Supplementary materials for the paper:

Nautical Tourism in Marine Protected Areas (MPAs): Evaluating an Impact of Copper Emission from Antifouling Coating

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The graphical user interface (GUI) of the program is shown in Figure S1. It consists of the main video online panel, which displays the video stream from the camera, and several other supporting panels, in which sequential images from the main video stream are displayed at defined time intervals. The motion detection algorithm is based on the differences in the change of RGB pixels between two consecutive images. If the change at certain parts of the video image is above the defined threshold, the image is captured and stored. The base signal in the main graphic represents the changes in the pixels. As a vessel passes through, the intensity of the pixel changes increases and produces a characteristic signal (peak). Together with the captured images, the raw signal of the intensity change is further processed to determine the size of the boats, which is related to the area under the observed peak (Figure S1).

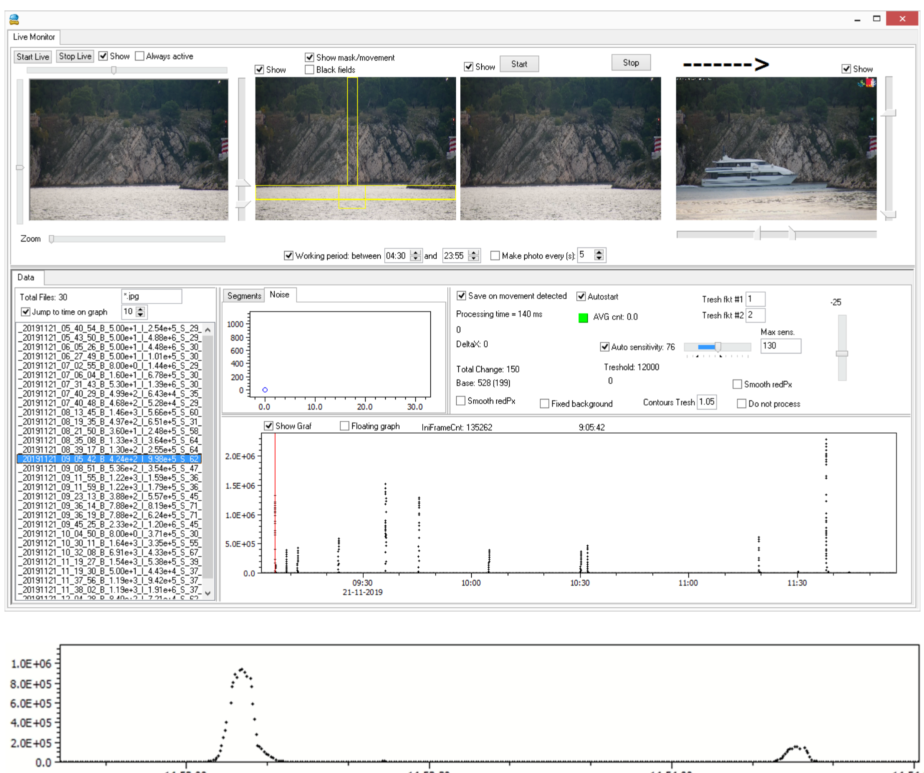

Figure S1. The screenshot of the boat tracking software.

The problems encountered during the monitoring survey included: fast boats passing, sun reflection and multiple boats passes for the “entrance” camera, or the vicinity of the boats passes for the “upstream” camera (Figure S2). Despite the speed for the vessels for the position of “entrance” camera was limited, there were boats passing with irregular speed, causing “false positive” high intensity, i.e., recognized as a big boat.

The algorithm of software was adapted to be self-adaptable so that the threshold value for triggering boat pass is automatically adjusted based on the estimated “video noise”, which is mostly related to the waves during windy days (Figures A3–A6).

Suitable PC system was selected to meet criteria for fast processing of video signal in real time. Basic PC specifications: Intel Core i7 8700, 8 GB RAM, 2 Tb HD, graphic card GeForce GTX1060. Two hard discs were added (fixed SSD and portable HD) after for backup purposes.

