Response to Comments: Third Report to the Legislature on Antifouling Paints in Washington State

Hazardous Waste and Toxics Reduction Program

Washington State Department of Ecology

Olympia, Washington

June 2024
Publication 24-04-035

DEPARTMENT OF ECOLOGY
State of Washington

Publication Information

This document is available on the Department of Ecology's website at:
apps.ecology.wa.gov/publications/SummaryPages/2404035.html

Cover photo credit

Washington State Department of Ecology

Contact Information

Hazardous Waste & Toxics Reduction Program

Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Telephone: 360-407-6700

Website: Washington State Department of Ecology[1]

ADA Accessibility

The Department of Ecology is committed to providing people with disabilities access to information and services by meeting or exceeding the requirements of the Americans with Disabilities Act (ADA), Sections 504 and 508 of the Rehabilitation Act, and Washington State Policy #188.

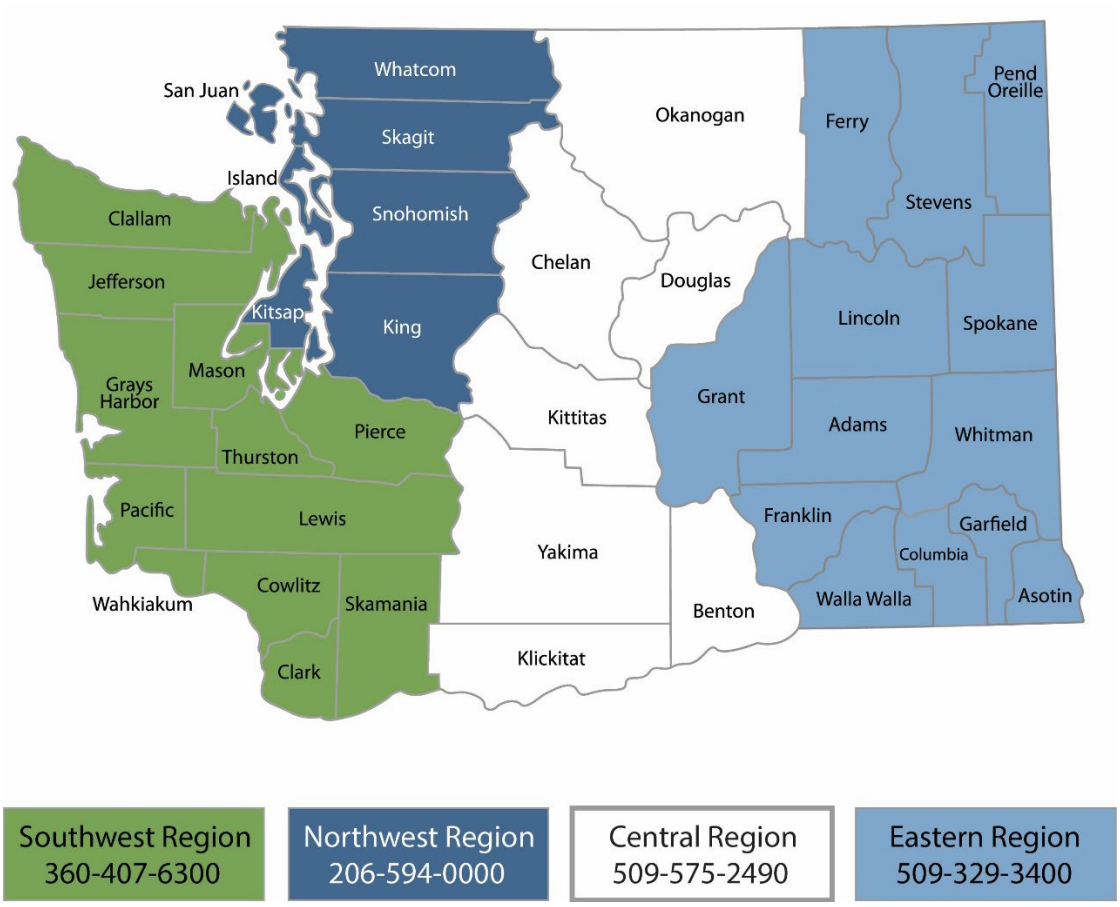
To request an ADA accommodation, contact Ecology by phone at 360-407-6700 or email at hwtrpubs@ecy.wa.gov. For Washington Relay Service or TTY call 711 or 877-833-6341. Visit Ecology's website[2] for more information.

