The Shift in Antifouling Coating Regulations: from Risk to Efficacy

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Fouling of underwater surfaces poses significant challenges for the global maritime sector. The attachment and growth of barnacles, algae, and other organisms can damage vessels, significantly decrease fuel economy and maneuverability, and transmit invasive species. To minimize these negative impacts, the maritime sector relies on effective antifouling coatings. Copper[1] is by far the most widely used active ingredient (AI) in antifouling coatings and there are a limited number of alternatives. Multiple risks assessments of antifouling coatings and the AIs in them have been conducted globally, on a national and regional basis, and these risk assessments are now becoming increasingly repetitive, relying on the same data to reach the same conclusions. With a push for sustainability of shipping and recreational boating and the growing realization that invasive species pose a much greater environmental risk than the fully assessed antifouling AIs, maritime regulations are focusing in a new direction: towards ensuring effective prevention of biofouling. This paper reviews the latest antifouling risk and efficacy regulations and highlights this shift in regulatory focus.

Background

Biofouling of vessel hulls begins within minutes of a vessel launch. Biofouling increases the ship's drag, which decreases speed and range, and increases fuel consumption and greenhouse gas emissions by as much as 40 percent[2]. Beyond these frictional effects, high levels of biofouling can require increased dry-docking operations for maintenance and repair, and reduce the overall integrity of recreational vessel hulls. These factors create significant financial impacts on vessel owners. Fuel costs account for more than 50 percent of commercial marine transportation costs. In-water hull cleaning to remove biofouling on commercial vessels costs from $5,000 to $50,000, depending on the size of the ship and level of fouling, and frequent cleanings delay voyaging. Fouling also has a significant effect on recreational craft where shipworms (e.g. *T. navalis*) on wooden hulls and barnacles on fiberglass hulls can cause significant damage.

In addition to causing hull damage and reducing fuel economy, fouling can result in the transport and introduction of nonindigenous, invasive species which pose a significant economic, environmental, and public health threat. The most widely cited reports state that invasive species cost the United States more than $100 billion in damages every year.[3] Reducing the transmission of invasive species is thus becoming an increasingly high priority for numerous governments and international organizations. Recreational

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[1] "Copper" is a generic term for inorganic copper compounds dicopper oxide, copper thiocyanate and metallic copper

[2] Vietti, P. (Fall 2009). "New Hull Coatings Cut Fuel Use, Protect Environment" (PDF). Currents: 36–38.

[3] Invasive Non-native Species: Background and Issues for Congress (Nov 25, 2002); Library of Congress. Congressional Research Service, CRS Report RL30123

vessel biofouling can be a significant vector in the transportation and introduction of invasive species, with marinas being an ideal habitat for non-indigenous species to establish themselves and become invasive.[4]

Supra-national efforts to create universal agreement on AIs in antifoulings are coordinated by the International Maritime Organization (IMO) under the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, instrumental in the global ban on the use of tributyltin (TBT). Antifouling coatings and their AIs are regulated on a national or regional basis (EU). Each regulatory body is charged with determining whether or not the coatings and actives pose an unreasonable risk to humans and the environment. The risk assessments are in-depth reviews of the effects of these products on a range of species, determined by the concentrations found in the environment, and human exposure scenarios and effects. Active ingredient and coatings manufacturers have spent millions of dollars producing the studies, as required, for regulators to make sound decisions. Some risk assessments also consider the benefits of these products, with effective antifoulings being key to preventing the negative consequences described above.

The most recent risk assessments include those conducted by the EU, New Zealand, Canada (where copper is the only approved active ingredient) and the USA (on-going for copper). A limited number of AIs were allowed prior to these assessments and this number has been reduced in some countries and regions, where some AIs were not defended by the manufacturers and others failed the risk assessments. The only AI approved universally in all four jurisdictions is copper.

Recent biofouling regulatory actions and initiatives by New Zealand, Australia, USA, California and the IMO require reduction of risks associated with biofouling. These activities are pushing the maritime industry to use the best economically viable coatings with appropriate hull management practices to minimize biofouling. There are also mandatory energy efficiency standards and targets for commercial shipping. To meet these goals anti-fouling efficacy is an essential element.

There is thus a shift in global regulatory focus from anti-fouling toxicity concerns, which have been addressed in multiple studies and assessments over many years, to antifouling efficacy requirements.

Past Antifouling Regulatory Activities and Methods

Biocidal antifouling coatings contain substances that deter organism attachment on hulls by leaching small amounts of chemicals from their surfaces. To assess the risk of this environmental input, and the risks from human exposures to the chemicals involved, regulatory bodies require extensive studies.

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[4] Jasmine Ferrario, Sarah Caronni, Anna Occhipinti-Ambrogi & Agnese Marchini (2017) Role of commercial harbours and recreational marinas in the spread of non-indigenous fouling species, Biofouling, 33:8, 651-660, DOI: 10.1080/08927014.2017.1351958

Risk assessments have become more sophisticated and expensive over time, with the data and information shared globally. Therefore the risk assessment methodology and outcomes have become increasingly similar globally. For example, mathematical models can be used to predict environmental concentrations in water and sediments. In some jurisdictions, the models are then verified for accuracy with *in situ* monitoring studies. The MAMPEC Model (Marine Antifoulant Model to Predict Environmental Concentration), first released in 1999, is accepted globally as a standard risk assessment tool. The leach rate of an AI from a coating is a key input used in the MAMPEC model and the ISO mass-balance calculation method (ISO10890:2010, published October 2010) has found acceptance in the EU, California, Australia and New Zealand as the best predictor of leach rate.

