HELCOM

Biofouling management

guidance for recreational craft

Baltic Marine Environment Protection Commission

Non-indigenous species

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1. Preamble

The International Maritime Organization (IMO) defines biofouling as the accumulation of aquatic organisms such as microorganisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment (MEPC.378(80)). The immediate impact of biofouling on recreational craft is a well-known problem to most owners of recreational craft: it slows the recreational craft and increases fuel costs for motor craft, and passage time for sailing craft that may be obliged to use the engine sooner, leading to increased air pollution. Even a biofilm layer, increases the hydrodynamic drag on hulls and propellers (Owen et al., 2018; Schultz, 2007), leading to increased hydrodynamic resistance, greenhouse gas emissions and fuel consumption. Furthermore, biofouling may cause structural damage, leading to reduced operational efficiency and increased maintenance costs (Schultz et al., 2011).

In addition to these effects, which are directly noticeable for recreational craft owners, biofouling poses a major risk to the local environment and biodiversity by introducing non-indigenous species (NIS). If biofouling organisms settle on ship hull or niche areas, they can be introduced beyond their natural range, spread further, and cause harm to native species, the environment, economy, human health or social/cultural values (Galil et al. 2019, and references therein). Whilst the translocation of many NIS across oceans is likely more commonly caused by commercial ships, recreational craft may transport NIS between marinas, anchorages, islands, protected areas, and inland water bodies. Recreational craft have even been identified as one of the largest unregulated vectors of introduction and spread of NIS (Clarke-Murray et al., 2011; Ferrario et al., 2017; Ashton et al., 2022) and can be mainly responsible for secondary spread of NIS (Zabin et al., 2014; Ulman et al., 2019; Ashton et al., 2022).

In some areas, marinas have proven to host a larger variety of NIS than commercial harbours (Ferrario et al. 2017). This can be explained by the longer length of idle time and the slower speed of recreational craft compared with commercial ships. This problem has been recognized by the IMO as well, hence the Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft was developed and adopted specifically for owners and operators of recreational craft with a length of less than 24 meters (MEPC.1/Circ.792, GEF-UNDP-IMO GloFouling Partnerships Project, 2022).

To prevent or reduce the biofouling, recreational craft owners commonly apply anti-fouling coatings (AFC) containing biocides on their recreational craft hull and niche areas. These AFC contain active compounds, such as enzymes or biocides, which hamper recruitment and/or affect early settlement or survival of fouling organisms. Biocide-based AFC are the most widespread coating typology and, currently, copper represents the most common active compound in combination with booster co-biocides (Ytreberg et al., 2010). This type of fouling prevention causes continuous input of biocides or organic substances into waters due to erosion, ablation, and self-polishing of antifouling paints in service. Rough in-water cleaning (IWC) on antifouling paints induces immediate release of biocides and polymeric backbone/paint flakes (Earley et al., 2014, Watermann & Eklund, 2019, Oliveira & Granhag, 2020).

The problems with ship's biofouling have worsened over the past few decades due to the increased volume of maritime traffic. In addition, slow steaming practices and long lay-up periods have increased the accumulation of biofouling locally, and the accompanied effects might increase in the future even more. Global climate change coming along with elevated temperatures, lower salinities, higher water turbulence and lower pH due to increased CO_2

emissions will also affect the development of biofouling communities (Dobretsov et al. 2009). Climate driven shifts in species boundaries towards higher latitudes may increase the potential of new introductions to the HELCOM and OSPAR regions.

Since the IMO Guidance mentioned above is rather general, this guidance provides regional information, recommendations, and templates for the boating community in OSPAR and HELCOM regions and aims to promote effective and sustainable biofouling management among the boating community. With little effort, recreational craft owners can help to minimize biofouling on their recreational craft. This will save fuel, help reducing ecological damages in fresh waters and in the marine environment, and in general protect biodiversity across the concerned aquatic ecosystems.

2. Scope of this document

This guidance summarises biofouling management options for recreational boaters, boating associations, marinas and administrations in the OSPAR and HELCOM regions for both, freshwater bodies and marine waters. The primary aim of this guidance is to draw attention to the problems associated with biofouling on recreational craft and trailers, as well as to raise awareness and offer solutions to minimize the following targets:

- the risk of transferring NIS via biofouling of recreational craft and trailers;
- decreased performance of recreational craft and increased fuel consumption and CO_2 emissions due to hull fouling; and
- discharge of hazardous substances and waste particles from anti-fouling systems (AFS) into water bodies.

This guidance serves as a recommendation aiming to prevent, disturb or eliminate the growth of biofouling on recreational craft and trailers. According to the EU Directive 2013/53/EU, recreational craft means any watercraft of any type, excluding personal watercraft, intended for sports and leisure purposes of hull length from 2,5 m to 24 m, regardless of the means of propulsion. This definition is used in this document.

This guidance should be considered by all owners of recreational craft in the HELCOM and OSPAR areas not only to prevent the spread of NIS, but also to reduce the input of hazardous substances and waste particles from AFS, and as well as to reduce fuel consumption and accompanied CO_2 production.

The Biofouling Check List for the development of a biofouling management plan and the biofouling record book, which are presented in Annex I and Annex II, respectively, should be utilised as a toolbox. Recreational craft owners can choose between the different options and customize them to the individual recreational craft, its region and personal usage- and maintenance profile. The checklist is a tool to select a suitable, and sustainable AFS, and/or suitable maintenance measures. It is recommended to take time with these tools that help to select sustainable measures for each type of recreational craft to be able to conduct user friendly and effective biofouling management.

This guidance focuses on best practices for biofouling management without specifying techniques and personal safety requirements of each strategy. However, in order to minimize health and environmental risks when dealing with AFS, it is recommended to follow the manufacturer's (e.g. paint/coating, cleaning equipment) instructions as well as the information contained in the safety sheets of AFS when, for instance, applying, maintaining or removing anti-fouling paints (IMO, 2012).

These recommendations should be used by different stakeholders with the overall aim to prevent biofouling on recreational craft to support:

- marinas, other ports, shipyards, recreational craft storage sites and boating associations: providing appropriate facilities, advising members and spreading information;
- recreational craft owners: developing a suitable biofouling management plan and record their biofouling management activities; and

- administrations and experts: providing active and regular support to marinas or other ports, shipyards, recreational craft storage sites and recreational craft owners and supplying them with detailed information in order to develop tailored measures

3. Biofouling management

The best-suited biofouling management strategy is recreational craft specific and depends on several factors. Therefore, a single strategy cannot be generalized, and it should be prioritized and evaluated by each recreational craft owner for every craft and/or trailer. The biofouling management can be described as a circle that is visualized in figure 1. A crucial step in the individual biofouling management is the choice of the best-suited AFS. An AFS means a coating, paint, surface treatment, surface or device that is used on ships and recreational craft to control or prevent the attachment of organisms. This choice depends on the (1) the assessment of the site-specific biofouling pressure, (2) the infrastructure and services in the home marina and (3) the recreational craft owner's profile and relevant regional regulations. These steps are described in the following chapters. Cleaning and maintenance opportunities as well as planning and recording procedures are components of the biofouling management cycle, and they should be also considered in the choice of an AFS but will be described thereafter in sections 0, 6 and 7. Raising public awareness (section 8) is crucial for the implementation of these recommendations and the overall goal, i.e. minimizing the risk of transferring NIS via biofouling of recreational craft and trailers and the discharge of hazardous substances and waste particles, but is a separate item to the individualised biofouling management cycle.

