Changing antifouling practices for leisure boats in the Baltic Sea

BONUS CHANGE PROJECT (2014-01-01 – 2017-12-31)

The final publishable summary report

1 Project outline of goals and results envisaged at the beginning of the project cycle

Due to the special hydrographical, biological and climatic conditions, the Baltic Sea is vulnerable. Marginal ecosystems such as the Baltic Sea can be of great conservation value because they may harbour unique genetic variation and even novel species. Over the past 100 years, the natural environment of the Baltic Sea has degraded dramatically. **The Baltic Sea is one of the most threatened marine ecosystems on the planet.**

The ultimate aim of the project has been to suggest changes in policy, infrastructures and practices in order to **reduce to a minimum the supply of toxic compounds from antifouling paints used on leisure boats in the Baltic Sea**. For that purpose, the project has developed an interdisciplinary and integrated scientific platform of business administration, environmental law and natural science that has worked in close collaboration with stakeholders and end-users to identify the interrelated impacts and driving forces inherent in the problem.

The project aim has been to provide a deep understanding of how individual behaviour and attitudes are linked to governance structures and in the end policy performance and by this propose how a change in behaviour among boat owners can be achieved to the benefit of the Baltic Sea coastal ecosystem. The specific objectives in BONUS CHANGE were to:

- **Obtain a behavioural change** perspective by mapping consumer practices and social barriers to sustainable use of antifouling products and techniques.
- **Suggest legal improvements** and propose incentives for environmentally sustainable antifouling systems by identifying legal barriers for antifouling eco-innovations and understanding the impact of market actors on consumer choices.
- **Establish credibility for the performance of non-toxic methods** by testing and evaluating the performance of different antifouling methods, e.g., approved biocide-based paints (copper), low-adhesion paints, emerging paint products based on readibly degradable biocides and various mechanical methods, in order to provide consumers for their use.
- **Contribute to new risk assessment of antifouling products** by measurement of the eco-toxicity of the paints described above, as well as of mixtures of hazardous compounds found in shipyard soil and marine sediments, on non-target organisms with particular focus on chemically-mediated behaviours related to overall fitness, e.g., mate searching and homing behaviours, as well as in situ assays in contaminated marinas.
- **Provide a new cost-efficient tool for use in regulatory supervision for boats and boat yards** in the Baltic region using an XRF analyser for field measurements to measure the amounts of antifouling toxicants, e.g., copper, zinc, lead and TBT directly on boat hulls, in yard soil and in sediments.
- **Facilitate networks**, i.e., on-site meetings with boat owners, local meetings with boat owners, boat organisations, antifouling service companies and authorities and develop communication strategies for stakeholder collaboration.
- **Arrange training and education of boat** owners in basic marine ecology, ecotoxicology, human toxicology and legal matters to create incentives for change in the form of creating collective values.

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- **Synthesize** our results into a working model for change of antifouling practices on leisure boats that may be used locally in the different regions in the Baltic Sea.

2 Work carried out in the project

Consumer practices:
The overall objective of this work was to develop models of behavioural explanatory frameworks for improving environmental impacts of consumer antifouling techniques among leisure boaters in the Baltic Sea region. Many maintenance practices include harmful toxic antifouling biocides, and analysis uncovered similarities along with some differences in leisure boat maintenance among the boat owners in the countries of Germany, Sweden and Finland.

The legal framework and the market:

The overall objectives were to map the legal framework and the market influencing consumers in their choice of antifouling techniques for leisure boats, in order to understand how consumers can be influenced to choose alternatives with less impact on the Baltic marine environment.

Testing and evaluating antifouling techniques:
The overall objective was to provide scientific data on antifouling performance and eco-toxicity to convince boat owners to use environmentally friendly antifouling techniques. For this purpose, we have made a careful performance analysis of the existing antifouling methods (physical and biocide-based). We have also studied the performance of biocide-free low-adhesion paints, i.e., easy-to-clean, in repeated boat tests. For the biocide-containing methods we have performed eco-toxicity analysis (risk assessment) of mixtures of biocide components from leachates in paints, sediments and soil, in the lab and in the field. Focus was given to ecological effects of antifouling biocides present in water, sediments and soil at shipyards. The use of the new X-ray Fluorescence (XRF) analyser for determination of residual heavy metal concentration on boat hulls and in sediments and soil at shipyards was also studied.

Stakeholder collaboration and communication:

The overall objective was to influence boat owners to change their antifouling practices to more sustainable techniques such as mechanical methods and non-toxic paints. The working model for change of boating practices relied on a thorough participation by stakeholders and communication at different levels: individual (boat owners), local (boat clubs, marinas, inspectors from coastal municipalities), national (government authorities) and regional (decision-makers).