Figure S2. Problems associated with the correct recognition of the vessels passes: fast vessels passing caused waves, sun reflection and multiple vessels pass for the “entrance” camera.

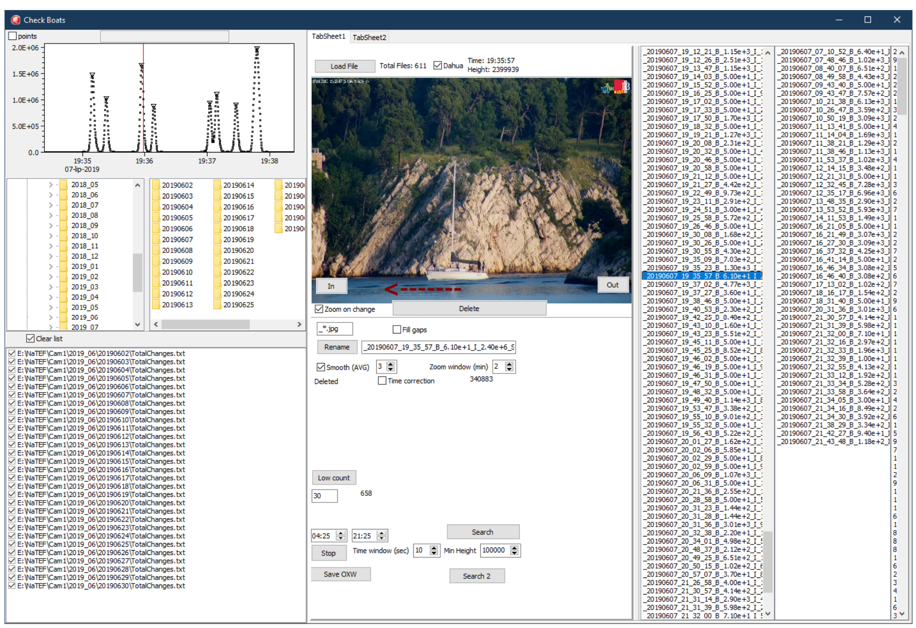

Figure S3. The screenshot of the program for analysis of collected data (pictures and signals).

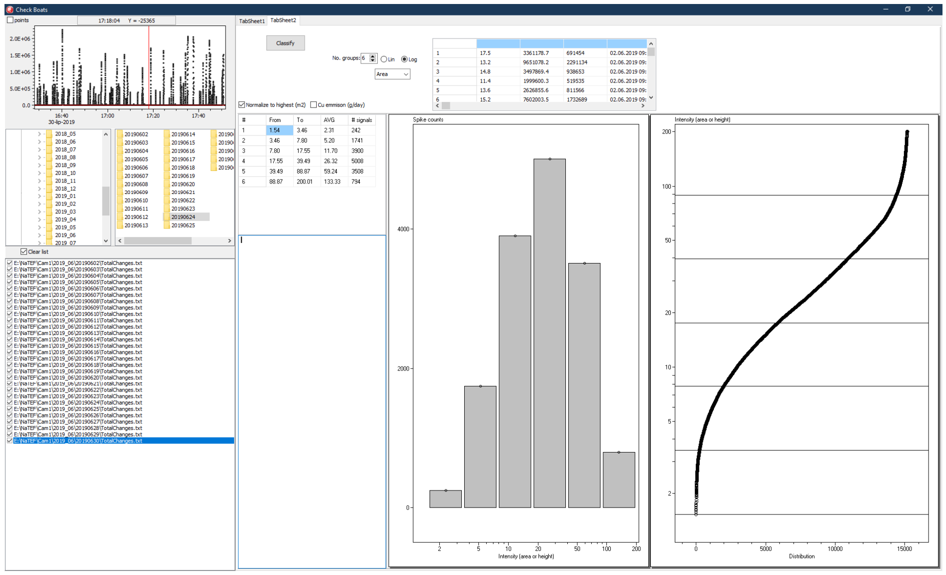

Figure S4. The screenshot of the program for classification and statistical analysis of boat passes.

