Antifouling emission scenario 2017
Oskari Hanninen

UPDATED FINNISH MARINA SCENARIO

Finnish Safety and Chemicals Agency

Contents

1. Introduction

Authorization of antifouling products in Finland started in the middle of 2000. For environmental exposure assessment MAMPEC 1.4 (Marine Antifoulant Model to Predict Environmental Concentrations) was used to develop Finnish marina scenario (Koivisto 2003). Since then the MAMPEC -model has been developed further and the current version today is MAMPEC 3.1.0.3. Therefore, it was considered necessary to update the national scenario and check relevant parameters used in MAMPEC regarding environment: dimensions of the marina, hydrodynamics, and properties of the environment as well as emissions. A lot of new data on environmental parameters in the Baltic and marinas have also become available.

In addition to the new version of MAMPEC also risk assessment agreements regarding MAMPEC made during EU antifouling active substance risk assessment have been taken into account in the updated Finnish scenarios. All agreements are listed in "*Consolidated list of PT 21 technical agreements*" and found on the ESD specific ECHA webpage, PT 21: http://echa.europa.eu/guidance-documents/guidance-on-biocides-legislation/emission-scenario-documents. The document is included also in ECHA`s Technical Agreement for Biocides (TAB 2017).

Only Finnish marina scenario has been updated because environment in marinas and around marinas have been considered especially important to protect. Besides, during discussions in the Commission it was decided to harmonise - as far as possible - decisions of authorisation of antifouling products and concluded that there are no grounds for Member States to implement different risks mitigation measures or decisions for the protection of environment, in relation to the risks related to the in-service life of antifoulants applied on large commercial boats or superyacht >25m where these vessels are expected to travel across EU. Indeed, if a product is authorised in one Member State, and the product is applied in this Member State, the treated boat can afterwards travel across EU, and harmonisation is therefore needed. On the other hand, on duly justified grounds, Member States could request derogation from mutual recognition and decide to refuse to grant or restrict the use of antifouling products on either commercial or pleasure boats at regional/local levels in accordance with Article 37 of the BPR, for instance to ban the use in sensitive areas, specific marinas, specific coastal zones etc. (CA-March14-Doc.4.2-Final Antifouling (PT21) Way forward for the management of active substances and the authorisation of biocidal products).

Thus, it was generally understood amongst member states that derogation from mutual recognition would be possible in pleasure craft context and in marinas.

This document focuses only on Finnish Marina scenario based on MAMPEC model. Environmental risk assessment contains, however, other assumptions and parameters which influence much calculated predicted environmental concentrations (PECs). These issues like leaching value, application factor, tiered risk assessment approaches are not considered here, but in a separate document related to Finnish AF-strategy for pleasure boats.

2. Biofouling in Finland

Biofouling phenomenon is the accumulation of microorganisms, plants, algae, or sessile invertebrates to vessels hull. Biofouling is economic and environmental problem. Biofouling increases the surface roughness and water flow resistance, which increasing fuel consumption and greenhouse gas emission (Demirel et al. 2013). Vessels could also transport fouling species to another seas and ecosystems.

In Finland, the fouling phenomenon, in general, is relative weak but it may form problem in the Gulf of Finland, Archipelago Sea and Bothnian Sea. Low salinity concentration is limiting a strength of biofouling in Bothnia Bay. *Amphibalanus improvisus* (former *Balanus improvisus*) is the main "hard fouler" in the Finnish costal area and can creates thick layer to the hull that is hard to remove. Improvisus (barnacle) is a small sessile crustacean, occurring in marine and brackish environments. Free swimming larvae attach to the hard and solid substrate and start to grow hard calcareous shell. An adult individual grows up to 17 mm in diameter and 10 mm in height, but usually in Finland the diameter is less than 10 mm (Jensen 2015). Today it is distributed everywhere in the Finnish coastal area except Bothnian Bay.

3. Fin marina 2017

Fin marina scenario developed in 2003 was designed to simulate environmental conditions in a late spring when boats are launched and initial active substance load could be very high. In updated marina scenario, the whole boating season from May to October was simulated and environment parameters was updated to correspond average values from the whole boating season. Analyses was limited to consist the area between Vaasa to Hamina, where fouling phenomenon is obvious.

3.1 Environment parameters

3.1.1 Hydrodynamics

In Fin marina 2017, a tidal period was set to default value 12.41 h and tidal difference to 0 m. No updates were made compared to earlier version (Table 3.1). The Baltic Sea is a small and closed sea. The differential gravitational force of the Sun and the Moon is not enough to generate strong tidal motions in the Baltic Sea (Johansson 2014). In the coast of Finland tidal amplitude is only a few centimetres and effects of tides are hard to detect.

Non-tidal daily water level change

Non-tidal daily water level change -parameter was changed from 0.11 to 0.1 m (Table 3.1). The value was calculated by using water level data in May to October in the last 10-years. Difference between daily maximum and minimum water level value was calculated for each day and average value of these was used in scenario. Data is based on open water level data provided by the Finnish Meteorological Institute. The data was measured by 7 mareographs (Hanko, Helsinki, Kaskinen, Pori, Rauma, Turku and Vaasa). Non-tidal water level changes are dominant in Finnish coastline and a change of water level could be more than one meter on a day. Air pressure, wind speed and direction, standing waves and water flow by Danish straits are main factors causing variation of the water level. The Finnish Meteorological Institute has measured water level over hundred years along the coast of Finland.

Flow velocity

In the Baltic Sea, there is no noticeable permanent currents. The upper layer water flow is dominated by the local wind. It was assumed, there is no significant change at flow velocity and the old value of flow velocity was used in Fin marina 2017 (table 3.1).

