TEXTE

133/2020

German scenario for inland water marinas

Development of a realistic worst-case scenario for antifouling biocides in German inland water marinas

German Environment Agency

Umwelt Bundesamt

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von

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Kurzbeschreibung: Entwicklung eines realistischen worst-case Szenarios für Antifouling-Biozide in Marinas in deutschen Binnengewässern

Das Inverkehrbringen von bioziden Antifouling-Produkten wird in Europa durch die Verordnung (EU) No 528/2012 geregelt. Ein wesentlicher Bestandteil dabei ist die Umweltrisikobewertung. Hier wird geprüft, ob die Verwendung eines Antifouling-Produkts akzeptable Risiken für die Umwelt verursacht. Wichtiger Bestandteil dieser Umweltrisikobewertung ist die Berechnung der Verteilung der in dem Produkt enthaltenen Antifouling-Wirkstoffe in der Umwelt mit Hilfe von Expositionsszenarien. Man unterscheidet hier einerseits zwischen Schiffen für kommerzielle Zwecke (z.B. Güter-/Personentransport) und Sport- bzw. Freizeitbooten sowie andererseits zwischen Schiffen oder Booten, die in Meeresgewässern verkehren und Schiffen oder Booten, die in Binnengewässern fahren. Für jede der genannten Kombinationen aus Wasserfahrzeug und Revier sind eigene Expositionsszenarien notwendig.

In Deutschland existieren rund 206.000 Sportboote. Daehne et al. (2017) bzw. Feibicke et al. (2018) schätzten, dass im Jahr 2016 ca. 19 % der gesamten Kupferfrachten in deutschen Oberflächengewässern aus bioziden Antifoulingbeschichtungen von Sportbooten stammten. 71 % der Sportboote in Deutschland haben ihren Liegeplatz in Binnenrevieren. Dieser Bereich ist daher in Deutschland besonders relevant und muss in der Umweltrisikobewertung von Antifouling-Produkten besondere Berücksichtigung finden. Deshalb wurde auf Basis von zwei Forschungsprojekten, die im Auftrag des Umweltbundesamtes durchgeführt wurden, das vorliegende Expositionsszenario für den Bereich der Sportboote in deutschen Binnengewässern entwickelt.

Abstract: Development of a realistic worst-case scenario for antifouling biocides in German inland water marinas

The placing on the market of biocidal antifouling products is regulated in Europe by Regulation (EU) No 528/2012. An essential part of this is the environmental risk assessment. Here it is reviewed whether the use of an antifouling product results in acceptable risks for the environment. An important part of this environmental risk assessment is the calculation of the distribution of the antifouling active ingredients contained in the product in the environment using specific exposure scenarios. A distinction is made here between ships for commercial purposes (e.g. freight or passenger transport) and leisure boats on the one hand, and between ships or boats that sail in marine waters and ships or boats that sail in inland waters on the other hand. Separate exposure scenarios are required for each of the combinations of watercraft and area mentioned before.

There are around 206,000 pleasure craft in Germany. Daehne et al. (2017) and Feibicke et al. (2018) estimated that in 2016 approx. 19% of the total copper loads in German surface waters came from biocidal antifouling coatings applied on pleasure boats. 71% of pleasure boats in Germany are moored in inland areas. This area is therefore particularly relevant in Germany and must be given special consideration in the environmental risk assessment of antifouling products. Therefore, on the basis of two research projects carried out on behalf of the German Environment Agency, the present exposure scenario was developed for the area of pleasure boats in German inland waters.

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List of abbreviations

AAS	Antifouling active substances
AF	Application factor
BPR	Biocidal product regulation
CA(s)	Competent authority(ies)
DIDT	5,6-Dihydro-3H-imidazo(2,1-c)-1,2,4-dithiazole-3-thione, (CAS No.: 33813-20-6)
DMSA	N,N-Dimethyl-N'-phenylsulfamide, (CAS No.: 4710-17-2)
DMST	N,N-dimethyl-N'-p-tolylsulphamide, (CAS No.: 66840-71-9)
DOC	Dissolved organic carbon
EU	European Union
ERA	Environmental risk assessment
POC	Particulate organic carbon
PT	Product type
SPM	Suspended matter
TP	Transformation product
UK	United Kingdom
WSA	Wetted surface area per boat
$WSA_{aggregated}$	Aggregated wetted surface area per marina

1 Introduction

Boat hulls are populated over time by aquatic organisms such as algae, barnacles or shells. This organism community is called fouling and has several negative impacts on the boat performance, like a higher fuel consumption and a reduced manoeuvrability. Therefore, antifouling coatings are applied on the boat hull to reduce or prevent the growth of fouling. These coatings act by releasing biocides into the water where the fouling organisms are killed or prevented from settling.

Biocides are regulated in the European Union (EU) by Regulation (EU) No 528/2012 (BPR). The BPR divides the different biocidal applications into 22 product types. Antifouling biocides are summarised in product type 21. All biocides have to pass an environmental risk assessment (ERA) before they are approved and can be used in biocidal products within the EU. While the approval of active substances is valid throughout the EU, the authorisation of biocidal products is a national procedure which must be applied for every single product or product family containing an approved active substance. Although the ERA for biocides should generally be harmonized as far as possible across the EU, there is still the possibility of taking certain national requirements or special features into account. This applies in particular to product type 21, as these products are used directly in surface waters and therefore pose high environmental risks per se.