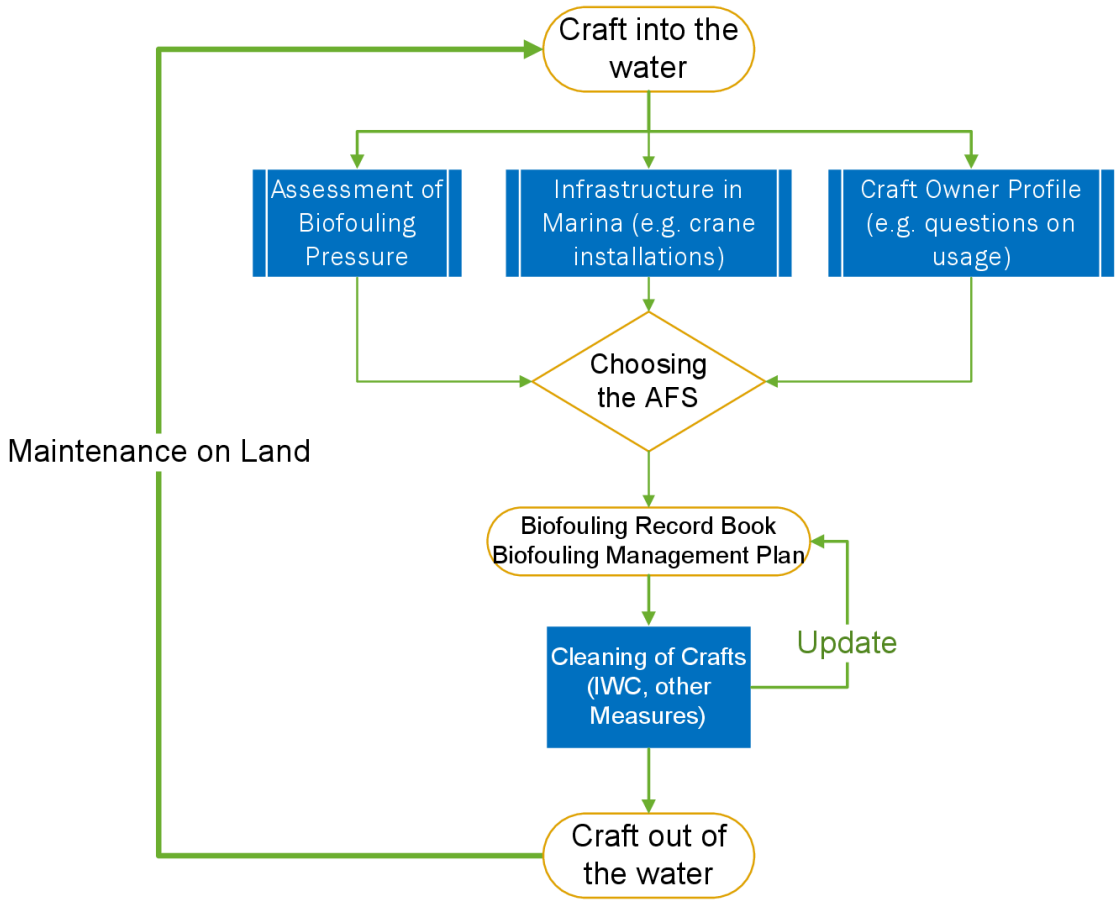

Figure 1. Biofouling management cycle for recreational craft.

4. How to choose a suitable AFS?

It is recommended to apply a suitable coating on all submerged surfaces of a recreational craft. Various coatings are designed for different operating profiles. Some are suitable for the hull and others for niche areas and therefore will require different maintenance strategies. Thus, it is essential that craft owners and responsible staff of the marina, port, shipyard or craft storage site obtain appropriate technical advice on this topic. AFS manufacturers are best suited to provide advice to ensure a suitable system is applied or installed. As biofouling may typically be found at higher abundance in niche areas, where flow characteristics change as the recreational craft moves through the water, it is recommended to choose a combination of AFS and Marine Growth prevention Systems (MGPS), suitable for different submerged areas.

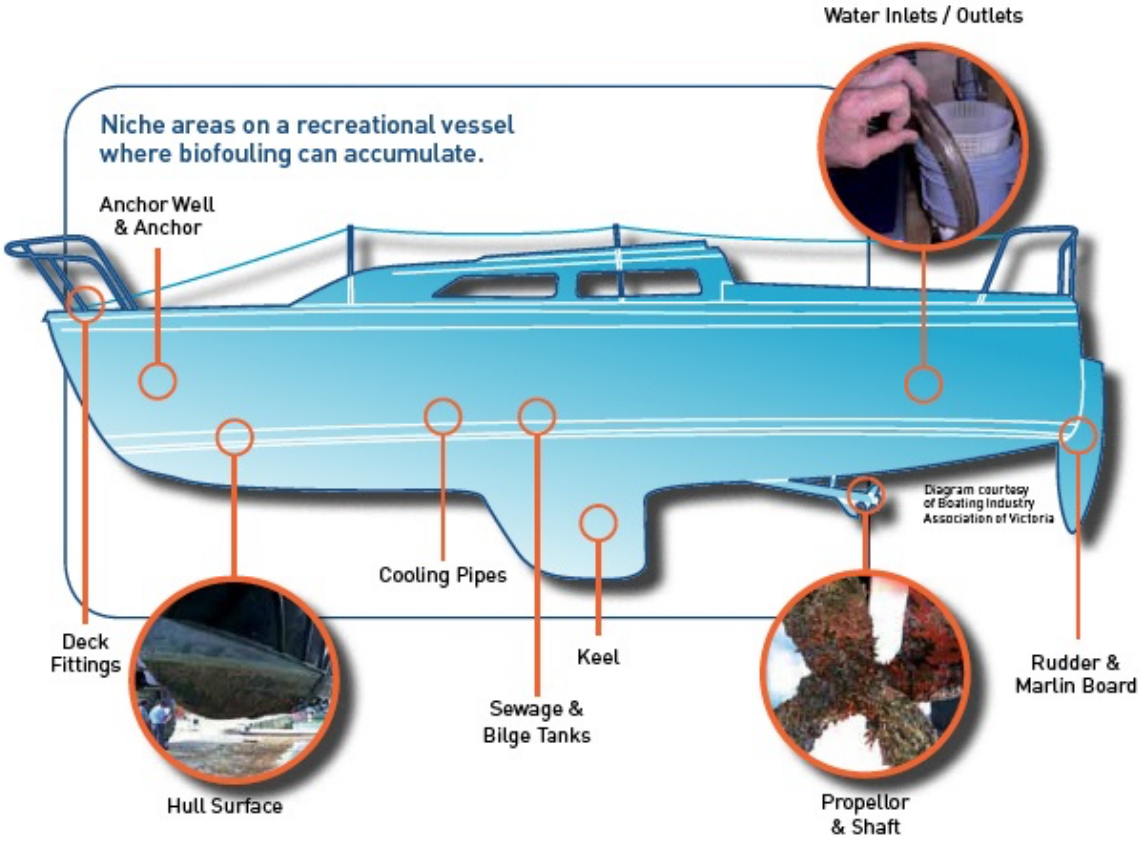

Figure 2. Typical niche areas of recreational craft (MPI, 2018)

A MGPS is an AFS used for the prevention of biofouling accumulation in niche areas or other surface areas but may also include methods which apply surface treatments like cathodic protection, ultrasonic pulses, anodic copper or chlorine-based dosing systems.
In addition, a biofouling management expert of the marina could help identifying a suitable AFS, as he should be acquainted with the local environmental conditions and legal requirements. This role could, for example, be filled by the marina staff or by a member of a boating association and should be announced electronically or analogously. Such advice should be evidence-based and not influenced by commercial arrangements between the marina and specific manufacturers.

In general, anti-fouling coatings can be divided into biocidal and biocide-free coatings. The biocidal coatings act chemically on the organisms i.e. releasing chemicals, such as copper, that harm the settlement of organisms. In recent years, there has been an increased focus on the development of eco-friendly anti-fouling paints that replace traditional, biocidal coatings. These coatings have been produced from non-toxic components. They act through a variety of physical and chemical control mechanisms to repel and prevent the attachment and growth on the craft 's hull (Kyei et al., 2020). Most marine coatings usually use polymers as binding agents bearing the potential for the release of microplastics (e.g., Gaylarde et al., 2021; Turner, 2021).