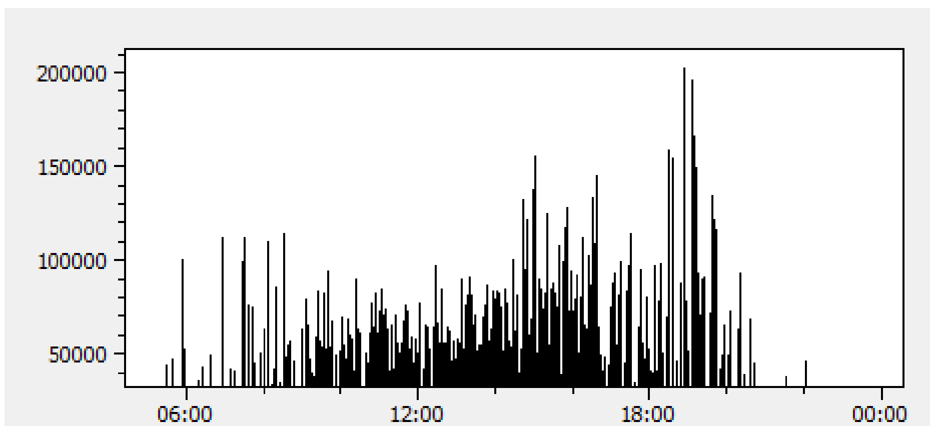

Figure S5. Typical intensity signal collected for daily monitoring of boats passes in summer period.

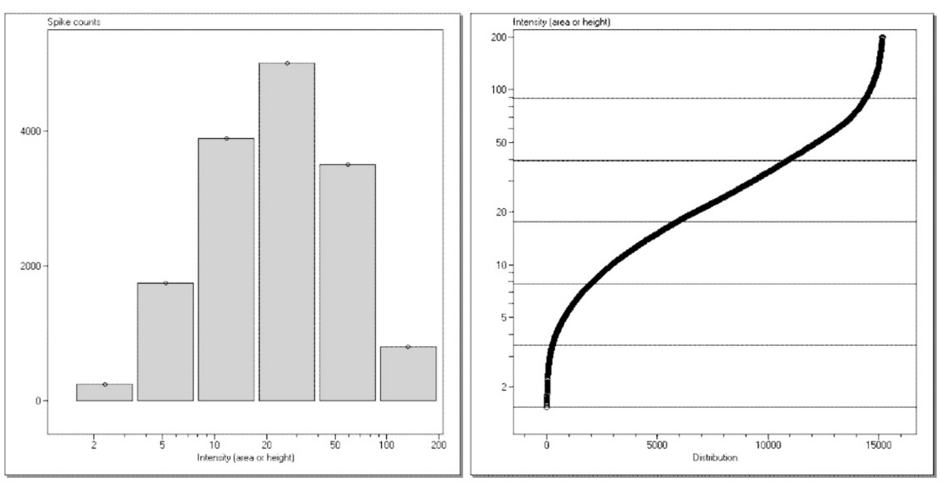

Figure S6. Typical size classification of boat and their distribution for the June 2019.

Figure S7. Examples of aerial images taken by the drone (8/2018 and 8/2019).