Table 3.1. Values of hydrodynamic parameters used at Fin marina and Fin marina 2017

	Fin marina 2003	Fin marina 2017
Tidal period (h)	12.41	12.41
Tidal difference (m)	0	0
Max. Density difference (kg m^{-3})	0	0
Non tidal water level change (m)	0.11	0.1
Flow velocity (m s^{-1})	0.01	0.01

3.1.2 Wind

An average wind speed parameter was changed in the Fin Marina 2017. Instead of keeping it 3.6 m s^{-1} it was raised to 3.9 m s^{-1}. This is based on the data of the Finnish Meteorological Institute, collected from 5 weather stations near the coastline (Table 3.2). The data is between May and October in years 2010-2016. The Finnish Meteorological Institute has made observations of the atmosphere at over 200 weather stations around Finland and it offers open weather observation data from year 2010. There is available wind speed data collected in every 10 minutes. Stations that are located outer parts of archipelago or inner Finland was left out of the analysis, because the wind data should be representative for the inner archipelago marina.

Because marinas differ from each other with shape and location a specific fraction of perpendicular wind direction was not determined and the old value of 0.1 was used.

Table 3.2. Average wind speed measured from May to October at 5 weather stations during the years 2010-2016.

		Wind speed (m s^{-1})		
Municipality	FMISID	Average	SD	n
Helsinki	101004	4.2	1.9	85259
Kemiönsaari	100951	3.1	2.1	134499
Pori	100949	2.8	1.5	133300
Porvoo	100683	4.3	2.1	24956
Rauma	101061	7.8	3.9	53473
Overall		**3.9**	**2.7**	**431487**

3.1.3 Water characteristics

Baltic sea is one of largest pool of brackish water in the world. The brackish water is a mixture of ocean water from the North Sea and fresh water from various rivers at drainage basin (Feistel et al. 2010). Different parts of the sea are very heterogenous, for example salinity ranges from 2 to 23 psu (Feistel et al. 2010). Highest values are measured in area of the Danish straits and lowest in the Bothnia Bay. In the coastal area of Finland, salinity ranges from 2 to 6 psu and near river estuaries salinity could be even lower. Difference between northern and southern parts of Baltic Sea could be seen also in temperatures. In Bothnia Bay, the water temperatures are lower than in Gulf of Finland and the ice covering time is longer. It is hard to find water characteristics values, which represent the whole coastal area. It was decided to restrict the area between Vaasa to Hamina, where main fouling phenomenon is detected.

Water quality data from 23 sampling points from the Finnish coast in May to October during 2010-2017 was analysed (appendix 1). There is no available data inside marinas. Hence data collected in the inner parts of archipelago was used. Average values for every sampling point were calculated. These values were used to calculate average values for Fin marina 2017 scenario (appendix 2). Values of suspended matter, pH and salinity were almost same with values at earlier version of Fin marina (Table 3.3).

Table 3.3. Values of water characteristics used at Fin marina 2003 and Fin marina 2017

	Fin marina 2003	Fin marina 2017
SPM (mg l^{-1})	10	11
POC (mg l^{-1})	0.2	0.4
DOC (mg l^{-1})	5.2	7
Chlorophyll (µg l^{-1})	3	13.5
Salinity (psu)	4.6	4.6
Temperature (°C)	10	15
pH	8	8

Chlorophyll-a

Concentration of chlorophyll-a was set to 13.5 µg l^{-1}, which is almost four time higher than the old value 3 µg l^{-1}. In the Fin marina 2003 value of chlorophyll-a was based on measurements made in outer parts of archipelago and open sea area. In the inner parts of archipelago and in shallow bays, a primary production could be much higher than in open sea area. Nutrition runoff from the land and higher sediment resuspension keep the nutrition level high and allow higher primary production (Jani Ruohola, Finnish Environment Institute, pers. comm.). Suominen et al. (2010) have also made observations, that chlorophyll-a concentrations are higher in inner parts of archipelago. The new calculated value should be more representative.

Organic carbon

Concentration of DOC was set to 7.0 mg l^{-1} and concentration of POC was set to 0.4 mg l^{-1} (Table 3.3). They have been estimated from a new determined total organic carbon value (TOC) of 7.4 mg l^{-1} by using the same dissolved organic carbon (DOC) and particulate organic carbon (POC) ratio of 26:1 as used in the Fin Marina 2003 scenario. There was no data available about DOC or POC but only TOC was determined. Total organic carbon consists of DOC, POC and VOC (volatile organic carbon). Portion of VOC is negligible compared to DOC and POC (Orlikowska & Schulz-Bull 2009). Hence it was assumed that measured value of TOC was sum of DOC and POC.

Temperature

In the Fin marina 2017 temperature was set to 15 °C which represent 5-month average temperature from May to October in years 1990-2017 (Table 3.4). Fin marina 2003 scenario simulated situation in late spring when water is still chilly. Fin marina 2017 try to simulate the whole boating season. The water quality data from 5 sampling points in inner archipelago in Helsinki and Espoo was used (appendix 3).

Table. 3.4. Monthly average water temperature in archipelago of Helsinki and Espoo at years 1990-2017.