A major part of the ERA is the estimation of the exposure of the environment with biocides, which shall according to §19(2) BPR consider “realistic worst-case conditions under which the biocidal product may be used”. These realistic worst-case conditions are laid down in use specific emission scenarios. The emission scenario for the EU-wide approval of antifouling biocides for pleasure boating is called “OECD Marina” scenario and is described in the so-called ESD PT 21[1] authored by van de Plassche & van de Aa (2004). The scenario is based on the situation found in a typical marina at the Mediterranean Sea. During the evaluation of the antifouling active substances, concerns have become up on whether the “OECD Marina” scenario is applicable to all water regions in the EU. Based on the work of Cheng Shan-I et al. (2013) the competent authorities (CAs) have developed therefore a new environmental risk assessment approach, called “Regional Marina Scenario”. This approach divides the EU into the four marine regions (Mediterranean, Atlantic, Baltic sea, Baltic transition) plus an additional EU freshwater region. In order to obtain product authorisation for a product in a specific country, an environmental risk assessment must be submitted for the region(s) that are appropriate for the respective country. The concept also provides for the possibility of considering additional national specific scenarios if this is deemed necessary at the national level.

Waterman et al. (2015) conducted a Germany-wide survey of pleasure boats and pleasure boat berths, respectively. The census revealed a total number of around 210,000 boats of which 71% were located in inland water, 26.2% in brackish waters and only 2.8% boats in marine waters. These data demonstrate the high importance of pleasure boating in inland water areas in Germany. Daehne et al. (2017) estimated the amount of antifouling active substance that are yearly released from pleasure boats antifouling coating in Germany. The study concluded for copper, one of the main active ingredients in biocidal antifouling coatings, that in the reference year 2016, a total of 70.5 t copper per year was released into surface water. This corresponds to approximately 19% of all diffuse copper loads in German surface waters.

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[1] Harmonisation of Environmental Emission Scenarios: An Emission Scenario Document for Antifouling Products in OECD countries European Commission, Directorate-General Environment, 23 September 2004, Final Report.

In view of the high relevance of pleasure boating in German inland water and the significant share of pleasure boat related copper entries into German surface water, a robust exposure assessment for inland waters is needed for the product authorisation. Therefore, a realistic worst-case marina scenario was developed in the present study, which (i) is based on the real situation found in German marinas and (ii) fulfils the requirements of the BPR and their relevant and recent guidance’s on exposure assessment.

2 Data basis

The scenario for German inland water marinas is mainly based on data gathered by Watermann et al. (2015) and Redeker et al. (2020). Three main datasets can be distinguished and are briefly presented in the following. Further information on the data records can be found in the respective publications.

2.1 **Dataset A:** Marina survey (Waterman et al., 2015)

Dataset A (Marina Survey) represents a count of all German inland and coastal marinas with a number of berths ≥5. A total number of 3091 marinas were recorded. The census was supplemented with many supportive information on the marina structures like geographic location, surface, width of the marina entrance, boundary conditions (in open water or in a closed basin or bay adjacent to the water body), salinity, number of berths or tidal range.

2.2 **Dataset B:** Monitoring 2013 (Waterman et al., 2015)

Dataset B (Monitoring 2013) is a selection of 50 inland- and coastal marinas from dataset A which were investigated further in detail. Beside a distinct recording of the above-mentioned structural marina parameters, water samples were taken and analysed for various water quality parameters, including among others the fraction of suspended matter (SPM) and dissolved organic carbon (DOC) and the water salinity, temperature and pH. Additionally, the water samples were analysed for selected antifouling active substances (AAS) and their transformation products (TP) including copper, Cybutryne and M1 (TP of Cybutryne) DMSA and DMST (TP of Tolyfluanid and Dichlofluanid).

Zinc oxide is a common additive in biocidal (and biocide-free) antifouling products either as auxiliary to regulate the erosion rate and/or as colour pigment. Despite the biocidal effect of zinc, it is not classified as AAS in product type 21 according to the BPR. However, it may be considered in the environmental risk assessment as so-called substance of concern (SoC) and is therefore of interest and was also measured. In the further course of this report and for better readability, zinc is not explicitly named SoC but is included under the abbreviation AAS.

2.3 **Dataset C:** Monitoring 2016 (Redeker et al., 2020)

Dataset C (Monitoring 2016) consists of 13 marinas which were further investigated by Redeker et al. (2020) analogous to the sampling of dataset B. The parameters collected included different water characteristics and marina structures. 8 out of the 13 marinas were also part of dataset B and 5 additional marinas have been included in the investigations. Nearly the same set of analyses was done for dataset C as it was done for dataset B.

3 Scenario development

3.1 Overall approach

The aim of the present work is to identify (a) realistic worst-case marina(s) with respect to (predicted) environmental concentrations of antifouling active substances within the marina basin. Pleasure boat marinas differ largely in terms of structural parameters (number of berth, open/closed structure, marina depth, etc.) and environmental conditions (water temperature, salinity, pH, etc.). Both aspects significantly alter the fate of AAS within the marina water body. In conclusion, the determination of (a) realistic worst-case marina(s) should ideally be based on the whole range of marinas existing in Germany – which are represented by dataset A. However, dataset A only contains basic information on the marina structures and environmental conditions which are not sufficient to define a marina scenario within MAMPEC. Several key parameters are missing. However, this additional information is included in dataset B and C.

