environment" for the benefit of future generations.

Taking all this into account, shipowners, shipbuilders, boat owners, naval architects, shipyards and all those who make decisions about the type of antifouling system that is applied to ships and boats around the world are duty-bound to thoroughly research the available approaches and adopt the one which best meets all these criteria, for the present and for the future.

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[25] Hydrex White Paper No. 4, "Ship Hull Coating Systems Simplified," www.shiphullperformance.org, 2011

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editors@shiphullperformance.org

European Headquarters

Hydrex nv
Haven 29
2030 Antwerp
Belgium

Phone: +32 3 213 53 00 (24/7)
Fax: +32 3 213 53 21
E-mail: hydrex@hydrex.be
www.hydrex.be

US Office

Hydrex LLC
604 Druid Rd E
Clearwater, FL 33756
USA

Phone: +1 727 443 3900 (24/7)
Fax: +1 727 443 3990
E-mail: info@hydrex.us
www.hydrex.us

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