Month	Temperature (°C)	SD	n
5	10	3	139
6	16	3	224
7	19	3	214
8	19	2	186
9	14	2	236
10	8	2	182
5-10	15	5	1181

3.1.4 Sediment

The depth of the sediment layer has been changed from 5 cm to 3 cm as agreed in the TAB 2017 and net sedimentation velocity was changed from 0.5 m d^{-1} to 0.2 m d^{-1}, which correspond to value of accumulation rate 690 g m^{-2} yr^{-1}. The old value 0.5 m d^{-1} correspond to value of accumulation rate 1800 g m^{-2} yr^{-1}, which is too high. Sediment parameters are difficult to estimate. Different processes like sedimentation and resuspension are variating widely spatially and temporally. In the Baltic Sea, the annual accumulation rate of sediment varies between 260-850 g m^{-2} yr^{-1} (Mirja Leivuori, Finnish Institute of Marina Research, per. comm., Koivisto 2003). Mattila et al. (2006) reported, that median accumulation rate in the Gulf of Finland is 690 g m^{-2} yr^{-1}. Values in shallow coastal areas could be, however, very different than in open sea area due to the higher resuspension and sediment transportation. Even so value of sediment accumulation rate was set 690 g m^{-2} yr^{-1} and it was used to determinate net sedimentation velocity.

Net sediment velocity was calculated by using formula (van Hattum et al. 2016):

$$v_{Sn} = \frac{M}{AS_S}$$

V_{sn} = net sedimentation velocity (m d^{-1})

M = mass of accumulated sediment per day (g d^{-1})

A = accumulation area (m^2)

S_s = Average concentration of suspended matter (g m^{-3})

3.1.5 Other parameters

MAMPEC allows to calculate exchange volume based on a small stream flush, but small rivers or ditches are, however, not typically flowing to the marinas in Finland. Therefore, value of flush was not changed but kept 0 m^3 s^{-1} as it has been.

Height and width of submerged dam were not changed but kept to 0 m and Depth-MSL in harbour entrance was kept also equal to depth of marina. In Finnish marinas, there is no submerged dams, because there is no tides and daily water levels changes are low.

In the FIN marina 2017 latitude was set to 60 ° northern hemisphere, which correspond latitude of Finnish south coast. An average cloud coverage was set to 6/10 based on the assumption that the number of cloudy days is usually higher every month than days with clear skies. Latitude and cloud coverage are factors, which were added to MAMPEC after version 1.4 and values were not determined in Fin marina 2003.

3.2. Determining a representative core marina

3.2.1 Definition of marina

In order to find out if the Fin Marina 2017 -scenario can still be based on the default marina Uittamo, chosen as a representative marina for FIN marina 2003 scenario a marina survey was carried out. The aim of the survey was to collect as many as possible real marinas for detailed analysis to be carried out by MAM-PEC. Because the diversity of marinas in the Finnish coastline is high, it was first considered necessary to define a marina for the national scenario in the following way: a small port that is used for pleasure boats. It should provide long-term secure mooring during the boating season and often offer certain facilities e.g. for repairing and painting boats and/or winter storage of boats. Usually marinas are managed and owned by municipalities, boat clubs or private owners. Small, few boats jetties and guest marinas without long-term boat mooring places were left out of analysis.

3.2.2 Marina survey

To determine one typical Finnish marina is challenging. In smallest marinas, there is only few boat places and larger marinas consists more than 1500 boat places. Some of marinas are protected by breakwater and others just located sheltered areas in inner archipelago. Shape of marinas are variable and some marinas are relative open and others are very closed. One common thing is, however, that all marinas are relative shallow. Total number of marinas in Finnish coastline is unknown but national database of soil condition (MATTI) consists data of 209 marinas, which could be used as an indicative number of marinas in Finland (Kymenvaara et al. 2015). Venestamat.fi website contains information of about 500 marinas and mooring places in the coastal area of Finland, but many of these places are nature shores, guest marinas or guest jetties, which should be left out of marina analyses.

Finally, altogether 55 marinas were chosen for analyses. Marinas for analyses were chosen randomly on the map, between Hamina to Vaasa. Information on depths was collected from several sources, i.e. nautical charts, boat magazine's marina data base (Venelehti), sailing clubs or marinas owners. If no information about the depth of the marina was available, the marina was rejected and not taken into account. Dimensions of marinas were measured from Google satellite pictures (appendix 5). In smaller marinas, number of boat places was also counted. In larger marinas, the number of boat places was based on information given by sailing clubs or municipalities. These 55 marinas include also 10 Finnish marinas referred to already in the New Castle Report (Thomason & Prowse 2013). Different sizes and shapes of marinas are considered well represented in the sample of 55 marinas, in general. Although the selection of marinas was made randomly, only marinas with information about depth were chosen for analyses. Nevertheless, representativity of the sample of marinas was considered to be sufficient for the time being. It is also possible to add marinas to comparison later, if it is necessary.

Analyses of marinas was carried out determined by using MAMPEC 3.1.0.3. Updated environmental parameters were taken into account (described above and appendix 6). Layout information was changed to correspond the dimensions of each real marina. Load for emission was calculated based on estimated/evaluated boat numbers in each real marina. Only one length class with wetted surface area 22 m^2 was used. Copper was used as an active substance with leaching rate 15 µg cm^{-2} d^{-1}.

The range of calculated aquatic PEC values in different marinas was wide (fig. 3.1). The smallest calculated PEC was 1.1 µg l^{-1} and the highest was 100 µg l^{-1}. An average predicted concentration was 19.8 ± 22,7 µg l^{-1}. Uittamo marina in Turku (marina 54) used as a default marina in the Fin marina 2013 scenario was shown to be a best case marina with the PEC of only 1.8 µg l^{-1} (appendix 4).