[1] www.ecology.wa.gov/contact

[2] www.ecology.wa.gov/accessibility

Department of Ecology's Region Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

Response to Comments

Third Report to the Legislature on Antifouling Paints in Washington State

Hazardous Waste & Toxics Reduction Program

Washington State Department of Ecology

Olympia, Washington

June 2024
Publication 24-04-035

DEPARTMENT OF
ECOLOGY
State of Washington

Table of Contents

List of Tables

Public Outreach Summary

As directed by the Revised Code of Washington (RCW) 70A.445.020, the Department of Ecology (Ecology, we) conducted a scientific review of information about antifouling boat paints and ingredients in Washington State. We published the Draft Antifouling Paints in Washington State: Third Report to the Legislature[3] in November 2023 for review by the public. We then opened a public comment period from December 4, 2023, to January 17, 2024, to obtain expertise and input from relevant stakeholders and other interested parties. This document summarizes the public outreach activities related to this antifouling report and comment period.

Industry workshop

- On September 7, 2023, we held an industry workshop to seek early input from interested parties from industry prior to finishing the draft report.
- We sent an email invitation to a list of industry members, including Northwest Marine Trade Association, American Coatings Association, American Chemistry Council, Washington Retail Association, and others.
- During this workshop, Ecology staff presented an outline of the draft report and an overview of the literature review. We then opened the conversation by asking industry members to share additional scientific evidence that can further support this report.
- We shared contact information and timelines with interested parties from industry to encourage follow-up communications.

Prior to draft report release

To prepare for the launch of the public comment period, we:

- Submitted a miscellaneous announcement to the Washington State Register to announce the public comment period.[4]
- Created two webpages as Ecology's Public Input and Events webpage to support the event announcement. We updated our antifouling webpage[5] with a banner to highlight the links to the draft report and the two event pages.
- Sent email announcements and reminders to boatyards and ports, paint and chemical industry members, environmental organizations, local and state governments, and boating associations.
- Sent email announcements to Natural Resource Directors of Tribal governments.

[3] apps.ecology.wa.gov/publications/SummaryPages/2304057.html

[4] www.ezview.wa.gov/Portals/_1962/Documents/antifouling/WSR%2023-22-117.pdf

[5] ecology.wa.gov/waste-toxics/reducing-toxic-chemicals/washingtons-toxics-in-products-laws/antifouling-boat-paints

- Provided information through a brief presentation at Northwest Marine Trade Association meeting in November 2023.
- Planned a public workshop that took place in December 2023.
- Created a public comment form.
- Shared information about the release in a GovDelivery message.
- Shared information with Waggoner editors. They developed an article[6] on their website to inform subscribers about the public comment.

Public workshop

- On December 6, 2023, we held a public workshop through Zoom.
- We promoted the invitation through multiple channels, including individual emails, Ecology's website, a local cruise guide article, the Washington State Register, and GovDelivery messages.
- During the workshop, we provided an overview of the draft report, emphasized the draft determinations, shared public comment information, and provided an opportunity for the public to ask questions. The research team from Washington State University also presented preliminary results from the performance test of antifouling paints in four Puget Sound locations.
- Attendants at the public workshop included interested parties from industry and the environmental sector, boatyards, and the pesticides registration team from Washington State Department of Agriculture (WSDA).

Public comment period

- The public comment period launched on December 4, 2023, and closed January 17, 2024.
- During and after the public comment period, project staff sent recognition emails to commenters and provided the timeline for next steps. This document provides a response to the comments we received.

Continuous outreach

- We sent introduction emails to a number of Natural Resource Directors for Tribal nations before the public comment period. After taking feedback from email responses, we followed up with two emails and offered to host individual Tribal workshops to any interested parties. We also developed a focus sheet and mailed copies to Tribes that had expressed an interest in this topic.

[6] https://waggonerguide.com/antifouling-paints-wa-dept-of-ecology-report-comment-period/

- We will use the Antifouling Boat Paints: Update 2024,[7] published in January 2024, as an informational sheet for ongoing communication efforts.
- We will use our antifouling boat paints project page[8] to keep interested parties and the public informed of any updates or opportunities for engagement around the project.

[7] apps.ecology.wa.gov/publications/SummaryPages/2404004.html

[8] www.ezview.wa.gov/site/alias__1962/39937/antifouling_boat_paint.aspx

Comment Summary

We invited public comments on the Draft Antifouling Paints in Washington State: Third Report to the Legislature[9] from December 4, 2023, to January 17, 2024. Ecology received a total of seven submissions through the automated form or emails. We are counting duplicate submissions or repeated contents as one comment.