The environmental impact of the selected AFS with respect to the release of harmful substances should be considered. The limitations of an AFS to minimize biofouling should be known and may include its operating profile, the aquatic environment where it is applicable, design characteristics of the recreational craft and lifecycle of the AFS. Recreational craft owners should be aware of the limitations of each AFS installed on their recreational craft and the recommended in-water cleaning methods in order to minimize potential environmental impacts and damage to the AFS.

For recreational craft mainly operating in waters with low biofouling pressure or between different salinities, an AFS free of hazardous substances and appropriate for the regional fouling pressure in combination with good maintenance are the best ways for preventing biofouling accumulation (Lindgren et al. 2018; Lagerström et al. 2020).

Not all AFS can be cleaned by every cleaning technology or method (e.g. scraping, high pressure, sand blasting). The choice of the AFS should be compatible with the cleaning technologies available to ensure a clean hull, a reduced risk of damage to the AFS and a minimal release of harmful substances to the environment. The lifespan of an AFS should be considered and cleaning may be required at more frequent intervals towards the end of its lifetime.

In addition to the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001 (IMO, 2001), any national or local regulatory requirement, if relevant, should be considered in any case in the selection of AFS.

Table 1. Overview of recommended AFS for recreational craft (source: COMPLETE Best practice guide (Watermann et al. 2021).

Coating	Techniques	Application	Benefits	Risks	Costs	Availability
Biocide-free hard coatings in combination with IWC	Epoxy-silicone hybrids, abrasion resistant with foul release properties or other	Hull and cleanable niches	Long service life, durable, negligible input of paint flakes	Must be cleaned pro-actively in biofilm stage	Comparable to current AFS	Several products on the market

Foul release coatings (FRC)	Silicone based rubber-like polymers	Hull and cleanable niches	Long service life, durable, negligible input of paint flakes	Must be protected from mechanical impact, not suitable for ice conditions at sea	Double price compared to current AFS	Several products on the market
Biocide-free self-polishing coatings (SPC)	Hydrolyzing paint matrix without biocide release	Hull	Smooth hull without release of biocides	Efficacy strongly connected with activity level, and speed; not suitable for ice conditions at sea	Comparable to current AFS	Several products on the EU-market tailored for different craft types
AFS with copper release of 5µg/ cm^2 per day	Hydrolyzing paint matrix and biocide release	Hull and niches	If craft is active, fouling prevention	Release of biocides; not suitable for ice conditions at sea	Varying costs depending on copper content	Many products on the market

4.1 Biofouling pressure

Biofouling pressure is the biofouling accumulation rate, which differs regionally and seasonally (IMO 2023). Even within a same marina, different biofouling conditions may occur. Biofouling development depends mainly on salinity, water temperature, turbidity (presence of nutrients) and hydrodynamic effects (e.g. sea currents). High biofouling pressure means the development of dense biofouling within a short period of time. The knowledge of biofouling conditions in the "home marina" can support the individual biofouling management aiming for a low hull-fouling during the whole season. A practical and cost-effective method to assess the fouling pressure is the exposure of PVC-Settlement plates in marinas. A set of settlement plates may consist of 3 untreated plates (15x15 cm), aligned vertically to a wire rope so that they locate at different depths and a suitable weight (e.g. scrap metal, brick) which is placed at the end of the set up (Figure 3). At the beginning of the sailing season settlement plates which provide habitat for sessile and mobile fouling organisms should be placed at different water depths (water surface, middle and bottom). Regular monitoring of the set up can help to more accurately determine seasonal differences and biofouling pressure. The results of biofouling pressure mapping can facilitate the development of a detailed "Biofouling pressure" map, a simple and understandable visualization of biofouling pressure in marinas (e.g. in the form of traffic lights) can contribute to education and acceptance among stakeholders and to the selection of the best suitable AFS. In regions with low fouling pressure, biocide-free AFS may be applied in order to reduce the biocide input in the aquatic environment.

Figure 3. Method to assess biofouling pressure of the home marina. Examples of biofouling accumulation on both sides of the settlement plates at different locations with different salinity concentrations.

4.2 Infrastructure and maintenance facilities in marinas and in other ports

Recreational craft in the Baltic Sea are usually kept in water throughout the summer and stored on land during winter due to the risk of damage to the craft caused by storms, ice or floods. Cranes that are needed to lift larger craft out of the water are quite expensive and therefore most owners usually clean their recreational craft hulls once a year. To minimize the environmental risk of the land-based cleaning actions, the waste should be collected and disposed in appropriate facilities. The existence of suitable land-based cleaning places, crane installations and slipways can be helpful also during the boating season. A well-develop infrastructure is the key for the implementation of an effective biofouling management in order to mitigate the biofouling risk (Table 2).

Table 2. Compilation of facilities and services that might be helpful in implementing an effective biofouling management.

Infrastructure	Marina
Facilities	Slipways, crane installations, boat lift, shipyards, waste management, fully bunded wash down and scraping facilities to prevent

	contamination of the local water body by run-off
Cleaning methods	Manual cleaning by scrapes, high pressure water or sand cleaner, boat washer, and other installed systems
Other cleaning services	Professional companies, biofouling management expert

4.3 Recreational craft owner and operational profile

In addition to the knowledge on the local biofouling pressure, environmental conditions, and the local infrastructure, the recreational craft owner's and the operational profile (Table 3 and

Table **4**) are also crucial for the choice of a suitable AFS. The lack of time, and knowledge of recreational craft owners, and the absence of binding cleaning regulations result in poor maintenance and long idle periods that can lead to heavy biofouling of the recreational craft. If possible, recreational boat owners may consider to choose a biocide-free antifouling system, some of which are suggested in table 4.

Based on the above-mentioned steps every craft owner should ask themselves the following questions. In order to better assess the individual profile, Table 3 gives exemplary answers for a low (green), a medium (yellow) and a high (red) risk profile.

Table 3. Examples of questions that might help to assess the individual profile. Exemplary answers are representative for a low (green), a medium (yellow) and a high (red) risk profile.

Question	**Risk profile**		
	Low	**Yellow**	**Red**
What are the water conditions and how is the biofouling pressure in my home marina?	Marina located in fresh or brackish water with low biofouling pressure e.g. inland waterways or the northern Baltic Sea.	Marina located in brackish water with high turbidity and medium biofouling pressure e.g. regions of central Baltic Sea.	Marina located in marine water with high turbidity and high Biofouling pressure e.g. regions of south-western Baltic Sea, NE-Atlantic and Mediterranean Sea.
Is an "emergency" cleaning possible during the boating season?	Yes: cleaning facilities, cranes, slip ways available in my home marina.	Yes/No: cleaning facilities, cranes, slip ways available in close proximity.	No: co cleaning facilities, cranes, slip ways available in close proximity.

What is my planned operational profile (e.g. idle periods, voyages to other areas with different conditions like different salinities, water temperature, fouling pressure etc.)?	Regular short-distance trips on the weekends to close locations with the same conditions as in my home marina and short idle periods.	Regular short-distance trips on the weekends and holidays trips to a region with different conditions as in my home marina and medium idle periods.	Trips to regions with different conditions as in my home marina and long idle periods.
Should I update my biofouling management plan?	Nothing has changed since last season and the well-established Biofouling management plan will be followed again.	There will be minor changes in my profile (e.g. longer trips or longer idle periods) and I will update my Biofouling management plan accordingly.	The biofouling plan has not worked and I need to find the reasons why and I will establish a new plan.