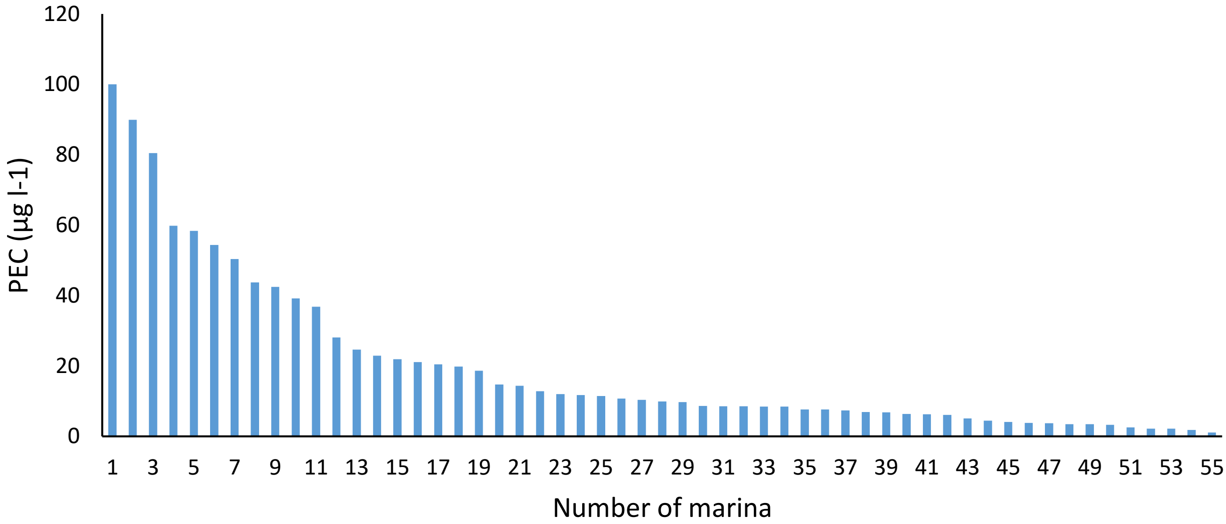


Fig. 3.1. Distribution of predicted environmental concentration (PEC) in water of 55 marinas.

3.2.3 Layout of marina in Fin marina 2017

When comparing calculated PECs of different marinas, it came out that Uittamo marina was more like a best case than a typical Finnish marina. PEC in Uittamo was one of the lowest. Marina analyses showed, that Uittamo marina wasn't a representative marina. Thus, it was decided to replace Uittamo with a new marina which would be more protective for the environment. The 75th percentile concentration from marina comparison was chosen to be used in the Finnish marina scenario 2017 as representative realistic worst case. Based on the marina PECs comparison Poroholma marina in Rauma was considered to protect 75 % of Finnish marinas and chosen as a new representative marina. Marina dimensions to be used in Fin marina 2017 are shown in Table 3.5 and Appendix 5.

Table 3.5. Marina dimensions used at Fin marina 2017

Poroholma marina					
Length x1 (m)	Length x2 (m)	Width y1 (m)	Windth y2 (m)	Depth (m)	Mouth width (m)
55	55	90	90	1.9	50

3.3 Emission

3.3.1 Determination of wetted surface area and length classes

Wetted surface area of boats was calculated from the data provided by the Finnish Sailing and Boating association. Data contained basic information on 27 000 boats, which are registered as a member of some Finnish sailing or boating club. Data was, however, restricted to contain only boats of which owners live in or near coastal municipalities. Besides, coastal municipalities north from Vaasa were left out of the analyses. The target of the analyses was boats used in the Baltic Sea, only. The boat register data from the Finnish Transport Safety Agency was checked also, but found later not to be suitable for this kind of detailed analyses. Thus, it was decided to use data from the Finnish Sailing and Boating association only, because the data was considered to represent better boats in marine marinas.

Boats missing value of length, width or depth were excluded from the analyses. Also, boats of which dimensions were odd/incorrect were excluded. Finally, totally 13 666 boats were analysed, 53 % of them were motor boats and 47 % were sailing boats. Boats were sorted out to 10 length classes (Fig 3.2). Most of the boats belonged to length classes of 8-9 meters and 9-10 meters. Both length classes contained 17 % of total number of boats. Comparing the values with values used in Fin Marina 2003 it can be seen that the proportion of big boats was increased and small boats was decreased (Table 3.6). Thus, the mean length of boats was increased in 15 years.

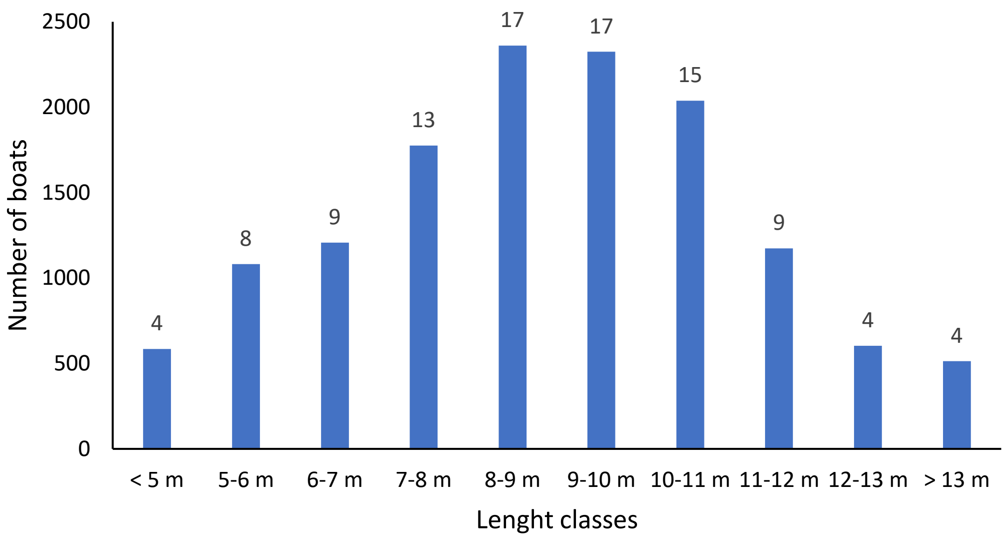


Fig 3.2. Number of boats in the different length classes and percentage share of boats in each length class. Calculation based on data provided by the Finnish Sailing and Boating association.