But the selection of the marinas of dataset B and C has neither been made with the aim of being representative for all German marinas nor was the selection made from a perspective of identifying worst-case marinas, with high (predicted) environmental concentrations of AAS. It is therefore unclear, where the marinas of dataset B and C rank in the overall picture.

In order to solve this dilemma all three datasets were considered in an overall combined selection approach. As a first step (step 1), several structural marina characteristics were identified which promote tentatively higher environmental concentrations of AAS on the basis of the monitoring data from dataset B. Then dataset A was filtered by these factors and reduced to a relatively small number of marinas. It is assumed that this subset of dataset A includes the “worst-case marinas” in Germany.

In a second step, the marinas from dataset B and C which are as well contained in the identified “worst-case marina” subset of dataset A have been selected. These marinas where further investigated with MAMPEC simulations. The intention of this step was to identify the realistic worst-case German marina by studying the effects of the different marina characteristics for the chemical fate modelling.

In a third and last step, the realistic worst-case marinas identified in the previous step were then finally parametrised with representative values for Germany and/or EU agreed factors.

3.2 Filter concept (step 1)

Structural marina characteristics leading (presumably) to higher environmental concentrations of AAS were identified by interrelation analysis between different marina properties and measured AAS concentrations within dataset B. These interrelations were then applied to dataset A to identify potential worst-case marinas from all the German inland water marinas. To do so, the sum of organic AASs and TPs (DMSA, DMST, cybutryn, M1) and of inorganic AASs (Cu, Zn) is calculated and separately interrelated with the following marina properties for every marina in dataset B. The concentrations of inorganic AASs are considerably higher than the organic AAS due to other anthropogenic sources for Cu- and Zn like metal-bearing or Cu slags in water way construction as well as higher copper leaching rates from antifouling products compared to the organic AAS. Therefore, both groups of AAS are analysed separately to avoid an overlay of the overall results by the higher inorganic AAS concentrations.

The single parameters that have been analysed and identified to be a suitable criterion for the identification of realistic worst-case marinas are briefly presented in the following. For more details on the analysis please refer to Redeker et al. (2020).

3.2.1 Parameter I Tidal range (Fig. 1 a, b)

Figure 1 shows Whisker-Boxplots from either (a) the sum of all organic AAS and (b) the sum of inorganic AAS separated into marinas with tidal exchange (left) and without tidal exchange (right) for all closed marinas in salt-, brackish- and freshwater. The parameter tide shows a high effect on the concentrations of organic AASs. In marinas without tide, the highest total concentration of organic ASS is six times higher than in marinas with tidal exchange. In contrast, the lower concentrations for both categories (left, right) and groups of AAS (a, b) are within the same order of magnitude.

The median concentrations of the sum of organic ASS is significantly higher in marinas without tide than in marinas with tide, whereas no significant difference of the median concentrations can be observed for the sum of inorganic ASS. The concentration of organic AAS can predominantly be assigned to the use of antifouling products. In contrast, inorganic AAS are of widespread use, not only in antifouling products but in multiple anthropogenic applications. Therefore, the background concentration of Copper in the water is presumably high and covers the additional copper input from antifouling product. This may be the reason why the above-mentioned interrelation is not applicable to the inorganic dataset.

Disregarding the results for the inorganic AAS due the reason describes above it can be concluded that the parameter “tidal range” can serve as a suitable parameter to identify a worst-case marina.

3.2.2 Parameter II Closed/open marina (Fig. 1 c, d)

The Whisker-Boxplots in Figure 1 shows (c) the sum of all organic AAS and (d) the sum of inorganic AAS separated into closed (left) and open marinas (right) only for inland water marinas. The sum of organic and inorganic ASSs scatter in closed marinas more than in open marinas. Maximum and median concentrations are both higher in closed marinas than in open marinas, showing significant differences between the median concentrations for both groups of AASs. Therefore, the parameter closed marina can be regarded as suitable to identify a worst-case marina.

3.2.3 Parameter III Number of berths (Fig. 1 e, f)

Figure 1 (e) and (f) plot the number of berths against the sum of organic (e) and inorganic (f) concentration of ASS for the group of closed marinas. No correlations between both parameters can be identified. However, it can be observed that comparatively large concentrations only occur in marinas with more than 30 berths. Thus, the parameter number of berths ≥ 30 is considered as suitable to identify a worst-case marina.

3.2.4 Parameter IV Width of marina entrance (Fig. 1 g, h)

Figure 1 (g) and (h) plot the width of marina entrance against the sum of organic (g) and inorganic (h) concentrations of ASS for the group of closed inland water marinas. Again, no correlations between both parameters can be identified. However, comparatively high ASS concentrations occur only in closed marinas with a relatively narrow entrance under 60 m width. The value of 60 m was set here freely and could also have been slightly above or below. However, due to the visual evaluation of the figures, this value seems to be reasonable to help identifying a worst-case marina.