Table 4. AFS choice according to operational profile (Source: Best practice guide, Pachernegg 2020, Eurostat 2020)

Region	**Craft activity level**	**Coating recommendation**	**Cleaning strategy**
OSPAR region I Arctic Waters	Low (6 %)	-Biocide-free SPC (Self-polishing coatings) for low activity level -FRC in combination with cleaning (not for operation in wintertime)	Regular cleaning on FRC (foul release coating)
OSPAR region II Greater North Sea	High (47%)	-Biocide-free SPC for high activity level -Non-toxic hard coating in combination with cleaning -FRC except operation in wintertime	Regular (proactive) cleaning at the microfouling stage (see chapter 5.2)
OSPAR region III Celtic Seas	Moderate (20%)	- Biocide-free SPC for moderate activity level - Non-toxic hard coating in combination with cleaning	Regular (proactive) cleaning at the microfouling stage
OSPAR region IV Bay of Biscay and Iberian Coast	Moderate (27%)	-Biocide-free SPC for moderate activity level -Non-toxic hard coating in combination with cleaning	Regular (proactive) cleaning at the microfouling stage

OSPAR region V Wider Atlantic	Low (<1%)	-Biocide-free SPC for low activity level -FRC in combination with cleaning (not for operation in wintertime)	Regular cleaning on FRC
Western and Southern Baltic Sea	High	-Biocide-free SPC for high activity level -Non-toxic hard coating in combination with cleaning -FRC except operation in wintertime	Regular (proactive) cleaning at the biofilm stage
Western and Southern Baltic Sea	Moderate	-Biocide-free SPC for moderate activity level -Non-toxic hard coating in combination with cleaning	Regular (proactive) cleaning at the biofilm stage
Western and Southern Baltic Sea	Low	-Biocide-free SPC for low activity level -FRC in combination with cleaning (not for operation in wintertime)	Regular cleaning on FRC
Kattegat to Central Baltic Sea	High	-Biocide-free SPC for high activity level -Non-toxic hard coating in combination with cleaning -FRC except operation in wintertime	Regular (proactive) cleaning at the biofilm stage
Kattegat to Central Baltic Sea	Moderate	-Biocide-free SPC for moderate activity level -Non-toxic hard coating in combination with cleaning -FRC in combination with cleaning (not for operation in wintertime)	Regular (proactive) cleaning, weekly at the fouling season
Kattegat to Central Baltic Sea	Low	-Biocide-free SPC for low activity level -Non-toxic hard coating in combination with cleaning -FRC in combination with cleaning (not for operation in wintertime)	Regular/weekly (proactive) cleaning at the fouling season
Eastern and Northern part of the Baltic Sea	High, moderate and low	-Non-toxic hard coating in combination with cleaning -FRC except operation in wintertime	Regular/weekly (proactive) cleaning at the fouling season
Freshwater	High, moderate and low	-Non-toxic hard coating in combination with cleaning	Regular/weekly (proactive) cleaning at the fouling season

5. Cleaning of recreational craft and other measures

Recreational craft can be mechanically cleaned of biofouling. The cleaning is recommended to be performed on all submerged surfaces of the craft such as hull and niche areas. Different cleaning practices can be combined or used on different craft surfaces since the success of each practice depends on the type and rate of the biofouling. This guidance will not recommend any specific cleaning techniques as the techniques and methods available on the market are subject to constant change.

Regardless of the cleaning of the hull being applied on land or in water, removed material should be treated as waste if cleaning is conducted on macrofouling and not be allowed to enter the water. Ideally, the recreational craft is lifted from the water for cleaning, since it is easier to collect the removed material on land. On land, it is important to avoid the cleaning into the nearest waterway or near storm water drains. Some hull cleaning machines and stationary boat washers (COMPLETE Supplementary recommendations for a secure maintenance of Drive-in-boat washers, 2021) provide an enclosed coverage system for the work-place where the removed material does not reach the open air and water, as they are fitted with air extractors to force vertical ventilation and with filters for particular matters and volatiles (see DIN EN ISO 16890).

It is recommended to clean the biofilm on the craft as often as possible to hinder the attachment of macrofouling organisms (proactive cleaning). A hull cleaning machine or hand-held tool should not be used if the vessel has been painted with anti-fouling paints containing biocides. This is especially important if the hull was treated with self-polishing paints (so-called “soft” paints) that are designed to wear off with water friction. Cleaning of ablative antifouling coatings that require anything more than a soft cloth should be undertaken in a special facility.

5.1 Clean before you leave

When the craft’s operational profile has not changed during the boating season the biofouling species are likely to be of domestic origin and the risk of new NIS to the area being found on the vessel could be considered low. However, craft travelling to further destinations e.g. abroad, might have been exposed to species that are not present in the homeport area. Before a trip to a destination that is not within a usual domestic operational profile, the recreational craft should be inspected for biofouling and cleaned to reduce the amount of biofouling and hinder the establishment of NIS. Therefore, it is important to check the biofouling situation on the hull and clean it if necessary before a longer (time and distance) voyage and before leaving the area visited (“clean before you leave”).

5.2 In-water cleaning (IWC) and maintenance

The cleaning procedure should always be done according to the regulations that are in force in the respective country. Therefore, competent authorities/ administrations have to be consulted to check if IWC is permitted and what are the requirements to be fulfilled to perform it.

In general, cleaning with capture should be applied to hull and niche areas when the biofouling rating is likely beyond “low” (Table 5). Cleaning activities can be conducted on land, which is

preferable, or in-water. Cleaning may physically damage the AFS, shorten coating service lifetime and release organisms and harmful waste substances into the environment. These aspects should be considered when choosing a cleaning procedure. In-water cleaning can be divided into “proactive” and “reactive cleaning”. Proactive in-water cleaning is used to maintain a clean hull by preventing or minimizing attachment of biofouling by removing the biofilm at regular frequent intervals. It should only be used on microfouling that is biofouling caused by bacteria, fungi, microalgae, protozoans and other microscopic organisms that creates a biofilm, also called a slime layer. Reactive cleaning is a corrective action during which biofouling is removed from a craft’s hull and niche areas either in-water with capture or on land by lifting the recreational craft out of the water. Reactive cleaning could also be used on macrofouling that is biofouling caused by the attachment and subsequent growth of visible plants and animals on structures and craft exposed to water. Macrofouling is large and visible to the human eye such as barnacles, tubeworms, mussels, fronds/filaments of algae, bryozoans, sea squirts and other large attached, encrusting or mobile organisms.

In-water cleaning is recommended on abrasion-resistant, non-biocidal hard coatings, which release no biocides during the cleaning process and where the abrasion of paint flakes is minimal (Watermann and Eklund, 2019).

The intervals of cleaning actions that are needed to obtain a macrofouling-free recreational craft depend on the before mentioned factors like the fouling pressure (section 0) and the craft owner and operational profile (section 4.3).

An interactive map of good practices hull cleaning services and applied technologies (https://maps.helcom.fi/website/mapservice/index.html) has been produced, covering the entire BSR.

Table 5. Fouling rating for the assessment of the biofouling extent and for the choice of the recommended cleaning measure.

Rating	Description	Recommended cleaning
0 - Clean	**No fouling.** Surface entirely clean. No visible biofouling on surfaces.	No cleaning action necessary.
1 – Low fouling	**Microfouling.** Only microfouling, no macrofouling organisms.	Proactive IWC can be recommended as specified in section 5.2.1.
2 – Medium fouling	**Microfouling with macrofouling species.** Presence of microfouling and individual macrofouling patches.	Reactive IWC with capture of waste material is recommended as specified in section 5.2.2.

3 – Heavy macrofouling	**Heavy macrofouling.** Large and multiple patches or submerged areas entirely covered with macrofouling.	Cleaning on land is recommended as specified in section 0.

5.2.1 Procedures for proactive cleaning

Proactive cleaning may include wiping or use of hydrodynamic forces to clean the hull of slime and avoid its development into a more pronounced fouling. Such measures can keep the hull free of macrofouling organisms that need to be removed with stronger forces. Proactive cleaning without capture should only be used if:

- the biofouling rating is ≤ biofouling rating “low” (in line with Table 5);
- the proactive cleaning technology and AFS are compatible to reduce the risk of damage to the AFS and the potential release of harmful waste substances to the environment;
- the cleaning operation is safe for personnel involved in the activity; and
- the cleaning operation is performed in an area allowed for this activity by the relevant authority.