Only the overall lengths of boats were available. LWL is 10-15 % less than the overall length (Koivisto 2003). In calculations, overall lengths were converted to LWL using factor 0.9. Length class specific wetted surface areas are shown by Table 3.6. The wetted surface areas were calculated by using the same method than used in FI marina 2003 scenario:

Wetted surface area of motor boats: $LWL \cdot (B + D) \cdot 0.85$

Wetted surface area of sailing boats: $LWL \cdot (B + D) \cdot 0.5$

LWL = Length of waterline

B = Beam (width)

D = Draft (depth)

Table 3.6. Distribution of boat sizes and average wetted surface area in each length class in Fin marina 2003 and Fin marina 2017 -scenarios

	Fin marina 2003			Fin marina 2017		
Length (m)	Average (m^2)	n	%	Average (m^2)	n	%
< 5	7	1223	10	8	585	4
5-6	11	1393	11	11	1082	8
6-7	16	1551	12	15	1208	9
7-8	19	2537	20	17	1776	13
8-9	23	2479	19	20	2361	17
9-10	26	1562	12	23	2324	17
10-11	29	1171	9	27	2038	15
11-12	30	507	4	31	1174	9
12-13	30	185	1	36	604	4
> 13	32	229	2	51	514	4

3.3.2 Emission parameters in Fin Marina 2017

In Fin marina 2003 scenario several different boat length classes and specific number of boats and wetted surface area for each class were used. In updated Fin marina 2017, it was decided to use only one length class and average wetted surface area of 22 m^2 of all boats for the sake of simplicity (Table 3.7). The total value of wetted surface area will be the same using one length class or several different classes.

In Poroholma marina with 50 boat places, it is not realistic to assume that all places are filled. It can be assumed that 10 % of boat places are always empty. Calculating number of boats for Fin marina 2017 emission scenario the number of boat places was multiplied by a factor 0.9 and number of boats was set to 45 (Table 3.2)

Table 3.7. Value of each factor in emission scenario in Fin marina2017

Fin marina 2017		
Length class (m)	Wetted surface area (m^2)	Number of boats
1-50	22	45

4 Conclusion

Finnish marina scenario was updated based on new environmental, marina and boat data. Many parameter changes affected PECs only slightly. The following changes, however, have more significant effects. The average wetted surface area of boat raised from 19.8 to 22 m^2, net settlement velocity lowered from 0.5 to 0.2 m s^{-1}. The most important change was, however, a change of marina dimensions (layout). Marina analyses showed, that Uittamo marina wasn't representative marina with low boat density and big water exchange. Thus, Uittamo marina was replaced with Poroholma marina, which is considered to protect 75% of Finnish marinas. This change was considered to assure higher environmental protection level in Finnish marinas.

5. References

Demirel, Y. K., Khorasanchi, M., Turan, O., & Incecik, A. (2013). On the importance of antifouling coatings regarding ship resistance and powering. In 3rd International Conference on Technologies, Operations, Logistics and Modelling for Low Carbon Shipping.

Feistel, R., Weinreben, S., Wolf, H., Seitz, S., Spitzer, P., Adel, B., & Wright, D. G. (2010). Density and absolute salinity of the Baltic Sea 2006–2009. Ocean Science, 6(1), 3-24.

Jensen, Kathe R. (2015): NOBANIS – Invasive Alien Species Fact Sheet – Amphibalanus improvisus – From: Identification key to marine invasive species in Nordic waters – NOBANIS www.nobanis.org, Date of access 24/8/2017

Johansson, M. (2014). Sea level changes on the Finnish coast and their relationship to atmospheric factors. Finnish environment institute contributions No. 109

Koivisto, S. (2003). Proposal for Finnish exposure scenarios for antifouling products. Finnish Environment Institute.

Kymenvaara, S., Rontu, J., & Ekroos, A. (2015) Antifouling for leisure boats in the Baltic Sea-Mapping the legal situation. http://changeantifouling.com/wp-content/uploads/2014/10/Antifouling-for-leisure-boats-in-the-Baltic-Sea-Mapping-the-legal-situation-Finland1.pdf

Mattila, J., Kankaanpaa, H., & Ilus, E. (2006). Estimation of recent sediment accumulation rates in the Baltic Sea using artificial radionuclides ^{137}Cs and ^{239},^{240}Pu as time markers. Boreal environment research, 11(2), 95.

Orlikowska, A., & Schulz-Bull, D. E. (2009). Seasonal variations of volatile organic compounds in the coastal Baltic Sea. Environmental Chemistry, 6(6), 495-507.

Suominen, T., Tolvanen, H., & Kalliola, R. (2010). Geographical persistence of surface-layer water properties in the Archipelago Sea, SW Finland. Fennia-International Journal of Geography, 188(2), 179-196.

Thomason, J., & Prowse, G. (2013). Defining Typical Regional Pleasure Craft Marinas in the EU for Use in Environmental Risk Assessment of Antifouling Products.

van Hattum, B., van Gils, J., Elzinga, H., & Baart, A. (2016). MAMPEC 3.0 HANDBOOK.