Table 1: List of commenters on the antifouling draft report.

No.	Commenter's Name	Agency/ Organization/ Business	Submitted By
1	Vernon Moore	Tacoma Youth Marine Foundation	Non-profit
2	Rhett Cash	American Coatings Association	Organization
3	Julian E Hunter	Consultant to Hempel A/S	Business
4	Rus Graham	Rushton Gregory Communications	Business
5	Bill Kraus	CeRam-Kote Marine Coatings	Business
6	Neal Blossom	American Chemet Corporation	Business
7	Tim Dugas/Jeff Fellows[10]	Seawide Distribution	Business

[9] apps.ecology.wa.gov/publications/SummaryPages/2304057.html

[10] The submissions from these two commenters are the same, so their names are combined.

Comments and Responses

The public comments are presented below, along with our responses. We quote comments directly before our responses in this section. We have not edited or modified the comment text in any way. You can view comments in their original format in Appendix A.

Comments from: Youth Marine Foundation

Comment NP-1-1: Performance

"With our new vessel we choose to use EPaints SN-1 based on its reputation and recommendation of the boat yard that applied it, and that the maker states it is used by the U.S.C.G. In short this paint has proven to be total ineffective for the waters of Puget Sound based on the rate of growth that started in short order. This is also on a vessel that is used far more that most vessels. The amount of growth has caused concerns for the safe operation of the vessel due to fouling of sea water intake screens for the main engines and generators. The Doolin-Rogers is a USCG inspect passenger vessel by class of inspection. We had to involve the USCG because we MUST return to drydock a full year ahead of schedule to correct this issue.

Bottom Job Details:
Vessel: M/V Doolin-Rogers 110' aluminum training vessel
Haul-out date: 30 Dec 2022
Work: Sanded, dewaxing solvent wipe, barrier coat touchup, two coats EPaints SN-1 (Sea-Nine), new zincs, shaft and prop treatment
Launch Date: 18 Jan 2023
First sign of Issues: Late April growth was noticed at the waterline. Midsummer July 2023 more growth was observed getting a good hold on the stern of the vessel.
Vessel use: Year to date 433 hours underway
Inspection: As the growth was getting alarming by September we had a former USCG inspector dive on the vessel and tape the attached video footage of the bottom in October 2023
Corrective measures: Seawater Intakes are inspected before each use of the vessel and vessel is set for haul-out at Port Townsend for bottom paint service 1 full year early due to poor antifouling paint performance."

Response

Thank you for your comment. We appreciate your feedback regarding real-world performance of a non-copper antifouling paint.

Comments from: American Coatings Association

Comment O-1-2: Safer Criteria

"While ACA appreciates the research discussed and conducted in the report, we have a comment on the studies referenced regarding salmon in freshwater environments. The draft report notes on page 12:

> In Washington State, one of the motivations to phase out copper in antifouling paints is to protect culturally and ecologically important species, such as salmon. The sublethal effects of copper on Coho salmon, and particularly on the salmon's sensory function, have been well documented (Baldwin et al, 2003; McIntyre et al., 2008, 2012; Sandahl et al., 2007; Hecht et al., 2007).

ACA urges WA DOE to clarify in the report that the studies cited take place in freshwater environments and not marine saltwater. The majority of WA DOE's study is focused on saltwater environments, including three of the four testing sites. This important distinction should be noted because a data gap exists regarding dissolved copper's effect on salmonid olfaction in saltwater environments 1. In fact, some studies show that the olfactory effect of copper is significantly reduced in marine saltwater environments.2 It's critical for WA DOE to include language in its report to the legislature that highlights this distinction, as the current draft implies that dissolved copper has the same effect in marine saltwater."

Response

Thank you for submitting your comment to Ecology.

We acknowledge that the effects of dissolved copper on salmonid olfaction can depend on salinity and that the effects can be different between saltwater and freshwater environments. We incorporated this clarification into the relevant section of the final report.

Comment (O-1-3): Regulation

"Lastly, the report notes that U.S. EPA's maximum allowable leach rate for antifouling paints that contain copper is 9.5 μg/cm^2/per day (see page 4). ACA encourages WA DOE to clarify in the report that this maximum allowable leach rate only applies to coatings used on recreational vessels."