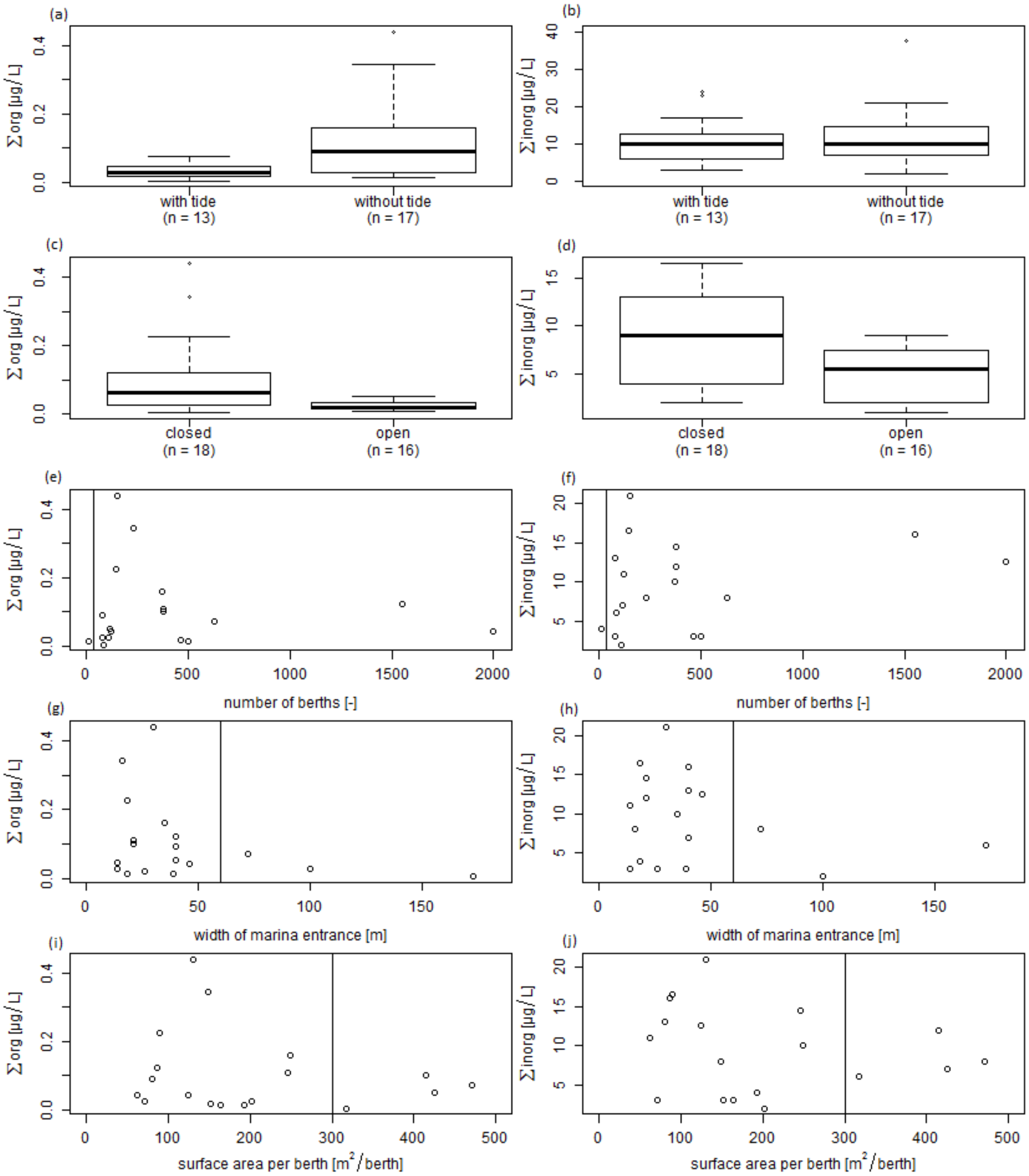
3.2.5 Parameter V Surface area per berth (Fig. 1 i, j)

Figure 1 (i) and (h) plot the surface area per berth against the sum of organic (i) and inorganic (j) concentrations of ASS for the group of closed inland water marinas. For the parameter, no clear interrelation can be observed. Apparently, higher concentration for both groups of ASSs occur in marinas with smaller surface areas per berth. An area of < 300 m^2 per berth was set as the threshold for marinas that tend to have higher AAS concentrations and was further considered for the identification of a worst-case marina. Again, the threshold value was set here freely and could also have been slightly above or below.

3.2.6 Parameter VI Visual exclusion

As a final step, all remaining marinas were visually inspected on aerial photographs. All marinas were sorted out that obviously differed from the strongly geometric structure of the MAMPEC port layout (e.g. bays, round shapes, or the like) or that had any type of water structure in the marina basin that could not be reproduced in the MAMPEC marina layout (e.g. jetty) or (c) that exhibited any other atypical structures.

Figure 1: Total concentration of organic AAS on the left (a), (c), (e), (g), (i) and total concentration of inorganic AAS on the right (b), (d), (f), (h), (j); inside closed marinas with and without tide (a), (b); in inland water marinas subdivided into closed and open marinas (c), (d); in closed inland water marinas in relation to number of berths (e), (f); in relation to the width of the marina entrance (g), (h) and in relation to the surface area per berth (i), (j). The lines in figures (e), (f), (g), (h), (i) and (j) mark the cut-off criterion for the parameter.



Reference: Redeker et. al (2020)

3.2.7 Conclusion on Step 1

The above described selection parameters are summarised and applied in the following. At first, all marinas located in brackish or saltwater were removed from the dataset as the scenario for

German inland water marinas obviously should represent typical situations in inland waters. The classification according to the salinity of the three water types was done by Waterman et al. (2015). The limit values for salt water are > 18 ‰), for brackish water 1 - 18 ‰ (brackish water) and for fresh water < 1 ‰. From a total of 3091 pleasure boat marinas in Germany, 2470 are situated in inland water areas. Of those marinas, 2386 do not have any tidal influence. Selecting then only closed marinas leads to a number of 483 marinas. A further selection of marinas with a number of berths ≥ 30, marina entrance ≤ 60 m and a ratio marina surface per berth < 300 m^2 results in a number of 318 marinas. Finally, the visual examination of the remaining marinas further reduced the number of marinas that are possibly worst case to 55.