Biocide-containing coatings will release biocides and possible other harmful substances in the surrounding water during proactive cleaning. Thus, proactive cleaning is highly recommended only on biocide-free coatings (see section 4). Taking note of the operational situation, proactive cleaning, when used, should be carried out at regular intervals to avoid development of heavy microfouling. The proactive cleaning should avoid transfer of non-indigenous species.

Procedures for proactive cleaning and frequency should be described in the Biofouling Management Plan (BFMP) (see Annex I). All proactive cleaning actions, including the determination of the biofouling rating (according to Table 5) prior to the cleaning, should be recorded in the Biofouling Record Book, which may be in electronic format (see Annex II).

5.2.2 Procedures for reactive cleaning

Reactive cleaning systems physically remove micro- and macrofouling from the hull and niche areas. There are various cleaning methods with capture available and more under development. Regardless of the cleaning technique, the reactive cleaning should:

- use a reactive cleaning system that is compatible with the AFS in order to minimize damage of the AFS;
- be safe for personnel involved in the activity;
- be conducted with the aim to remove any visible biofouling to achieve a clean hull (Table 5);
- capture biofouling and waste substances when reactive cleaning is performed in-water (BIMCO & ICS, 2021);
- collect biofouling and waste substances when reactive cleaning is performed on land; and

- the cleaning operation is performed in an area allowed by the relevant authority for this activity.

When in-water reactive cleaning is conducted, every effort should be made to capture any debris which is dislodged from the recreational craft during the operation. To optimize capture efficiencies, the cleaning and capture technology should be designed for the area to clean (i.e. flat or curved surface). Cleaning and capture devices should be certified and only used by people that are trained in the operation of these techniques. Operators undertaking reactive in-water cleaning should familiarize themselves with any regulations or requirements, e.g. regarding the discharge of biofouling and waste substances into the marine environment or the location of sensitive areas.

A report on the cleaning may be prepared by the operators undertaking reactive cleaning and might contain several aspects (Annex II) as well as the cleaning outcome. The analog or electronic cleaning report may be available on board and the activity entered in the BFRB if applicable.

5.2.3 Cleaning of niche areas

Niche areas (Figure 2) of recreational craft are of high importance for the transfer of species when recreational craft are trailered for weekends or summer holidays from freshwater inland water bodies to the lesser saline areas of the Baltic Sea and vice versa. Apart from the cleaning effect by varying between freshwater and marine waters, brackish water organisms can be transported and survive in a wider range of salinities. Therefore, special attention should be paid to the niche areas, which are harder to access and to clean. Capturing the biofouling waste material is also challenging. Biofouling management in niche areas should include the following or similar adequate measures:

- maintenance of any MGPS, if installed, to ensure they operate effectively to prevent accumulation of biofouling in relevant niche areas;
- regular polishing (with capture of debris) of uncoated propellers to maintain operational efficiency and minimize macrofouling accumulation;
- appropriate treatment of internal seawater cooling systems and discharge of any treated water in accordance with applicable regulations; and
- minimized use of any soap, cleaner or detergent on surfaces and ensure they are toxic- and phosphate free, biodegradable and non-hazardous to the marine environment.

5.3 Lifting the recreational craft out of the water

Lifting the recreational craft out of the water protects the hull of biofouling and facilitates the cleaning and capture of biofouling waste. This can be done by using e.g. boatlifts. The longer the recreational craft is out of the water, the more efficient impact on biofouling organisms, since drying damages most of the aquatic organisms and therefore prevents the spread of NIS.

The same effect is achieved with the natural tide-related dry fall. Recreational craft owners that are located in tidal waters can also use the dry fall to inspect the hull and assess the degree of fouling pressure.

5.4 Recreational craft trailer cleaning

Recreational craft trailers also have the potential to spread NIS and can represent a significant vector for NIS introductions especially since their surface is rarely treated with any anti-fouling system (Rothlisberger et al. 2010). After a trailer has been in contact with the aquatic environment, it should be inspected thoroughly for biofouling or other organisms present. Surfaces on trailers that should be inspected include the frame, axle, tires, lights, licence plates, wires, cavities and niches.

The trailer should be cleaned of all organisms before transporting it to another location. This can be done by using similar mechanical cleaning equipment as for recreational craft, e.g. brush, scrape, sponge or pressure washer. It is recommended to give the trailer a rinse with a pressure washer, even if the fouling rate is low, as several NIS will not be visible to the naked eye. It is also recommended to let the trailer dry before transporting it to a new waterway (NOAA, 2018; Bleitz et al., 2024; GEF-UNDP-IMO GloFouling Partnerships Project, 2022). There is a risk with trailers because they can be transported overland large distances to other areas. The risk of spreading NIS is reduced the longer the trailer and the recreational craft stays out of the water (Chapter 5.3).

6. Inspection

Recreational craft owners should regularly (depending on the regional biofouling pressure) inspect the rate of biofouling and take actions for their craft and trailers as appropriate (Table 6).

Table 6. Overview on possible inspection methods and the respective technique, application (on board, land or in water), benefits, risks, costs (€ = 0-50 €; €€ = 50 – 500 €; €€€ = > 500 €) and the general availability.

Method	Techniques	Application	Benefits	Risks	Costs	Availability
Collecting evidence that indicates increased biofouling	Monitoring of fuel consumption, speed, manoeuvrability	On board, during operation	No equipment or special training/skills are needed. Fast and cheap.	Low levels of biofouling and fouling in niche areas might not be detected.	€	On board
Visual inspection	Diving, snorkelling	In water	Good impression of biofouling rate on hull and niche areas	Low visibility restricts the assessment. Risks for the diver/snorkeler while working under water.	€€ - €€€	Diving/snorkelling skills and equipment is needed, or a professional diving company could be hired
	Inspection of the waterline	On board	Impression of biofouling status along the waterline	Biofouling along the waterline might not represent the hull and niche fouling sufficiently.	€	On board
Camera inspection	Lowering an underwater camera or a ROV (Remotely Operated Vehicle)	In water	Good impression of biofouling rate on hull and niche areas	Low visibility, quality of the equipment and individual skills might limit the outcome of the assessment.	€€ - €€€	Special tools and skills are needed, but several products are available on the market.

Lifting the recreational craft out of the water	Lifting by crane, boat lift, trailer (slip) etc.	On land	Good impression of biofouling rate on hull and niche areas	No	€€ - €€€	Facilities for lifting larger craft out of the water are not available in every marina
Falling dry	Tide-dependent dry-fall	On land	Restricted impression of biofouling rate	Possible restricted view of hull and niche areas dependent on the size and design of the recreational craft.	€	Recreational craft should be located at tide-dependent marinas.

7. Biofouling check list for biofouling management plan and record book

In order to keep the recreational craft constantly as free from biofouling as possible, the development of a craft-specific biofouling management plan (BFMP), the description of the individual biofouling management strategy, is a significant support. Biofouling management comprises the choice of a suitable AFS, maintenance and control practices, and, if needed, integrated cleaning activities. The more tailored these aspects are, the more effective the results of the overall management are. The documentation of biofouling management activities is as relevant as the development of the management plan because it enables the recreational craft owner to periodically assess whether the planned activities are really appropriate and practical for reaching the intended efficiency of biofouling management. If this is not the case, the management plan can be adapted accordingly. Furthermore, it may serve as evidence for anti-fouling measures already taken and planned. Highest biofouling rates occurred on recreational craft whose owners had no information about the applied AFS, which clearly demonstrates the importance of planning the biofouling management and keeping a biofouling record book.

The check list in Annex I should provide guidance in the development of the BFMP. The aspects that apply to the own recreational craft and usage profile can be described in more detail, creating a management plan. It is important to occupy oneself with biofouling management and especially with the choice of a suitable and sustainable AFS and/or alternative maintenance measures.

A first step to improve biofouling management of recreational craft is the recommendation to keep information about the actual AFS (specification, age, and condition) on board (if possible). In addition, receipts or documentation of cleaning and maintenance actions including cleaning before overland transport should be included in the BFRB, which should be present on each craft sailing coastal waters. Another advantage of the BFRB is the ability to track the history of the AFS when buying a used recreational craft. This information is lacking quite often and leads to uncertainties in applying an appropriate AFS (Section 4).