The multidisciplinary work in the project has resulted in Policy Recommendations and a popular science book, in addition to the 18 or so scientific articles and manuscripts prepared during the project.

3 Main results achieved during the project

Antifouling paints are used to prevent fouling organisms to attach and grow on boat hulls. These paints typically work by a constant leakage of toxic substances. If no antifouling method is used, the fouling by organisms on the boat hull will increase the friction and drag when driving, which in turn increases fuel consumption that leads to increased CO_2 discharges.

Tributyl tin (TBT) – still a marine environmental threat

TBT used to be an important ingredient in antifouling paints on boats, but it was prohibited for use on leisure boats in Europe in 1989. Since 2003 commercial vessels are no longer allowed to port in Europe if they are coated with TBT-paint, and since 2008 there is a global ban by a UN convention for all ships to carry TBT.

Even if TBT and organotin compounds have been prohibited since 1989 we still observe high concentrations in marine sediments, particularly in marinas. The fact that it is the surface layer of the sediment that has the highest concentrations is a strong indication that TBT from antifouling paints is still discharged into the environment. It is not only in sediments we find TBT-contamination, but also on land where boat maintenance takes place. Within BONUS CHANGE, we have found concentrations in boat yards, that are roughly ten times higher than in the sediment. Since TBT is no longer sold in Europe, it is not obvious where the TBT found in the environment come from. One explanation is that some boat owners are still using TBT illegally. The most likely explanation is however, that TBT found in the sediment and in the ground originates from TBT in old paint layers, which during maintenance work is scraped off and accumulated in the environment. Our results show that approximately 10-20 % of the boats still have significant layers of TBT paint left on their hulls.

Within BONUS CHANGE, we see two ways of dealing with the TBT-issue:

1. All old paint from boats older than 2008 should be removed professionally
2. Or to seal the old paint layers with a paint designed to enclose old paint layers and their release of AF biocides.
   Both methods have their own pros and cons. Removing the paint is by far the best solution for the aquatic environment.

Performance of copper based antifouling paints in the Baltic Sea

The authorization of antifouling products differ between countries bordering the Baltic Sea making toxic high-copper content paints allowed in Finland, Denmark and Germany but not in Sweden, despite similar environmental conditions. This highlights the need for a better understanding on the basis for the need of these toxic paints. If the degree of fouling varies in time and space and is less in the Baltic Sea compared to strict marine waters, it would call for a harmonization of the regulations between Baltic Sea countries towards more restrictive use of AF toxins in marine paint like in Sweden and thus, reduce the negative impact of unsustainable antifouling practices.

In the Bonus CHANGE project we have collected data on natural fouling intensity throughout the Baltic Sea area during four consecutive boating seasons (2013-2016). Furthermore, we have evaluated performance of five different commercial antifouling paints with variable copper (Cu) content, over several years. We have also tested efficacy of paints containing even lower Cu concentrations than available on the market today (4.3 weight %).

It was found that the <u>overall fouling pressure is generally much lower in the Baltic Sea than in the Kattegatt and the Skagerrak</u>. Thus, the need for use of AF products should also be considered lower.

The commercial antifouling paints containing low concentrations of copper, i.e., (7.5% (w/w)) completely resists fouling of barnacles throughout the Baltic Sea, as studied over several seasons. Clearly, copper concentrations in antifouling paints could be reduced drastically and still work. Tests of a non-toxic antifouling paint with added copper and zinc (Zn) at low concentrations show that a **Cu concentration of 4.3% (with 10% Zn), is highly efficient against barnacle fouling.**

Salinity affects the release of copper in the sense that low-salinity waters of ~5 PSU releases less copper than more high-salinity water of ~15 PSU. This influences total antifouling efficacy. However, we have found that an average release rate of copper of 3 $\mu g\ cm^{-2}\ day^{-1}$ totally inhibits fouling for a period of ~90 days during the most intense fouling season in a high-fouling pressure area. This release is lower than what we have measured for the commercial paints studied within BONUS CHANGE. In conjunction to the above results on the excellent performance of low-copper content AF paints we draw the conclusion that:

<u>The need for use of an antifouling product in a sensitive sea area like the Baltic Sea could be restricted to paints containing copper of <5% in a strict combination of a maximum release rate of copper of 5 $\mu g\ cm^{-2}\ day^{-1}$</u>

Several of the commercial AF paints that we have studied are efficient during two seasons without re-painting, (provided that the coating is cleaned carefully - not using high-pressure hosing). Thus, <u>fouling protection could be achieved by avoiding to paint each year, focus on re-painting exposed parts only and</u>

avoid using high-pressure hosing, since it destroys the paint layer and hampers the second year performance of the AF paint.