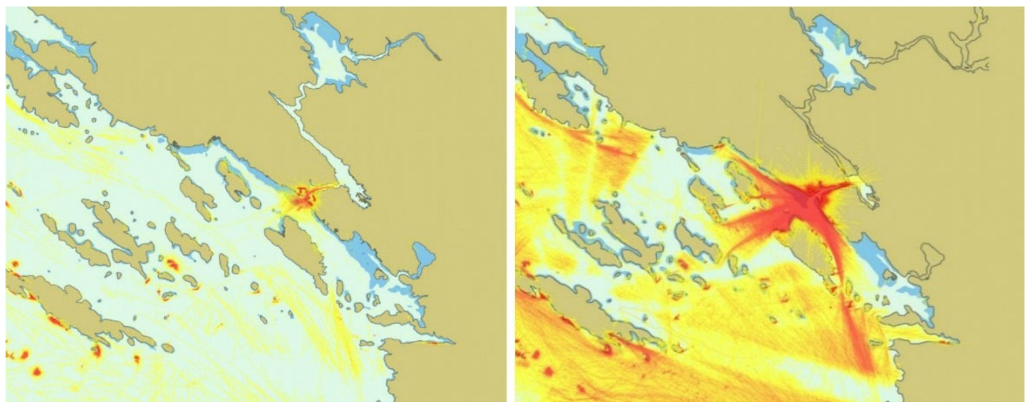

Figure S8. Representative examples of nautical traffic heatmaps for winter and summer period in wider area.

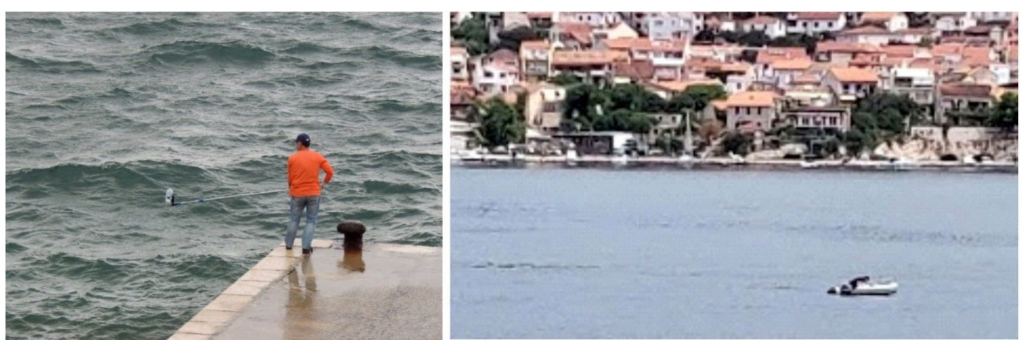

Figure S9. Sampling of surface water in front of the marine station Martinska and "upstream" transversal profile sites.

Table S1. Scanned area and the number of anchoring places with the MPA.

Place	Number of Sites
Šibenik port	280
Šibenik Vernaža	392
Marina Mandalina	320
Skradin	250
Bilice	119
Bilice Vrulje	100
Rasline	64
Zaton	197
Jadrija	208
Total:	**1930**

Classification of boats according to type

As we were not able to find solution for the automatic boats recognition, the classification of boats was performed manually for representative days for Winter, Spring and Summer periods. The selected days were: 17.11.2018, 22.12.2018, 16.1.2019, 15.2.2019, 16.2.2019, 7.3.2019, 13.3.2019, 7.4.2019, 7.5.2019, 13.5.2019, 12.7.2019, 13.7.2019, 26.7.2019, 27.7.2019, 16.8.2019, 17.8.2019.

Vessels are classified into total 6 categories:

1. Rubber boats
2. Small motorboats (MB) (MB < 10 m)
3. Motorboats MB (10 m < MB < 20 m)
4. Sailing boats
5. Catamarans
6. Big MB (MB > 20 m)

Note that this classification does not necessarily follows the size trend of the boats, and thus is not directly comparable to size-classification as presented in below figures:

1. Rubber boats

This category represents boats with small underwater surface and includes all rubber boats, except ones belonging some bigger boats. Considerable part of this category is without antifouling paints. However, it was impossible to quantify this part.

Figure S10. Examples of rubber boats

2. Small motorboat (<10 m)

This category represents all motorboats smaller than 10 m total length.

Figure S11. Examples of small motorboat (<10 m).

3. Motorboats (>10 m and <20 m)

This category represents all motor boats with total length bigger than 10 m and smaller than 20 m.