8. Public awareness

It is of major importance that the information on biofouling management and recreational boating is publicly available and easily accessible for the targeted stakeholder group. Key messages of the Guidance document should therefore be reflected in a short flyer and translated to the OSPAR/HELCOM national languages, as well as distributed to the relevant stakeholder groups.

In addition, national competent authorities are encouraged to establish a dedicated website which contains information on the topic and links to the guidance document, the flyer, as well as other relevant recommendations and guidelines for preventing and/or managing biofouling. The links can be quickly and effectively communicated through familiar channels using multimedia tools, as well as used for downloads. Another example is the BSH scribble video (https://www.youtube.com/watch?v=Thg3pnK1Zgk, 2021) on biofouling management and recreational boating, which proved to be a good tool to reach out to the target audience, and was translated to different languages.

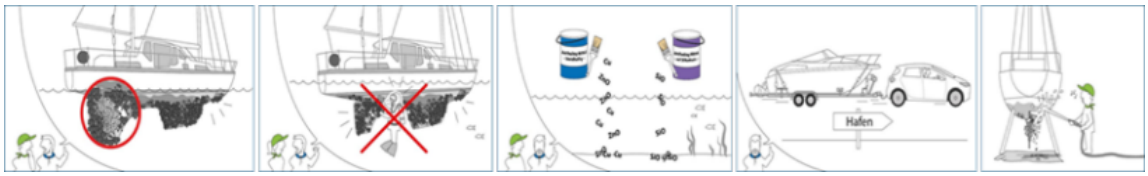

Figure 4. Small glimpse into the BSH scribble video (2021)

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Annex I – Check list for customized biofouling management

INTRODUCTION

Biofouling on your recreational craft can be a significant vector for the transfer of invasive aquatic species. Biofouling management practices may also improve the hydrodynamic performance of your recreational craft and can be effective at enhancing energy efficiency, hence reducing air emissions from ships as well as fuel costs.

This Biofouling Management Plan (BFMP) shall assist you in conducting biofouling management and is specific to your recreational craft. It describes the biofouling management for one season. The plan should be re-evaluated and, if necessary, updated before the next season if any relevant changes are made (e.g. planned trips, new AFS, changed marina) that have an impact on the anticipated biofouling. Additionally, a well-documented BFMP could be beneficial for possible sales negotiations.

Completing the form below is intended to help creating an individual biofouling management plan. Only fields that are relevant to the individual boat and operating profile might be filled in. The form asks for the following aspects: information about the boat and anti-fouling system (AFS), description of operating profile and conditions in marina(s), description of hull and niche areas where biofouling may accumulate, description of applied coating/ AFS, installation of AFS, cleaning on land and in-water cleaning, monitoring of biofouling risk parameters and contingency actions.

Recreational craft particulars and specification of AFS

Date [dd.mm.yyyy]
Name of recreational craft
Date of construction
Craft type / Model Name
Size (length, width, draught) [m]
Motor Power [KW]
Craft identification number, if available

Product Name of AFS

Installation of AFS e.g. on your own or professional (company)

Note:

DESCRIPTION OF OPERATING PROFILE AND CONDITIONS IN MARINA(S)
(Chapter 1-4)

The recreational craft's operating profile is described below and is the basis for the selection of the ship's anti-fouling systems (AFS) and operational practices (e.g. cleaning/maintenance measures.

Location	
Home Marina [name]	
Coordinatines [GPS WGS84]	
Environmental characteristics	
Salinity	<EXAMPLE> <fresh water, brackish water and/or marine water>
Water temperature in summer [°C]	
Biofouling pressure	<EXAMPLE> <low, medium, high>
Available infrastructure and maintenance facilities	
Facilities in the marina	<EXAMPLE> <slipways, crane installations, boat lift, land-based cleaning places, waste management>
Available cleaning methods	<EXAMPLE> <manual cleaning by scrapes, high pressure cleaner, boat washer>
Other cleaning services	<EXAMPLE><professional companies, biofouling management expert>
Operational profile	
Planned idle time [days]	
Typical/mean operating speed [knot]	
Are AFS installed suitable for typical operating profile? (Y/N)	

Main Planned Trips (1,2,3..)

1. Guest marina [name]	
1. Location [GPS WGS84]	
Environmental characteristics	
1. Salinity	<EXAMPLE> <fresh water, brackish water and/or marine water>
1. Water temperature in summer [°C]	
1. Biofouling pressure	<EXAMPLE> <low, medium, high>
Available infrastructure and maintenance facilities	
1. Facilities in marina	<EXAMPLE> <slipways, crane installations, boat lift, land-based cleaning places, waste management>
1. Available cleaning methods	<EXAMPLE> <manual cleaning by scrapes, high pressure cleaner, boat washer>

1. Other cleaning services	<EXAMPLE> <professional companies, biofouling management expert>
Operational profile	
1. Planned idle time [days]	
Typical/mean operating speed [knot]	
Are AFS installed suitable for typical operating profile? (Y/N)	

DESCRIPTION OF HULL AND NICHE AREAS WHERE BIOFOULING MAY ACCUMULATE

The hull and niche areas where biofouling may accumulate to a higher degree are described below. A diagram of both side and bottom of the ship identifying the location of each area that may accumulate biofouling could be included.

Areas on hull	<EXAMPLE> <flat-bottom- front, flat-bottom- mid, flat-bottom- aft, bow dome, boot top, vertical sides – port side, vertical sides – starboard side, vertical side – aft transom, or others>
Niche areas (including quantity where relevant)	<EXAMPLE> <sea chests, bow dome, bow/stern thruster, tunnel, tunnel grates, cathodic protection anodes, bilge keels, anchor chain, chain locker, stabilizer fins, rudder, inlet gratings, sea inlet pipes, propeller, propeller shaft>

DESCRIPTION OF APPLIED COATING/ANTI-FOULING SYSTEM (AFS)
Chapter 1

The selected AFS that is applied, reapplied, installed or renewed is described below according to the manufacturer's instructions. When more than one type of AFS is applied, reapplied, installed or renewed, each AFS should be described individually and in accordance with each manufacturer's instructions.

Prior to a planned reapplication/renewal of the AFS, an evaluation of qualitative observations regarding the recreational craft's biofouling should be made with the purpose of a potential improvement of the AFS selection. Previous reports (if available) on the performance of the AFS should be part of the evaluation.

Manufacturer(s) and type(s) of AFS	<EXAMPLE><hard coating, self-polishing, fouling release, etc.>
Biocides in AFS	<EXAMPLE><copper oxide, zinc, etc.>
Expected lifetime and, if any, expected reduction of efficiency of AFS	
Operating profiles which are suitable for the AFS including temperature, salinity, speed, periods of inactivity	
Recommended regime for repairs, maintenance and/or renewal to receive the AFS optimal performance	<EXAMPLE> <regime for repairs> <regime for maintenance>

	<regime for renewal> <N/A>
Cleaning methods recommended for AFS	
Cleaning methods not appropriate for AFS, if any	
IAFS Certificate (applicable only for ships in international traffic with gross tonnage ≥400)	

INSTALLATION OF ANTI-FOULING SYSTEM
Chapter 1

AFS applied	**Date of application**	**Recommended cleaning technique**
		<EXAMPLE> <soft brush, blades, metal brushes or water jet>

CLEANING ON LAND AND IN-WATER CLEANING
Chapter 5

Recommended cleaning technique	**Specifications of cleaning technique**	**Proactive or reactive cleaning**
<EXAMPLE> <soft brush, blades, metal brushes or water jet>	<EXAMPLE> <suitable for my coating, suitable for removing microfouling, suitable for flat and curved hull>	<EXAMPLE><regular proactive cleaning, every 2 months>
Possible harmful discharge from cleaning with cleaning method	<EXAMPLE> <AFS biocides, biofouling, particles or other>	
Manufacturer and model of cleaning device, if applicable		
Cleaning method suitable for AFS		
Description of how to avoid macrofouling		
Cleaning device tested in line with <name of the standard> (Y/N), if applicable		

MONITORING OF BIOFOULING RISK PARAMETERS AND CONTINGENCY ACTIONS

The biofouling risk parameters given below should be monitored by the recreational craft owner. When a parameter goes beyond the deviation limit, the risk of biofouling increases, and the recommended contingency actions may be used as described.