Performance evaluation of antifouling techniques as a behavioural intervention study

Most boat owners are combating marine biofouling by using toxic antifouling paints containing heavy metals entering the marine environment. The toxic antifouling biocides are spread into the marine environment by eroding from antifouling paints and hull maintenance work which leads to contamination of soil and sea beds (especially in harbour areas) but also with severe consequences for marine organisms and ecosystems. Alternative, more environmental-friendly methods exist. The most common biocide-free antifouling methods and techniques include brush washers, handled cleaning devices, hull covers, boat lifts, foul-release coatings and ultrasound systems.

These alternative techniques have been tested by boat owners in Sweden, Finland and Germany and then qualitatively evaluated through field visits in marinas and by interviewing the test boat owners. Applying a social science perspective, the evaluation focused on boat owners' own experiences to identify barriers and drivers for biocide-free antifouling methods.

The qualitative evaluation finds that a majority of the boat owners that have tested biocide-free antifouling methods accept them and find them effective.

Information will not do it; there is a gap between environmental awareness and antifouling practices. Positive attitudes towards the environment do not necessarily lead to sustainable consumption behavior, even if a relevant number of boat owners agree on the environmental problems caused by biocide-containing antifouling paints, they continue to use them. But if alternative methods are perceived as easy and more convenient, they will be preferred by the boat owner.

There consequently has to be a match or "fit" between boating lifestyle and several material elements including the water type, the choice of antifouling method, accepted workload spent on antifouling, marina infrastructures and financial resources. Antifouling practices are thus not only a matter of individual choices but rather dependent on structural and cultural conditions, boating lifestyle and marina infrastructure. T**he study suggests that alternative methods, infrastructure and financial resources therefore has to be made viable options in order for leisure boat owners to use more sustainable and environmental friendly solutions, phasing out the use of toxic antifouling paints.**

Leisure boat owners' ways of using of antifouling products and techniques and their understanding of environmental consequences

Efforts have been focusing on new sustainable ways to combat fouling. This is highly linked to marina infrastructure since leisure boat antifouling practice entails a large number of mechanical and technical arrangements and installations. This includes for example availability of alternative biocide-free antifouling techniques (e.g. boat washers, lifts) and infrastructures that support sustainable maintenance of leisure boats painted with biocide-based antifouling paints (e.g. provision of recycling and waste collection, wash-pads with waste water treatment, protective foil that hinders scrape-offs to contaminant the soil), often accompanied with adequate rules. Infrastructure is here consequently understood as both physical elements (material infrastructure) and as rules, regulations, codes (institutional infrastructures). The rationale behind this is that sanction based rules and regulations influences and conditions the way that material infrastructure is used, thereby steering consumer behaviours.

Thus, antifouling is not only a matter of individual choices but also highly dependent on marina infrastructure which can either promote or prohibit sustainable antifouling consumption including maintenance practices. The study finds that marinas and boat yards throughout the Baltic provide infrastructure which either encourage or limit the sustainable boat maintenance practices. Sustainable antifouling practices is dependent on the provision of supporting marina infrastructure both in terms of the mechanical antifouling techniques (e.g. boat washers), but also infrastructure that support sustainable maintenance of leisure boats painted with biocide-based antifouling paints (e.g. water collection and waste management system).

Use of infrastructure has strong linkages to rules and regulations directed to boat maintenance work, important for constructing sustainable maintenance of products. Findings suggest that the mechanical and technical infrastructure in marinas (material infrastructure) also should be supported by sanction based rules and regulations (institutional infrastructure) in order to have a positive effect on the marine environment. Moreover, the study finds that enforcement of these rules differs whereas stricter enforcement and sanctions has potential positive effects on the environment.

Our results illustrate that sustainable leisure boat maintenance is linked to specific marina infrastructures**,** suggesting that the provision of marina infrastructure supported by rules or regulations to ensure boaters and marinas to act according to the rules, could achieve a change in dominating unsustainable boat maintenance practices related to antifouling.

Differences in Leisure Boat Maintenance Practices: Perspectives for Product Life-cycle Sustainability

The research in BONUS CHANGE in consumer ethnography examines the ways **consumers' use** of toxic paints in boat maintenance contributes to the spread of toxic antifouling biocides in the catchment and the Baltic Sea water body in three countries bordering the Baltic Sea. This multi-site approach allowed us to compare to what extent the ways boat owners used antifouling paints in their boat maintenance differed from each other. We concentrated on boatyards in Germany (Kiel); Sweden (Gothenburg and Stockholm; and Finland (Helsinki). These sites were carefully chosen to represent multiple distinctive features found in marinas in the Baltic Sea.