Start	Dataset A	(3091)
X.	Only inland water marinas	(2470)
I.	tidal range = 0	(2386)
II.	closed marinas	(483)
III.	number of berths ≥ 30,	(376)
IV.	marina entrance ≤ 60 m	(331)
V.	ratio of surface area to number of berths < 300 m^2	(318)
VI.	Visual exclusion	(55)

In summary, the above described selection procedure identifies within the group of all German pleasure boat marinas 55 marinas which do tend to have relatively high(er) AAS concentrations. If we now compare this selection with the marinas in dataset B and C, we see that these 55 marinas contain 9 marinas from dataset B and 13 marinas from dataset C. Some marinas are contained in dataset B as well as dataset C. If these marinas are only counted once, 17 marinas remain. This selection of 17 worst-case marinas is referred to as dataset D in the further course of the text. It remains unclear where these 17 marinas individually would rank in the overall picture of the 55-marina selection. However, on the basis of the selection scheme, it was possible to identify those marinas within datasets B and C which have certain worst-case properties due to their structural properties as identified in Step 1. These marinas will therefore be considered in the further course of the scenario development.

3.3 MAMPEC simulation (step 2)

In step 2 of the scenario development, the 17 marinas from dataset D, which have worst-case properties, were further examined in model simulations in order to identify the scenario(s) for German inland waters.

3.3.1 MAMPEC simulations with dataset D

The environmental fate of selected AAS was simulated using the latest version of MAMPEC (version 3.1). The three relevant input categories (1) environment, (2) compound and (3) emission have been parametrised as following. For details on the parametrisation, please refer to Annex A.

Environment: The individual simulations have been conducted based on the environmental conditions that have been found at the day of the sampling of dataset B or C. For the marinas, which are contained in both dataset and have been sampled twice, the average values were used in the simulation.

Compound: The step 2 simulations were conducted for the AASs or TPs Tolylfluanid, DCOIT, Medetomidine, Zineb, DIDT (TP of Zineb), Zinc and Copper. All relevant compound related input values like water solubility, degradation rate constants or solid-solution partition coefficients were taken from the lists of endpoints (LoE) which are contained in the respective assessment reports for substance approval under Regulation (EU) No 528/2012 (see Annex A.2).

Emission: A full occupancy of each marina is assumed, equivalent to the number of berths recorded in dataset B and C. The boat census in Waterman et al (2015) introduced a classification system which assigns ships into five different length classes. Additionally, the authors determined the typical wetted surface area (WSA) of boats within each of these length classes (see Annex A.1.1). Accordingly, based on the number of boats of each length class and the typical wetted surface areas of the corresponding length class, an aggregated underwater surface area ($WSA_{aggregated}$) of all boats within each marina was calculated. This $WSA_{aggregated}$ is contained in the below mentioned Excel-File "German inland water marina_marina input_Ver.1.0" (chapter 3.4.1) for each marina and was used for the emission calculations.

The authors also estimated the share of specific AASs in relation to all available AASs in Germany based on a register of antifouling products available for pleasure boats in Germany. These values have been considered as Application Factor (AF) in the simulations (Please refer to Annex A.3 for further information).

Further, a default leaching rate of 2.5 $\mu g\ cm^{-2}\ d^{-1}$ was considered for all organic AASs as recommended in the ESD PT21. For the inorganic AASs a leaching rate of 12 $\mu g\ cm^{-2}\ d^{-1}$ was applied based on results by Lagerström et al. (2018).

3.3.2 Results and discussion (step 2)

The results of the simulations for the individual AAS and TPs are displayed in Table 1. It contains the average freely dissolved concentration of each AAS inside the marina basins. The results are ranked from the highest to the lowest value for each AAS/TP. The results for the OECD-EU Marina scenario are also displayed to enable a comparison to the 17 German realistic worst-case marinas. Additionally, marina No. 11, No. 1, No. 2 and No. 3 are coloured in lightening green tones representing the marinas with the highest measured concentrations in dataset B and C.

The major finding from the table is that the rankings of the marinas within the active ingredients differ between all groups. A certain degree of consistency of order can be found within the group of organic AAS / TP. In contrast, there are clearer differences between organic and inorganic AAS/TP. For example, while Marina No. 15 is the marina with the highest concentration for most organic substances (except from zineb), it ranks more in the lower middle field for inorganic substances. Of course, the simulation results are strongly influenced by the physical-chemical properties of the modelled substance. Beside the distribution coefficients between water and particulate matter, the degradation rates of the substances are a key parameter for the environmental fate. In contrast to the group of organic AAS/TP, the two inorganic AAS are not degradable. Due to that, the environmental fate in the simulations of the inorganic AAS may be more driven by the hydrodynamic processes in the model, whereas for the organic substances hydrodynamic processes as well as degradation determine the environmental fate. This may be one reason for the relatively clear separation of both groups rankings from each other.