Biofouling risk parameters to monitor	**Evaluation of a deviation including deviation limit of the risk parameter**	**Contingency actions**	**Long-term actions**
<EXAMPLE> <deviation from speed, salinity, temperature specifications acceptable for the AFS>	<EXAMPLE> <incidental deviations should be evaluated for potential biofouling impact. Continuous or regular deviations, or deviations not rectified, should lead to contingency actions>.	<EXAMPLE> <inspection as soon as possible. When recommended by the AFS manufacturer, more frequent proactive cleaning activities could be implemented between inspections.>	<EXAMPLE> <evaluate the need for a potential improvement of the AFS selection prior to the next renewal.>
<EXAMPLE> <deviation from the maintenance/service regime of the AFS>	<EXAMPLE> <if the maintenance and service time, specified by the manufacturer, is exceeded, the risk of biofouling is elevated, and contingency actions should be implemented>.	<EXAMPLE> <an inspection should be carried out. Maintenance or repair should be performed at the earliest possible opportunity.>	<EXAMPLE> <regular maintenance and repair (e.g.) may be necessary actions for proper protection by the AFS. Evaluate the need to update the maintenance programme.>
<EXAMPLE> <AFS damage>	<EXAMPLE> <a failure caused by a mechanical damage to the AFS may result in a higher risk of biofouling in the areas affected, if not rectified within reasonable time. The damage should be evaluated for potential biofouling accumulation.>	<EXAMPLE> <an inspection should be carried out for the relevant area. Repair should be performed at the earliest opportunity. More frequent inspections of damaged area should be implemented until a repair is undertaken.>	
<EXAMPLE>	<EXAMPLE>	<EXAMPLE>	<EXAMPLE>

<exceeding expected lifetime of AFS>	<once an AFS has exceeded its lifetime, as specified by the manufacturer, the biofouling risk increases.>	<more frequent inspections should be implemented until the AFS is back in operation.>	<the performance of the AFS, and any necessary change in the maintenance or the inspection schedule, based on experience, should be included in the next update of this BFMP.>
<EXAMPLE> <extended ship idle time (berthed, anchored, moored)>	<EXAMPLE> <if the idle time is longer than estimated in the ship's operating profile, it could lead to an elevated risk of biofouling. If the idle time is beyond the guarantee of the AFS supplier, the risk of biofouling accumulation increases. The risk also depends on the biofouling pressure, e.g. temperature and distance to the coastline. If the ship is idle in an area far from shore (>200 nm and >200 m depth) and far from other installations, the risk may still be considered low.>	<EXAMPLE> <if the idle time is within the guarantee of the AFS supplier, a short voyage with speed as specified for AFS could be conducted, sea chests could be blanked off or, when recommended by the AFS manufacturer, more frequent proactive cleaning activities could be implemented. If the idle time is beyond the guarantee of the AFS supplier, an inspection should be carried out.>	EXAMPLE> <evaluate the need for a potential improvement of the AFS selection prior to the next AFS renewal/maintenance.>

INSPECTION OF BIOFOULING LEVEL
Chapter 6

Recreational craft owners should regularly inspect the rate of biofouling and take actions for their craft and trailers as appropriate (e.g. in-water cleaning, maintenance measures).

Method	**Technique**	**Application**	**Frequency**

<EXAMPLE> <collecting evidence that indicates increased biofouling>	<EXAMPLE> <monitoring of fuel consumption, speed, manoeuvrability>	<EXAMPLE> <on board, during operation>	<EXAMPLE> <continuously during operation>
<EXAMPLE> <visual inspection>	<EXAMPLE> <diving, snorkelling>	<EXAMPLE> <in water>	<EXAMPLE> <after clues for increased biofouling. After damage of the AFS or after the AFS exceeded its lifetime. Fixed schedule that should be adapted to environmental factors.>
<EXAMPLE> <visual inspection>	<EXAMPLE> <inspection of the waterline>	<EXAMPLE> <on board>	<EXAMPLE> <continuously>
<EXAMPLE> <camera inspection>	<EXAMPLE> <lowering an underwater camera or a ROV>	<EXAMPLE> <in water>	<EXAMPLE> <after clues for increased biofouling. After damage of the AFS or after the AFS exceeded its lifetime. Fixed schedule that should be adapted to environmental factors.>
<EXAMPLE> <lifting the recreational craft out of the water>	<EXAMPLE> <lifting by crane, boat lift, trailer (slip) etc.>	<EXAMPLE> <on land>	<EXAMPLE> <after clues for increased biofouling. After damage of the AFS or after the AFS exceeded its lifetime.>
<EXAMPLE> <falling dry>	<EXAMPLE> <tide-dependent dry-fall>	<EXAMPLE> <on land>	<EXAMPLE> <tide-dependent>

Annex II - Example form of a biofouling record book for recreational craft

The Biofouling Record Book Part should be maintained by every recreational craft owner who wishes to record relevant biofouling activities such as inspections, maintenance and cleaning activities in table 1. An increased risk of biofouling accumulation according to the BFMP and related contingency actions should also be recorded in table 2.

Recreational craft Particulars

Name of the recreational craft	
Date of construction	
Craft type / model name	
Size (length, width, draught) [m]	
Craft identification number, if available	
Product name of AFS	

	Month and year	Month and year
Period	from:	to:

Note:

INTRODUCTION

The management of biofouling should be in line with the Biofouling Management Plan (BFMP) and consider the biofouling management guidance. The use of an electronic record book to record activities is an alternative method to a hard copy record book.

Any observations regarding e.g. fouling rating, fouling species or altered recreational craft performance may be included in separate reports and corresponding photos/video. The entries in the biofouling record book may be a summary only including a conclusion on whether the activity is in line with the BFMP. The biofouling record book should be kept on board the recreational craft in a place where it is readily available at all reasonable times and for the life of the recreational craft.

Also, the existing record book can be used to record the history of application of AFS and any cleaning undertaken. One advantage of this approach is that the records will be kept alongside usage, mileage and location information so will inform future decisions on the most appropriate AFS to be applied. For open recreational craft and day craft that are kept in the water any records may be kept on shore.

LIST OF ITEMS TO BE RECORDED

Table 1: Biofouling management activities

	Date [dd.mm.yy]	**Location** (e.g. dock, in water	**Method/Technique** (e.g. manual cleaning, video etc,)	**Observation regarding biofouling** (Level of fouling in niche areas?)	**Observation regarding AFS** (e.g. performance)
Inspection					
Proactive cleaning					
Reactive cleaning					
Other biofouling activities					

Table 2: Increased biofouling risk and contingency actions

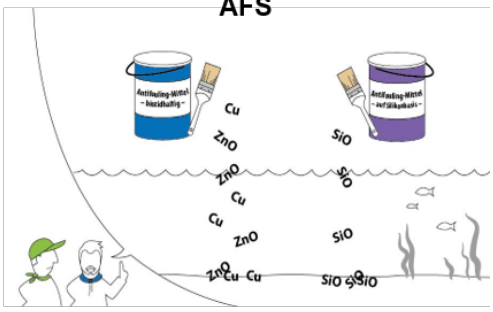
	Description	**Duration**	**Location**	**Reason**	**Contingency action**	**Observation/ records regarding biofouling and/or AFS**
Operation outside expected profile (BFMP)	<Example: deviating speed, temperature or salinity>				<Example: more frequent inspections)>	
Damage of the AFS	<Example: observed damage of AFS>				<Example: more frequent inspections>	
Maintenance of the AFS	<Example: observed reduction of the efficacy>				<Example: more frequent inspections>	

Deviation from expected cleaning regime (BFMP)	<Example: proactive cleaning could not be conducted as specified in the BFMP>				<Example: more frequent inspections or reactive cleaning before returning to proactive cleaning activity>	
Extended idle time	<Example: biofouling pressure, temperature, distance to the coastline where craft was laid up>				<Example: inspections, short voyages taken prior to and following the period laid up>	
Other deviations						

Annex III – Flyer of biofouling management recommendations for recreational boaters and marinas

Biofouling is inevitable but you can preserve your boat and the marine environment if you follow this Guidelines, nice sailing!!!