Our multicultural analysis uncovers the similarities and differences among boat owners in different cultural contexts. The variety of practices in each cultural context, which engage more or less with sustainability, is in large part to do with presence and compliance with prevailing rules and regulations and how these are supported and surveilled by local authorities. Boat owners in Germany are expected to follow quite strict rules of use and disposal. Separate bins are provided in the marinas to encourage proper disposal of toxic AG waste and fines are levied on boaters who are caught breaking the rules of failing to put tarps or some protective foil under lifted boats to catch old paint flakes and scrape-offs during hull scraping prior to the application of fresh paint. Sailing in Sweden is deeply embedded in the culture and some boaters are interested in the practicalities of getting the best results while at the same time using less paint than recommended by manufacturers. Yet other Swedish boaters purchase and use more toxic paint formulas than necessary for their location. In Finland there is very little awareness of the negative environmental effects of toxic antifouling paint use and also very little in the way of infrastructure to support more sustainable practices. Fouling of the sea in Finland means visible litter and industrial effluence; antifouling paint is not recognized as a source of environmental degradation.

Analysis and findings offer possibilities for public policy programs, in particular social marketing efforts, to increase awareness of the often unseen toxicity by consumers of antifouling paint use and suggest new ways to effectively maintain leisure boats resulting in less environmental damage to the sea and sea life. For example, more focus should be paid to intervention possibilities in the sustainable use of products and services, at the level of consumer behaviour. Additional policy intervention could be directed to regulating the maintenance of the boat hull by imposing fines or other sanctions on boaters who fail to contain paint scrapings. Social marketing campaigns educating harbour masters, yacht club members and individual boat owners about the best and proper use of the least toxic paints would also improve the practices surrounding boat maintenance and the health of the sea.

Legal findings in the Biocidal Products Regulation (BPR)

Antifouling paints containing biocides are subject to product authorisation after risk assessment by competent authorities in the EU member states. This authorisation is governed by the Biocidal Products

Regulation (BPR)1 and the procedure for risk assessment is described in article 19 and the Annex VI to the BPR. Also, Article 22 describes that an authorisation decision can be conditioned. This is an important point for the possibility for competent authorities to apply a restrictive approach. The BPR was put into force in 2012 and leaves a limited, but present, room for member states for national interpretation of the risk assessment in the regulation (art 19; Annex VI). Indeed, the prevailing restrictive legislation in Sweden concerning the risk assessment in the AF product authorisation is a national interpretation of the BPR. The legal assessment in BONUS CHANGE concludes that there is room for restrictive interpretation, like the one in Sweden, for all Member States in the Baltic Sea in article 19. The sensitivity of the Baltic Sea is one ground that can probably be used for restricting biocidal AF paints in the sea, but how the regulation will be interpreted by the Court, and thus the exact room for national interpretation, is not yet clear.

In the BPR there are provisions for mutual recognition of product approval, meaning that when an AF product has been authorized in a Member State the producer of the product may apply for mutual recognition of the approval in all member states. In article 37 of the BPR, member states may request for a derogation of mutual recognition due to environmental concerns. However, the legal scholars in BONUS CHANGE suggest that this might be more difficult than restricting the availability of AF products under the national authorisation procedure. The burden of proof here instead lies with the competent authority where the competent authority must prove that the product is not acceptable out of environmental concerns. This also must be done within a short time frame. The BONUS CHANGE project has scientific results on various angles of AF products that could be compiled into a dossier to support Baltic Sea member states who would like to apply article 37 in the BPR for a restrictive authorisation of AF product for the protection of the marine environment.

4 Recommendations

The BONUS CHANGE proposes the following 8 recommendations for achieving sustainable antifouling practices in the Baltic Sea:

1. **Phasing-out of biocidal antifouling products** in the Baltic Sea on leisure boats including adjacent freshwater areas until 2030
2. Introduce a **stepwise reduction of copper concentrations** in paints down to 4% with a concomitant upper limit of leaching rate of copper of 5 µg cm^{-2} day^{-1}
3. Competent authorities in the member states around the Baltic Sea **restrict the availability of biocidal antifouling paints** as far as possible within the framework of the product authorisation provisions of the Biocidal Products Regulation, and by using the possibilities to derogate from mutual recognition.
4. **Promote an initiative inside of HELCOM** with reference to the Baltic Sea Action Plan goals on hazardous substances to make the Baltic Sea free from antifouling biocides on leisure boats through HELCOM recommendations[2]
5. **Improvement of antifouling practices and maintenance work** in marinas through better enforcement of environmental protection regulations regarding antifouling practices and through enhanced infrastructures in Baltic Sea member states
6. **Call to paint less** and paint only when necessary as a first step.
7. **Promotion of effective biocide-free alternatives** by the Baltic Sea Environmental Agencies and Competent Authorities

[1] REGULATION (EU) No 528/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 May 2012 concerning the making available on the market and use of biocidal products

[2] One of the most important duties of the Helsinki Commission is to make Recommendations on measures to address certain pollution sources or areas of concern. These Recommendations are to be implemented by the Contracting Parties through their national legislation.