In conclusion, the rankings of these different ASs show that it is not possible to identify one specific worst-case marina within dataset D. It has already been found out by the UK CA[2] that it is not possible to identify a single marina from a group of marinas, which represents the worst-case marina for substances with significant different physical-chemical properties. Therefore, it

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[2] WGI2017 ENV 7-2b(i) Analysis of regional pleasure craft marina scenarios and proposals for a PEC calculation tool

follows, that the whole group of German realistic worst-case marinas (dataset D) has to be considered in the scenario for German inland water marinas.

Table 1: Rankings of model results of the OECD marina and the 17 marinas from dataset D for the ASS and TP: Tolylfluanid, DCOIT, Medetomidin, Zineb, DIDT, Zn and Cu for chosen marinas with collected input parameters.

Tolylfluanid		DCOIT		Medetomidine		Zineb		DIDT		Zinc		Copper	
No.	Conc. [µg L^{-1}]	No.	Conc. [µg L^{-1}]	No.	Conc. [µg L^{-1}]	No.	Conc. [µg L^{-1}]	No.	Conc. [µg L^{-1}]	No.	Conc. [µg L^{-1}]	No.	Conc. [µg L^{-1}]
15	3.158	15	2.594	15	2.594	OECD	0.152	15	10.928	4	97.1	16	123.2
12	2.751	12	2.288	12	2.288	15	0.060	16	10.842	8	55.4	4	111.9
16	2.711	16	2.187	16	2.187	12	0.057	12	8.106	12	52.9	11	111.1
11	1.905	11	1.545	11	1.545	16	0.048	11	7.707	16	47.2	12	72.0
8	1.751	8	1.453	8	1.453	13	0.045	8	5.301	11	45.0	1	60.3
13	1.364	13	1.159	13	1.159	8	0.036	3	5.116	1	19.4	8	56.5
7	1.198	7	1.004	7	1.004	11	0.033	1	4.963	3	13.4	3	45.9
1	1.145	1	0.928	1	0.928	17	0.028	7	3.200	15	13.2	15	39.3
3	1.126	3	0.879	3	0.879	7	0.026	2	2.543	5	12.4	7	18.3
17	1.012	17	0.864	17	0.864	2	0.021	13	2.356	2	11.6	2	17.9
2	0.938	2	0.779	2	0.779	1	0.019	17	2.007	7	9.6	5	17.3
14	0.566	14	0.475	14	0.475	3	0.018	14	1.560	9	9.5	9	14.6
9	0.297	9	0.244	9	0.244	14	0.012	4	1.158	14	8.1	14	11.8
4	0.261	4	0.211	4	0.211	9	0.006	9	1.067	17	7.7	6	11.8
6	0.207	6	0.169	6	0.169	4	0.004	6	0.801	13	6.3	17	11.0
OECD	0.213	OECD	0.152	OECD	0.152	6	0.004	5	0.303	6	5.8	13	10.5
5	0.070	5	0.057	5	0.057	10	0.002	OECD	0.152	10	0.3	OECD	1.0
10	0.047	10	0.041	10	0.041	5	0.001	10	0.080			10	0.4

3.4 Step 3 – German Inland water Scenario

3.4.1 Scenario parametrisation

In contrast to the MAMPEC simulations conducted under step 2 – which intended to represent the situation in each marina at the day of sampling – the scenario for German inland water marinas should be parametrised in a more generalized way. Therefore, some of the values used in step 2 have been adapted.

For most of the structural marina categories (e.g. *Hydrodynamics, Layout, Wind, Submerged dam specification*, …) as well as the number of berth and the $WSA_{aggregated}$ the values from Redeker et. al (2020) have been taken as they are more recent in comparisons to the values from Watermann et al. (2015). Where marina specific values for the water characteristics have been considered, values have been taken either from Watermann et. al (2015) or Redeker et. al (2020). Average values have been considered when values from both sources were available. The remaining water characteristics as well as values for the categories *Sediment*, *Flush* and *Cloud coverage* have been overtaken from the EU freshwater marina scenario. The *Water temperature* has been set to 12 °C which is the agreed environmental temperature for risk assessment of biocides according to the Guidance on the BPR (2017). The *flow velocities* were taken from the step 2 modelling.

All parameters which are needed to define the scenario for German inland water marinas within MAMPEC are displayed in Table 2. All values which are labelled with `Marina specific` can be looked up in the Excel-File `German inland water marina_marina input_Ver.1.0` which is contained in the data folder “German scenario for inland water marinas_data_1.0” published on the UBA webpage.

https://www.umweltbundesamt.de/dokument/german-scenario-for-inland-water-marinas-data

The tables also contain the respective reference for each parameter.

Table 2: MAMPEC input parameters for the German inland water marina scenario.