For the choice of the best-suited AFS



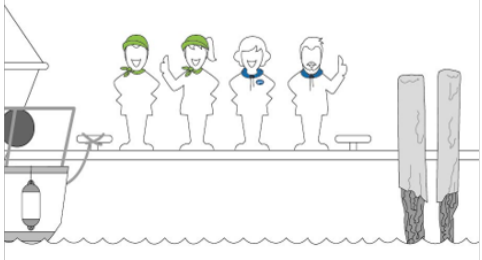
Please take into account:

- → Assessment of biofouling pressure
- → Infrastructure in your marina (e.g. crane, cleaning opportunities)
- → Your usage (e.g. idle times, speed)

Please document your activities

- → Biofouling Management Plan
- → Biofouling Record Book

And clean you boat appropriatly!



What do I need to consider before cleaning?

Take Time

- Check beforehand, if in-water cleaning is locally permitted
- Cleaning measures should be adapted to operating profile (speed, travel/standing-relation, visiting places)
- Anti-fouling system and cleaning measures should be carefully aligned and documented

Good for your boat, good for marine environment

- cleaned boat equals better sail performance (less fuel consumption)
- awareness of anti-fouling system details facilitates cleaning decisions, coating renewals and potential boat sale
- biofouling management avoids marine pollution (chemicals) and preserve marine biodiversity (non-indigenous species being introduced)

Further information

Guide on best practices of biofouling management in the Baltic Sea

GloFouling: Reports, videos and infos on the subject biofouling and shipping

AquaNIS: Information system on aquatic non-indigenous species

OSPAR COMMISSION

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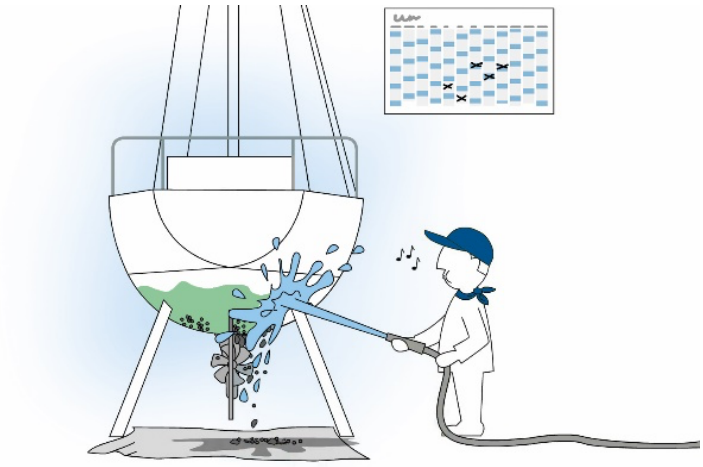
Let’s protect our boats, and the environment - you will save money!!!

Background and recommendations for prevention of biofouling on recreational boats



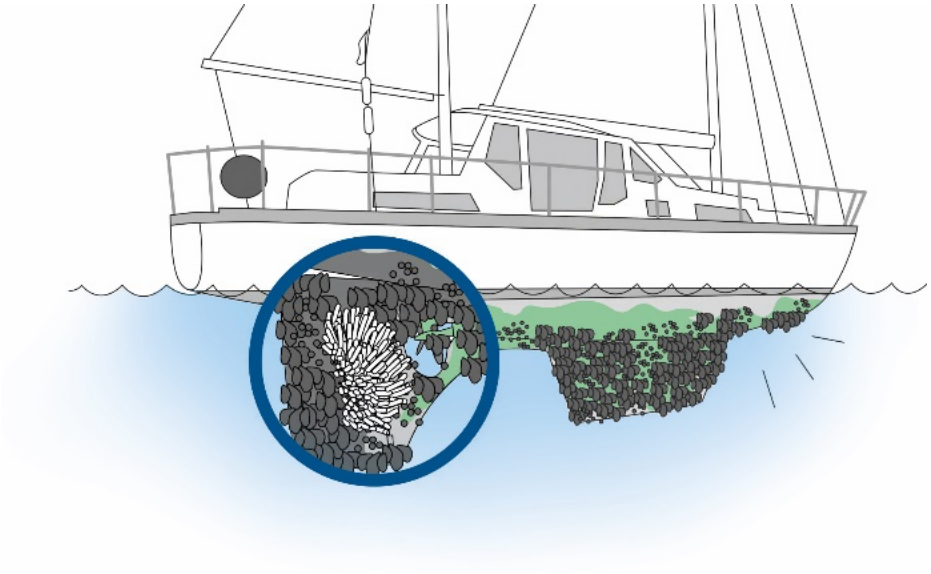
What is biofouling?

Submersed surfaces naturally become colonized by diverse organisms such as microbes, algae or mussels. This accumulation of aquatic organisms is also known as biofouling. The biofouling community, including the density of organisms and growth rate depends on water parameters, such as temperature, salinity, and nutrient levels.

What is the problem?

In general, biofouling increases the fuel consumption and as a result, the amount of emissions. Furthermore, fouling in niche areas such as on the propeller or rudder influences the manoeuvrability of the boat and increases the risk of accidents.

Additionally, biofouling is recognized as a major vector for the introduction and spread of non-indigenous species (NIS). NIS are organisms, which have overcome their biogeographical boundaries through human activities. NIS that cause adverse impacts are classified as “invasive alien species” (IAS).



How can I protect my boat?

- ✓ decision for suitable anti-fouling system based on information by the manufacturer's specifications (including installation, maintenance, service life etc.);
- ✓ regular and coating-specific cleaning/maintenance, as well as preferably short idle periods. Planning and documentation of boat operation and maintenance are half the battle;
- ✓ biocidal anti-fouling systems should be considered carefully, as these can negatively affect our health and the ecosystems; and
- ✓ if possible, biocide-free anti-fouling systems should be used (for instance if biofouling pressure is low and cleaning is done regularly).

Comparison of anti-fouling systems

Not all AFS can be cleaned by every cleaning technology or method. Especially the lifespan of AFS should be considered and cleaning may be required at more frequent intervals towards the end of the service life.

Coating	Techniques	Application	Benefits	Risks	Costs	Availability
Hard coatings in combination with in-water cleaning (IWC)	Epoxy-silicone hybrids, abrasion resistant with foul release properties	Hull and cleanable niches	Long service life, durable, negligible input of paint flakes	Must be cleaned pro-actively in biofilm stage	Comparable to current AFS	Several products on the market
Foul release coatings (FRC)	Silicone based rubber-like polymers	Hull and cleanable niches	Long service life, durable, negligible input of paint flakes	Must be protected from mechanical impact, not suitable for ice conditions	Double price compared to current AFS	Several products on the market
Biocide-free self-polishing coatings (SPC)	Hydrolyzing paint matrix without biocide release	Hull	Smooth hull without release of biocides	Efficacy strongly connected with activity level, and speed; not suitable for ice conditions	Comparable to current AFS	Several products on the EU-market tailored for different boat types
AFS with copper release of 5µg/ cm^2 per day	Hydrolyzing paint matrix and biocide release	Hull and niches	If boat is active, fouling prevention	Release of biocides; not suitable for ice conditions	Varying costs depending on copper content	Many products on the market

Table: Overview of recommended AFS for recreational boats (source: Best practice guide).

Generally, a well-maintained coating system is a sustainable solution and contributes to environmental protection.