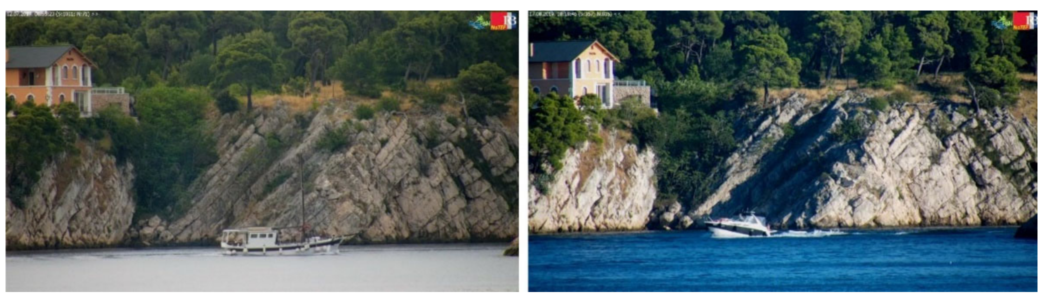

Figure S12. Examples of motorboats (>10 m and <20 m)

4. Sailing boats

This category includes all sailing boats independently of size and that kind of boats have the biggest underwater surface comparing to size of boat. However, some big boats with sails are includes in category big motorboats.

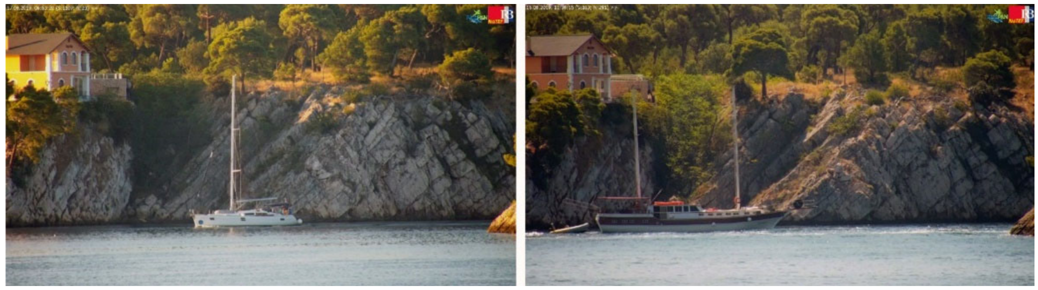

Figure S13. Examples of sailing boats

5. Catamarans

This category includes all boats with more than one hull (catamarans and trimarans). Mostly of these boats are sailing boats, but some are just motorboats. That category represents boats with biggest surface covered with antifouling paints.

Figure S14. Examples of catamarans.

6. Big motorboats (>20 m)

This category represents all motorboats with total length bigger than 20 m. That include boats bigger than 200 m (cargo boats and cruisers).

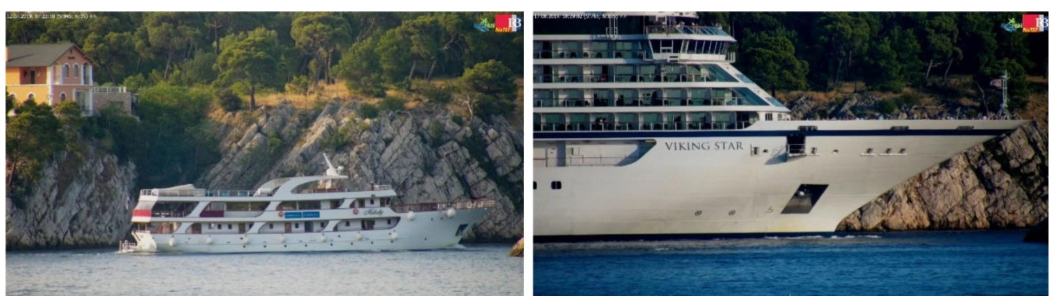

Figure S15. Examples of big motorboats (>20 m)

The Table S2 provides the data on classification of vessels according to types. Basically, similarly as obtained by the size—classification, there is the difference in the contribution of classes in relation to the season: generally smaller and big boats are more frequent in the winter period, whereas the contribution of mid-sized boats (sailing boats and bigger motorboats) is dominating during summer period.