MAMPEC - input parameter	Unit	Scenario for German inland water marinas	Reference
Environment			
Environment type	-	Marina	
Hydrodynamics			
Tidal period	hour	12.41	EU freshwater marina scenario
Tidal difference	m	0	
Max. density difference tide	kg m^{-3}	0	
Non-tidal daily water level change	m	0	
Flow velocity	m s^{-1}	Marina specific	Adapted from Redeker et. al (2020)/expert judgment
Water characteristics			
SPM concentration	mg L^{-1}	Marina specific	Waterman et. al (2015) and/or Redeker et. al (2020); average value if applicable
POC concentration	mg L^{-1}		
DOC concentration	mg L^{-1}		
Salinity	psu		
pH	-		
Chlorophyll	µg L^{-1}	3	OECD-EU Marina Guidance on the BPR (2017)
Temperature	°C	12	
Layout			
Length x1	m	Marina specific	Redeker et. al (2020)
Length x2	m		
Width y1	m		
Width y2	m		
Depth	m		
Mouth width x3	m		
General			
Latitude	°(dec) NH	Marina specific	Redeker et. al (2020)
Cloud coverage	class [0-10]	5	EU freshwater marina scenario
Sediment			
Depth mixed sediment layer	m	0.03	EU freshwater marina scenario
Sediment density	kg m^{-3}	1000	
Degr. Organic carbon in sediment	1 d^{-1}	0	
Nett sedimentation velocity	m d^{-1}	0.5	
Wind			
Average wind speed	m s^{-1}	Marina specific	Redeker et. al (2020)
Fraction of time wind perpendicular	-		
Flush			
Flush (f)	m^{3} s^{-1}	0	EU freshwater marina scenario
Max. density difference flush	kg m^{-3}	0	
Submerged dam specification			
Height of submerged dam	m	Marina specific	Redeker et. al (2020)
Width of submerged dam	m		
Depth-MSL in harbour entrance	m	set equal to marina depth/ height of submerged dam	
Emission			
Number of berths	-	Marina specific	Redeker et. al (2020)
WSA$_{\text{aggregated}}$	m^{2}		

3.4.2 Excel Spreadsheet model

In line with the European concept for environmental exposure assessment in product type 21, an Excel data sheet model was also developed for the scenario for German inland water marinas, which can be used to conduct the environmental risk assessment with this scenario. The Excel-Tool is contained in the data folder "German scenario for inland water marinas_data_1.0" and can be downloaded on the UBA web page.

https://www.umweltbundesamt.de/dokument/german-scenario-for-inland-water-marinas-data

Analogous to the European scenarios, the environmental fate of the PT21 substance under evaluation is firstly calculated in all sub-scenarios of the scenario for German inland water marinas. The PEC relevant for the environmental risk assessment is then derived from the 17 individual marina results. In the two European concepts (Regional Marina in marine waters and EU freshwater scenario) the 90% percentile value was defined as PEC for the whole scenario. For the scenario for German inland water marinas, it was determined that the median concentration is suitable for mapping the realistic worst case for the situation in German inland waters. In contrast to the two European concepts, the selection of 17 marinas, which are evaluated in the scenario, already represents a worst-case selection. It was therefore considered to be unrealistic if the 90% percentile value was then determined from this selection as relevant for approval. Due to the unequal distribution of the results of the 17 marinas, the median value is classified as robust.

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A MAMPEC input parameters (Step2)

In the following the parametrisation for the modelling of the 17 marinas from dataset D in Step 2 is explained in more detail. These values represent an **intermediate step** in the development of the Scenario for German inland water marinas and are **not** the final parameterisation of the Scenario for German inland water marinas.

A.1 Environment category

The input values for non-tidal daily water level change, the water quality parameters, layout, general information, wind and submerged dam specification are obtained from measured data of sampling in 2013 and/or 2016 (Watermann et. al, 2015; Redeker et. al, 2020). To create a scenario describing an average situation of service life during the boating season in summer (April to September), the following input parameters were adjusted: Marinas which have been sampled twice (2013/2016), water characteristics: SPM, POC, DOC, Salinity and pH are set to the average value. For single sampled marinas, the measured value is taken over. For the wind tab a mean value and associated wind frequency-strength rose between April to September in time periods depending on location (largest 1992-2015, shortest 2010-2015) is used.

The environment type, tidal difference, max. density difference tide as well as the sediment properties (sediment depth, organic carbon content, density) were taken from the EU freshwater marina scenario. The chlorophyll value is adopted from the OECD-EU marina scenario, which used an average value of 3 µg L^{-1} for European conditions.

The flow velocity is a key parameter in MAMPEC because it has a great influence on the water exchange rate within the model and therefore strongly influences the PECs in the simulation. There were no runoff data or measured flow velocities of the marina’s adjacent waters available. Therefore, measurement data of nearby levels were used to determine the flow velocity. However, this was only possible for the seven marinas located on rivers. For these marinas, the mean flow velocity for the period 2008 - 20017 was calculated from a database of the Federal Institute of Hydrology.

No comparable discharge measurements or water levels were available for the marina’s adjacent waters located on lakes and canals. Therefore, in consultation with hydrologists from the Deltares Institute and the Federal Institute of Hydrology, the flow velocities for these waters were determined on the basis of expert judgment to either 0.1 m s^{-1} (lake/ river lake) or 0.08 m s^{-1} (canal). For marina Nr. 3, 11, 17 the flow velocity is set slightly lower or higher because of special features of the layout.

Table 3: MAMPEC input environment parameters for the Step 2 modelling.