Venelehti. Marina database https://venelehti.fi/satamat/

6. Appendix

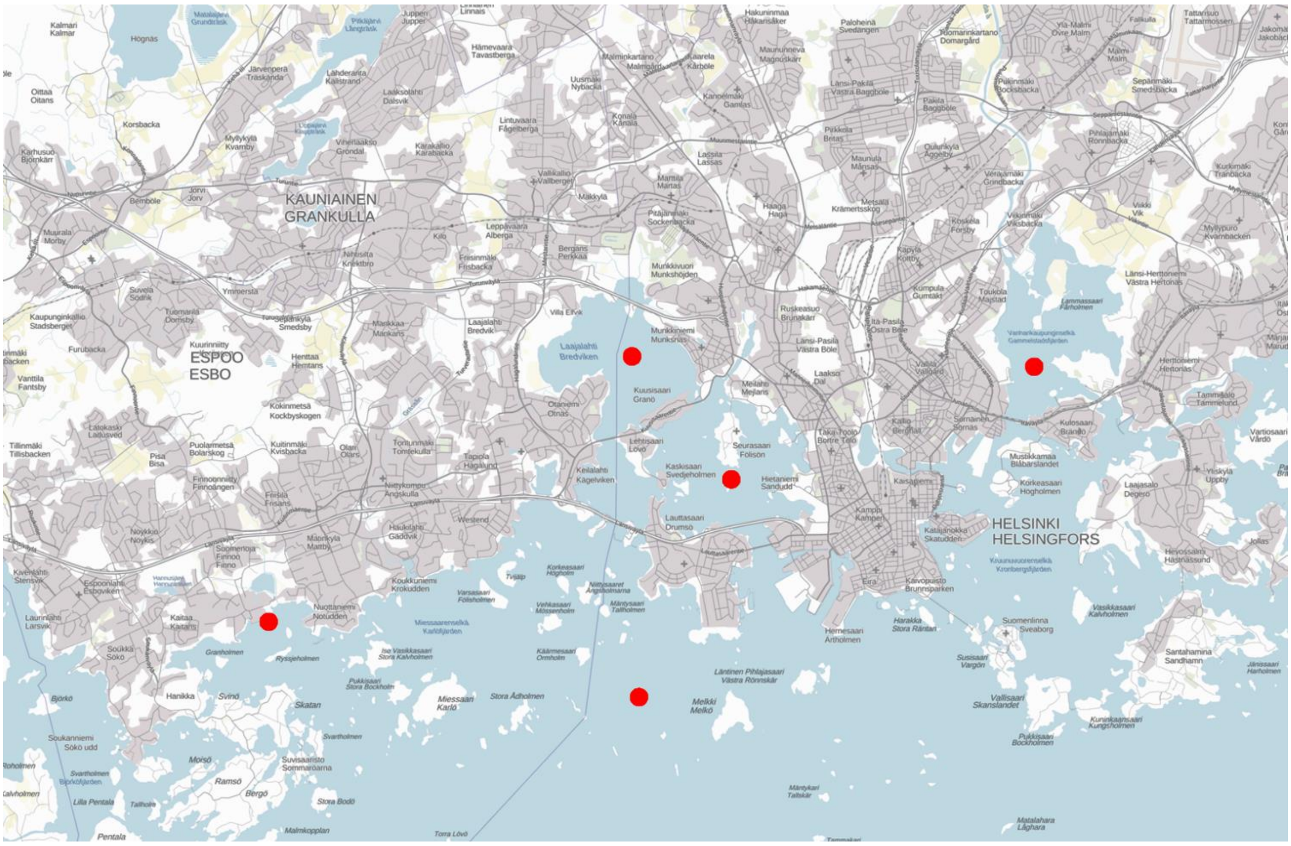
Appendix 1. Location and information of water quality sample points (map from National Land Survey of Finland)

No.	Name	ID	Municipality	ETRS-coordinate east	ETRS-coordinate north
1	Barkarsundet 51	3604	Inkoo	331085	6657388
2	Dicksholmen 42	69814	Kaskinen	202799	6927294
3	Fagerviken 64	3602	Inkoo	326722	6657406
4	Hala 127 Teijons loun	6853	Salo	273233	6683844
5	Illvarden koillinen 27	3277	Porvoo	420363	6688502
6	Laajalahti 87	3433	Helsinki	380713	6675121
7	Myla 320 Puttanjoki suu	66625	Vehmaa	213040	6728748
8	Olki 480 Pitkäk kulma	7187	Eurajoki	205418	6803185
9	Otsolahti 1	46969	Espoo	378978	6672608
10	Pernajanlahti 49	3156	Loviisa	443553	6705105
11	Piik 105 Pirttikari	7076	Kaarina	257465	6701682
12	Pikkalanlahti 21	3640	Siuntio	350948	6662783
13	Raum 380 Satamalahti	7164	Rauma	201253	6789379
14	Sipoonlahti 61	3198	Sipoo	408077	6683018
15	Suomenl Summanlahti 198	12640	Hamina	505958	6710544
16	Syningsviken 5	3680	Raasepori	286307	6647687
17	Torbackaviken 1	66563	Inkoo	345718	6660070
18	Turm 220 Rajakari	6991	Turku	230115	6703500
19	Uki 223 Madonmaa luot	7119	Uusikaupunki	195068	6752786
20	UUS-16 Pohjanp.lahti 92	3607	Raasepori	303551	6659097
21	Vanhankaupunginselkä 4	3435	Helsinki	388770	6674915
22	Vav-8 V-1	5440	Maalahti	215310	6986368