Organism and human health studies are expensive to conduct, and for ethical reasons repetitive animal exposure studies are to be avoided. The UN Office of Economic Cooperation and Development have developed guidelines for testing of chemicals for their toxicity, and these guidelines are being utilized globally. Thus the same toxicity studies are utilized in multiple risk assessments. A current example is the up-coming Korea Biocide Product Regulation, wherein much of the data used in the EU Biocide Product Regulation is being provided to Korean authorities.

As would be expected, when the same or similar risk assessment methodology is used with the same or similar input data, the outcome of the risk assessments are similar. For example, the recent risk assessments in New Zealand and the EU both agreed to approve the antifouling AIs cuprous oxide, copper thiocyanate, metallic copper, DCOIT (Sea-Nine), Zineb and Copper Pyrithione, while other AIs including diuron, octhilinone, thiram, ziram, chlorothalonil and Irgarol 1051 were either not approved, are phasing out, or were not defended.

<u>New Antifouling Regulatory Actions and Initiative Focus</u>

The IMO Ship Energy Efficiency Standard came into force in January 2013, the first global energy efficiency standard for any industry sector. Part of this standard is the requirement to institute a Ship Energy Efficiency Management Plan (SEEMP), which includes aspects of hull maintenance. The 2016 SEEMP guidelines recommend using the optimal coatings in combination with appropriate cleaning intervals and regular in-water inspection of the condition of the hull. It further recommends considering "*the possibility of timely full removal and replacement of underwater paint systems to avoid the increased hull roughness caused by repeated spot blasting and repairs over multiple dockings*."

In April 2018 IMO adopted a strategy to reduce greenhouse gas emissions by 50% by 2050. The discussion of the achievement of this goal highlighted the importance of the SEEMP. Clearly the emphasis on the effectiveness of antifouling coatings will garner increasing global attention in the years to come.

A number of recent regulations focus on the risk of transport of non-indigenous species that can establish in new environments and become invasive. IMO adopted the *Guidelines for Managing Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species* in 2011. These guidelines include maintenance history (including type, age and condition of any anti-fouling coating system), installation and operation of anti-fouling systems,dry-docking/slipping and hull cleaning practices. The guidelines note "*Implementing practices to control and manage biofouling can greatly assist in reducing the risk of the* *transfer of invasive aquatic species*" and that "*Antifouling systems and operational practices are the primary means of biofouling prevention and control for existing ships' submerged surfaces, including the hull and niche areas.*"

IMO also recognized that recreational craft are a key vector for the transfer of invasive species. The *Guidance for Managing Recreational Craft Biofouling to Minimizing the Transfer of Invasive Aquatic Species* was adopted in 2012. To maximize the benefits of antifouling it states in the guidance "*Different antifouling coating systems suit different craft and activities*." and "*… an appropriate anti-fouling coating system and good maintenance are the best way of preventing biofouling accumulation*."

An initiative that is just beginning to assist in the prevention of invasive species introduction, primarily in developing countries, is the Glofouling Project. This global project to help protect marine ecosystems from invasive aquatic species was founded by the Global Environment Facility, the United Nations Development Programme and the IMO. Initial funding is over $6.9 million for the project's preparation phase. One goal of this initiative is to maximize the benefits of antifoulings which it will partially achieve by focusing "*on the implementation of the IMO Guidelines for the control and management of ships' biofouling, which provide guidance on how biofouling should be controlled and managed to reduce the transfer of invasive aquatic species*."

Australia has extensive biofouling management regulations to promote "*marine biosecurity*" [5]. There are Biofouling Management Guidelines for commercial and recreational vessels, the aquaculture industry and the petroleum industry. In all of the guidelines there are extensive recommendations regarding the use of effective antifouling coatings. In addition to the national regulations, some individual territories have their own requirements. Northwest Territories and Western Australia have specific biofouling management regulations which can include mandatory reporting and hull inspections.

New Zealand has equally wide-ranging biofouling management guidelines and regulations including the 2018 "Craft Risk Management Standard for Biofouling". Again, the emphasis is on effectiveness of coatings by choosing "*an antifouling coating that matches the operational profile of the vessel*", "*operating within the specifications of the AFC*" and "*renewing antifouling coatings within the specified service life*".

In the United States several Presidents have issued executive orders to prevent the spread of invasive species. President Clinton signed Executive Order 13112 in 1999 that created a coordinating body -- the Invasive Species Council -- to improve the Federal response to invasive species. The action directs federal agencies to "not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere". President Obama with the 2016 Executive Order 13571 amended 13112 by expanding the council.

In Oct 2017 the California *Biofouling Management Regulations to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports* went into effect. The regulations apply to all vessels 300 gross registered tons or above that carry, or are capable of carrying, ballast water that arrive at a California port. The regulation is intended to align with the International Maritime Organization's 2011 Guidelines. Again there is a repeated emphasis to use effective antifouling coatings and hull maintenance.

Summary

Antifouling coatings, and the AIs in them perform the necessary beneficial functions of protecting vessel hulls, minimizing drag to optimize fuel efficiency, and reducing biofouling that can result in invasive species introduction. But there are risks that must be mitigated and this is ensured through extensive risk assessments. As more and more risk assessments have been completed, the safety of the AIs used in antifouling coatings has been verified multiple times using fully vetted data and studies. Recently shipping and recreational vessel sustainability, energy efficiency and prevention of invasive species introduction are becoming increasingly important both globally and regionally, requiring minimal biofouling and minimal fuel usage. Therefore the regulatory focus is now shifting from antifouling risk concerns to antifouling efficacy requirements.