MAMPEC - input parameter	Unit	Step 2 Modelling	Reference
Environment			
Environment type	-	Marina	
Hydrodynamics			
Tidal period	hour	12.41	EU freshwater marina scenario
Tidal difference	m	0	
Max. density difference tide	kg m^{-3}	0	
Non-tidal daily water level change	m	Marina specific	Redeker et. al (2020)
Flow velocity	m s^{-1}	Marina specific	Adapted from Redeker et. al (2020)/expert judgment
Water characteristics			
SPM concentration	mg L^{-1}	Marina specific	Waterman et. al (2015) and/or Redeker et. al (2020); average value if applicable
POC concentration	mg L^{-1}		
DOC concentration	mg L^{-1}		
Salinity	psu		
pH	-		
Temperature	°C		
Chlorophyll	µg L^{-1}	3	OECD-EU Marina
Layout			
Length x1	m	Marina specific	Redeker et. al (2020)
Length x2	m		
Width y1	m		
Width y2	m		
Depth	m		
Mouth width x3	m		
General			
Latitude	°(dec) NH	Marina specific	Redeker et. al (2020)
Cloud coverage	class [0-10]		
Sediment			
Depth mixed sediment layer	m	0.03	EU freshwater marina scenario
Sediment density	kg m^{-3}	1000	
Degr. Organic carbon in sediment	1 d^{-1}	0	
Nett sedimentation velocity	m d^{-1}	0.5	
Wind			
Average wind speed	m s^{-1}	Marina specific	Redeker et. al (2020)
Fraction of time wind perpendicular	-		
Flush			
Flush (f)	m^3 s^{-1}	0	EU freshwater marina scenario
Max. density difference flush	kg m^{-3}	0	
Submerged dam specification			
Height of submerged dam	m	Marina specific	Redeker et. al (2020)
Width of submerged dam	m		
Depth-MSL in harbour entrance	m	set equal to marina depth/ height of submerged dam	
Emission			
Number of berths	-	Marina specific	Redeker et. al (2020)
$WSA_{aggregated}$	m^2		

A.1.1 Length classes

The classification of ships according to their length classes has also been provided in the dataset and overtaken in the simulations. For these length classes, Watermann et al. (2015) determined the typical underwater surface area (WSA) based on a number of pleasure boats within each class. The length classes and corresponding WSA are given in Table 4.

Table 4: Classification/division of ships in length classes and consequently related average underwater surface area

Length class [m]	Wetted surface area [m²]
0 - 6	9.96
6 - 8	16.61
8 - 10	25.03
10 - 15	44.98
15 - 20	76.60

A.2 Compound category

The step 2 MAMPEC simulations were conducted for the AAS and TP mentioned in Table 5. All relevant compound related input values were taken from the lists of endpoints (LoE) which are contained in the respective assessment reports for substance approval under Regulation (EU) No 528/2012.

Table 5: Compound specific input parameters for the Step 2 MAMPEC modelling.

MAMPEC - input parameter	**Unit**	**zinc**	**copper**	**medetomidine**	**tolylfluanid**	**DIDT**	**DCOIT**	**Zineb**
Reference		RAR of zinc	LoE	LoE	LoE	LoE	LoE	LoE
Molecular mass	g mol^{-1}	65.4	63.5	200.28	347.3	176.48	282	275.74
Saturized vapour pressure at 20 °C	Pa	1E-10	0	3.5E-06	0.0002	0.0026	0.000406	3.6E-5
Solubility at 20°C	g m^{-3}	1.5	0.001	200	1.04	2310	3.47	0.22
K_d	m^3 kg^{-1}	110	30.246	-	-	-	-	-
Biodegradation rate constant	d^{-1}		-	1.38E-2	2.31	4.81E-1	2.87	1.48E+2
Biodegradation Half life	d	-	-	5.02E+1	3.00E-1	1.44	2.42E-01	4.67E-3
Biodegradation rate constant	d^{-1}	-	-	6.93E-4	6.90E-4	6.93E-4	6.93E-4	6.93E-4
Biodegradation Half life	d	-	-	1.00E+3	1.00E+3	1.00E+3	1.00E+3	1.00E+3
K_{ow}	10 log K_{ow}	-	-	2.50	3.90	1.60	2.80	3.20E-1
K_{oc}	10 log K_{oc}	-	-	3.33	3.35	1.60	4.45	3.00
Henry's constant at 20°C	Pa m^3 mol^{-1}	-	-	8.30E-6	6.60E-2	1.98E-4	3.30E-2	4.60E-2
Melting temp.	°C	-	-	0	93	122.4	41	165
pKa	-	-	-	14	14	14	14	12.2

A.3 Emission category

Within the input category "Emission" the service-life of an antifouling product is the only source. Parameters describing the emission of biocidal AAS from antifouling products on ships at berth have to be provided. The classification/division of ships in length classes and consequently related average underwater surface area is taken from Watermann et al. (2015) (see Tab. 2). A full occupancy is assumed based on the number of berths investigated during the sampling campaigns (datasets „Monitoring 2013" and „Monitoring 2016"). A generalised value representing the currently available products was obtained for the product specific properties: Application factor (AF) and leaching rate (LR). Because information about AF is not available, the factor is based on analysis of antifouling product lists for pleasure boats on German market in the years 2011 to 2013 (Watermann, 2015). The analysis shows for different AS the share of product of biocide-containing products. The estimated application factors are 10% for DCOIT, 20% for Tolylfluanid, Medetomidine, Zineb and DIDT, 90% for Cu and Zn. For leaching rate, we used a value of 2.5 µg $(cm^2 \cdot d)^{-1}$ for organic biocides which is recommended in the ESD PT21. A similar value was also obtained by Thomas (2001). For the inorganic biocides Cu and Zn a leaching rate of 12 µg $(cm^2 \cdot d)^{-1}$ was chosen based on results by Lagerström (2018). Lagerström (2018) found for a location with a much higher salinity (5 psu) compared to freshwater that leaching rates did not exceed 12 µg $(cm^2 \cdot d)^{-1}$. Therefore, it is considered to be a realistic value that won't lead to underestimation.