Appendix 2. Water quality data in the inner parts of archipelago in Finland

	Chlorophyll a (µg l^{-1})			spm (mg l^{-1})			TOC (mg l^{-1})			pH			Salinity (psu)		
No.	**Average**	**SD**	**n**	**Average**	**SD**	**n**	**Average**	**SD**	**n**	**Average**	**SD**	**n**	**Average**	**SD**	**n**
1										8.1	0.2	15	5.7	0.3	13
2	2.9	1.5	6				9.2	4.1	3	7.8	0.3	24			
3										8.0	0.3	15	5.6	0.4	13
4	26.8	11.2	6	8.6	10.5	24	6.3	2.1	18	8.1	0.4	24	3.8	1.1	18
5	15.2	11.3	38				6.8	1.3	22	8.2	0.3	36	4.9	0.3	25
6				14.0	0.0	2	8.6	0.2	2						
7	12.6	5.9	33	12.1	5.4	31	6.9	1.7	29	7.9	0.1	31	5.2	0.6	29
8				2.6	1.4	13	4.2	1.2	10	7.9	0.2	13	5.2	0.3	10
9										8.1	0.3	12	5.1	0.3	12
10	24.6	12.8	12	29.0	23.6	24	10.9	3.1	24	7.3	0.2	37	1.6	1.1	24
11	9.9	5.8	24	17.1	24.4	27	5.8	2.0	24	8.1	0.3	28	5.0	1.1	24
12	9.2	6.5	39	2.9	0.2	2	5.7	1.1	6	8.1	0.1	9	5.4	0.3	31
13	9.1	5.6	2	3.4	1.1	26				7.9	0.1	31			26
14	13.0	12.1	8	15.7	27.9	28	7.7	3.3	28	8.0	0.3	30	4.5	0.8	
15										8.1	0.3	36	3.7	0.4	36
16										8.2	0.2	21	5.4	0.7	36
17	5.7	3.7	9	8.1	10.3	16	5.7	1.2	16	8.2	0.2	16	5.4	0.3	18
18	10.8	4.5	8				4.7	0.6	13	8.2	0.3	28	5.7	0.2	16
19	11.1	5.0	20	7.1	3.0	27				8.0	0.2	41			14
20										7.9	0.3	37	1.8	0.8	
21	24.8	17.4	36	15.0	2.0	2	10.0	0.0	2						31
22				6.5	2.4	26	11.7	5.0	26	7.9	0.4	26	3.9	0.8	26
Overall	**13.5**	7.2	13	**10.9**	7.1	13	**7.4**	2.2	15	**8.0**	0.2	20	**4.6**	1.2	18

Appendix 3. Temperature measurement points at costal of Helsinki and Espoo (map: National Land Survey of Finland).



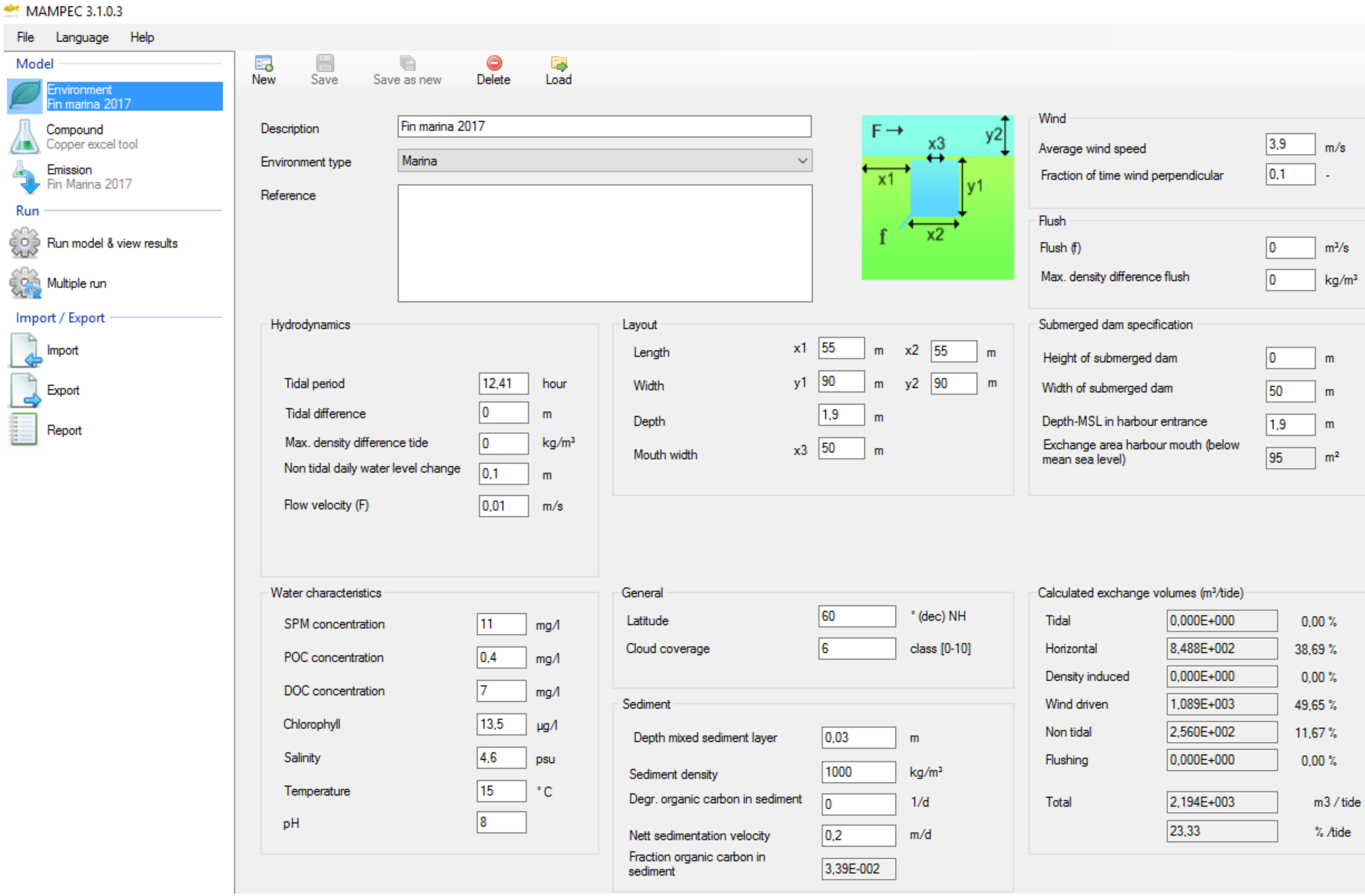
Appendix 4. Information of analysed marinas