Table S2. Classification of vessels according to types as explained above

Category	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1	1	1	3	4	2	2	2	0	5	7	1	0	2	2	1	1	6	6	0	2	78	83	41	41	76	72	48	48	104	106	66	93
2	11	15	8	13	22	22	3	3	25	30	1	1	14	16	8	3	10	6	4	4	134	144	71	74	201	191	144	122	131	162	224	225
3	2	2	4	2	6	4	5	3	2	1	0	0	9	10	4	2	12	9	3	1	42	34	31	19	57	36	36	24	77	89	62	68
4	2	3	1	1	1	1	1	0	7	10	0	1	3	2	26	9	52	73	43	39	100	70	48	67	157	70	74	35	177	100	71	98
5	2	2	0	0	0	0	0	0	0	1	0	0	1	2	6	2	9	13	9	8	39	19	17	31	41	22	25	12	42	32	20	45
6	11	9	7	5	8	6	6	6	8	11	5	5	9	9	10	6	17	14	15	17	34	38	42	39	49	46	44	33	38	40	44	8
SUM	**29**	**32**	**23**	**25**	**39**	**35**	**17**	**12**	**47**	**60**	**7**	**7**	**38**	**41**	**55**	**23**	**106**	**121**	**74**	**71**	**427**	**388**	**250**	**271**	**581**	**437**	**371**	**274**	**569**	**529**	**487**	**537**
Total	**61**		**48**		**74**		**29**		**107**		**14**		**79**		**78**		**227**		**145**		**815**		**521**		**1018**		**645**		**1098**		**1024**	

%	3.4	3.1	13.0	16.0	5.1	5.7	11.8	0.0	10.6	11.7	14.3	0.0	5.3	4.9	1.8	4.3	5.7	5.0	0.0	2.8	18.3	21.4	16.4	15.1	13.1	16.5	12.9	17.5	18.3	20.0	13.6	17.3
%	37.9	46.9	34.8	52.0	56.4	62.9	17.6	25.0	53.2	50.0	14.3	14.3	36.8	39.0	14.5	13.0	9.4	5.0	5.4	5.6	31.4	37.1	28.4	27.3	34.6	43.7	38.8	44.5	23.0	30.6	46.0	41.9
%	6.9	6.3	17.4	8.0	15.4	11.4	29.4	25.0	4.3	1.7	0.0	0.0	23.7	24.4	7.3	8.7	11.3	7.4	4.1	1.4	9.8	8.8	12.4	7.0	9.8	8.2	9.7	8.8	13.5	16.8	12.7	12.7
%	6.9	9.4	4.3	4.0	2.6	2.9	5.9	0.0	14.9	16.7	0.0	14.3	7.9	4.9	47.3	39.1	49.1	60.3	58.1	54.9	23.4	18.0	19.2	24.7	27.0	16.0	19.9	12.8	31.1	18.9	14.6	18.2
%	6.9	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	2.6	4.9	10.9	8.7	8.5	10.7	12.2	11.3	9.1	4.9	6.8	11.4	7.1	5.0	6.7	4.4	7.4	6.0	4.1	8.4
%	37.9	28.1	30.4	20.0	20.5	17.1	35.3	50.0	17.0	18.3	71.4	71.4	23.7	22.0	18.2	26.1	16.0	11.6	20.3	23.9	8.0	9.8	16.8	14.4	8.4	10.5	11.9	12.0	6.7	7.6	9.0	1.5

The main directives relevant to the issues discussed are the EU WFD—Water Framework Directive (Directive 2000/60/EC) and the MSFD—Marine Strategy Framework Directive (Directive 2008/56/EC). Specific chemical risks are addressed by the REACH Regulation (1907/2006), the Biocidal Products Regulation (528/2012), the Chemical Agents Directive (Directive 98/24/EC), the Carcinogens and Mutagens Directive (Directive 2004/37/EC) and instruments such as the European Pollutant Release and Transfer Register (E-PRTR).