No.	Marina's name	Municipalitie	PEC (µg l-1)	x2	y1	x3	Depth	Boat places
1	Storviken	Kristiinankaupunki	100	130	10	1.8	1.8	43
2	Ramsaynranta 4	Helsinki	89.90	340	40	1.5	1.5	224
3	Reposaari. sahan kanaali	Pori	80.5	323	40	2	2	163
4	Mustalahti	Helsinki	59.8	200	41	2	2	300
5	Haukilahti	Espoo	58.4	377	90	2	2	637
6	Syväraumanlahti	Rauma	54.4	300	190	1.6	1.6	1500
7	Pohjoisranta	Helsinki	50.4	150	32	3.8	3.8	61
8	Tammisaari. Pohjanlahti	Raasepori	43.7	95	40	2	2	70
9	Pajalahden satama	Helsinki	42.5	158	50	4	4	560
10	Åminne Marina	Maalahti	39.2	82	14	3.5	3.5	120
11	Hangonkylä	Hanko	36.8	200	40	2.5	2.5	585
12	Uutela marina	Helsinki	28.1	117	27	3.5	3.5	190
13	Aurinkolahden satama	Helsinki	24.6	280	47	2	2	147
14	Hietalahdenallas	Helsinki	22.9	100	9	2.5	2.5	66
15	Rauma. Poroholma	Rauma	21.9	55	50	1.9	1.9	50

16	Herttoniemen MARINA	Helsinki	21.1	100	83	3	3	190
17	Kalarannanpuisto	Vaasa	20.5	98	76	5	5	200
18	Hietasaari	Vaasa	19.8	180	99	5	5	500
19	Raisio. Hahdenniemi	Raisio	18.6	600	270	2	2	700
20	Krookka	Merikarvia	14.7	90	160	2.2	2.2	100
21	Otsolahti	Espoo	14.4	150	250	3	3	438
22	Svinö skatan	Espoo	12.8	125	168	2.5	2.5	235
23	Reila Marina		12	34	48	3.5	3.5	45
24	Hirvensalo. Lauttaranta	Turku	11.7	150	300	2.5	2.5	270
25	Reposaari. Santunranta	Pori	11.5	114	178	2	2	217
26	Helsinki. Pohjoissatama	Helsinki	10.7	160	230	3	3	345
27	Nuottaniemi	Espoo	10.4	176	292	2.3	2.3	425
28	Långviken	Kirkkonummi	9.9	80	100	1.5	1.5	70
29	Helsinki. Tervasaari	Helsinki	9.69	160	230	4	4	380
30	suomenojan venesatama	Espoo	8.65	250	800	2	2	982
31	soukan venesatama	Espoo	8.59	180	400	2.3	2.3	372
32	Santalahti	Kotka	8.52	80	100	2.5	2.5	80
33	Keisarinsatama	Kotka	8.49	65	100	3	3	130
34	Åminne	Maalahti	8.47	80	29	2.5	2.5	32
35	Ruissalo. Härkälänlahti	Turku	7.64	120	200	2.3	2.3	200
36	Eläintarhanlahti	Helsinki	7.63	230	380	2.5	2.5	199
37	Inkoo	Inkoo	7.32	130	390	2	2	550
38	Kabböle	Loviisa	6.95	80	190	1.8	1.8	104
39	Kallahti	Helsinki	6.8	90	220	2	2	220
40	Kokkila	Salo	6.36	40	55	1.8	1.8	28
41	Ruissalo. Santalanlahti	Turku	6.23	110	140	2.8	2.8	95
42	Loviisa. Laivasilta	Loviisa	6.1	140	300	2.5	2.5	354
43	Hanko. Itäsatama	Hanko	5.13	166	270	4	4	360
44	Iso-Sarvasto	Helsinki	4.47	330	136	1.8	1.8	678
45	Suninsalmi	Porvoo	4.1	90	150	3	3	86
46	laajalahden venesatama	Espoo	3.86	90	290	2	2	142
47	lököre	Kotka	3.76	100	300	1.2	1.2	75
48	Merikarvia. Mericamping	Merikarvia	3.48	40	100	1.5	1.5	30
49	Hamari	Porvoo	3.45	80	390	1.9	1.9	201
50	sepetlahden venesatama	Espoo	3.23	50	200	1.5	1.5	96
51	Rönnäs 1	Loviisa	2.57	25	65	2.5	2.5	20
52	Loviisa. Tullisilta	loviisa	2.17	40	100	2.7	2.7	25
53	Karhusaari	Sipoo	2.16	115	569	3.5	3.5	340
54	Uittamo	Turku	1.8	120	640	2	2	226
55	Mikonkari	Raahe	1.1	34	93	3.5	3.5	29

Appendix 5. Example of measurements taken using the Google satellite picture and Google's distance measure tool (x2 = 55 m. x3 = 55 m and y1 =90 m).

Appendix 6. Fin marina 2017 environmental sheet in MAMPEC.



Appendix 7. Fin marina 2017 environmental sheet in MAMPEC.