Table S3. Overview of the EU's legally binding policy objectives on the marine environment and chemical risks.

Achieve concentrations in the marine environment near background levels for naturally occurring hazardous substances and near zero for man-made synthetic substances.	WFD Directive 2000/60/EC;
Maintain concentrations of pollutants at levels that do not cause pollution effects.	MSFD Directive 2008/56/EC; GES, Commission Decision 2017/848;
Safeguard biodiversity by conserving natural habitats and wildlife.	Habitats Directive 92/43/EEC; Birds Directive 2009/147/EC

Improving the protection of human health and the environment through the registration, evaluation, authorisation and restriction of chemicals.	REACH Regulation (EU, 2006b)
Minimise use/emissions of listed POPs after a POP is added to the list.	EC and EP Regulation on persistent organic pollutants (850/2004), Disposal of polychlorinated biphenyls (PCBs) and polychlorinated terphenyls (PCTs) EC Directive 96/59
Priority hazardous substances under Directive 2008/105/EC are removed from surface waters in accordance with the WFD.	WFD (2000/60/EU)
Contaminants are not at levels that cause pollution effects.	MSFD (2008/56/EC)

The EU seas covered by the network of marine protected areas (MPAs) doubled in a very short period from 2012 to 2016. 75% of these were designated under the EU Habitats Directive (92/43/EEC) and the EU Birds Directive (2009/147/EC). The Natura 2000 network of protected sites is the largest coordinated network of protected areas in the world. Current management challenges are best illustrated in the European Environment 2020 report: no Member State has adequately reported on the current status of its marine waters as required by the MSFD by 2018, existing policies are poorly integrated, and existing pressures are being addressed through fragmented, ineffective approaches (EEA 2019). As a direct consequence, it is highly likely that the implementation of existing policies will be insufficient to achieve the Good Environmental Status of the MSFD by 2020. This is all the more worrying as "the risk extends to whether they will be able to mitigate the additional adverse effects of the expected increase in maritime activities in forthcoming decades. The risk is compounded by having to achieve both Good Environmental Status and the ambitions of the EU's blue growth strategy in a climate change context" (EEA 2019, p. 150).

The EEA report on contaminants in Europe's seas states that all four regional seas in Europe have a large-scale contamination problem (EEA 2019c). More specifically, 87% of the Mediterranean Sea has chemical pollution problems and is generally in poor condition (EEA 2019c). The 2001 International Maritime Organisation (IMO) International Convention on the Control of Harmful Anti-fouling Systems on Ships bans the use of harmful organotin substances in antifouling paints for ships. Notwithstanding the ban on organotin tributyltin (TBT), studies worldwide indicate that it is continuously released into the environment. In some countries, monitoring in marinas and ports is additionally required in environmental impact assessments where the implementation of mandatory monitoring is necessary to obtain a permit or concession.

In relation to the 11 descriptors of the MSFD implementation, standardized methods for monitoring and assessing marine waters are included in the Commission Decision on good environmental status of marine waters. The impacts of antifouling coatings relate to Descriptor 1—Biodiversity is maintained, Descriptor 4—Elements of food webs ensure long-term abundance and reproduction, Descriptor 6—The sea floor integrity ensures functioning of the ecosystem, and Descriptor 8—Concentrations of contaminants give no effects.

The European Green Deal aims to shield citizens against chemical risk through a new chemicals strategy and to implement the goal of zero pollution. This requires competent and effective national and regional policy frameworks, which are already not fully functioning. And to this end, cross-disciplinary approaches and tools such as those presented here could prove valuable.