Response

Thank you for submitting your comment to Ecology.

We acknowledge and appreciate your recommendation for greater clarity around the U.S. EPA's maximum allowable leach rate for antifouling paints containing copper. We agree that this specification of 9.5 μg/cm^2 per day is indeed exclusively applicable to coatings used on recreational vessels. Both the U.S. EPA document and Washington State RCW 70A.445.010 define recreational water vessels as any vessels that are no more than sixty-five feet in length.

We included this clarification in the relevant section of the final report to prevent any ambiguity and to reinforce the report's focus on antifouling paints for recreational use. Thank you for bringing this to our attention.

Comments from: Dr. Julian E Hunter

Comment B-1-1: Safer Criteria

"1. Biocidal paints

The draft report evaluates the comparative safety of antifouling biocides versus copper oxide on the basis of their hazard properties. The approach does not consider environmental or human exposure and is thus incomplete when evaluating safety of antifouling biocides. This may lead to erroneous conclusions about safety and is not aligned with Federal and internationally accepted risk assessment procedures currently used by US EPA, IMO and other regulatory authorities that evaluate the safety of antifouling biocides.

Furthermore, the draft report (page 8) defines antifouling chemicals as 'safer' if they 'release fewer toxic chemicals into the environment' – this element is missing from the evaluations in the draft report.

Evaluation of the potential inputs of biocides into the environment and an assessment of exposure to them is an essential part of a comparative evaluation for the safety of antifouling biocides. Consideration of hazard properties in isolation does not take account of the relative content of biocide in the paint film nor the biocide leaching rate when the paint is immersed. The draft report notes contents of non-copper biocides in paints (% w/w wet paint) versus copper are different, i.e. – typically Copper present at 15-40%, typical Tralopyril 6% w/w, ZPT typically <4-5% w/w, DCOIT (no specific amount noted), but this is not considered in the evaluation of their relative safety.

Recognised tools are available to determine biocide release rates and to model their fate and concentration in the environment
Biocide release rates from immersed paint film is a key element of an environmental safety assessment. Biocide leaching rates can be calculated for typical products using ISO methodologies, e.g. ISO 10890:2010 which specifies a method for estimating the mean release rate of biocide from an antifouling paint over its entire lifetime (in-service period) using a mass-balance calculation1. Biocide release rates can then be used as inputs internationally accepted environmental emission models such as MAMPEC2. Which can predict the environmental concentrations of biocide in marinas and harbours.

Predicted environmental concentrations (PEC) for antifouling biocides can then be compared with no-effect concentrations (PNEC) derived from sub- stance hazard data, and a PEC/PNEC ratio derived to determine environ- mental safety. This is a scientifically recognised approach used by regulatory authorities throughout the world when evaluating the safety of antifouling biocides.

The potential for exposure of biocide to applicators containing the biocide is also an essential part of a comparative evaluation of biocides.

We suggest that the evaluation of the biocides in the report is expanded to include an evaluation of relative safety for each biocide using the approach above for antifouling products containing a 'typical concentration' of biocide."

Response

Thank you for submitting your comment to Ecology.

Our approach to determine "safer" alternatives is based on hazard assessment, rather than risk assessment. A chemical hazard assessment focuses on identifying potential harmful effects and the conditions under which they might occur. It answers how toxic the chemicals are. In contrast, risk is a combination of chemical toxicity and how much human or an ecological system is exposed to them, as shown in the formula "Risk = Hazard x Exposure." We recognize that regulatory agencies often conduct risk assessments prior to restricting toxic chemicals. However, we decided on our hazard-based approach based on the following considerations:

- Ecology's Hazardous Waste and Toxics Reduction program uses a different approach from other agencies to regulate toxics in consumer products. Our approach is focused on preventing pollution. In this study, we prioritize source reduction to align with our program's strategy. Avoiding use of hazardous chemicals reduces overall risks. When focusing on hazard assessment, we ask, "Where are there opportunities to reduce exposure to toxic chemicals by using safer alternatives?" This perspective allows us to reduce the use of toxic chemicals before they harm humans or the environment. It also reduces environmental cleanup costs. Our antifouling study closely aligns with other toxics reduction work in Ecology, including the Safer Products for Washington program.

- Antifouling chemicals are regulated pesticides which undergo rigorous risk assessments by the U.S. EPA before approval. In our review, we included risk assessment results available from other regulatory bodies and combined this existing information with the results from our own hazard assessment.

- This approach supports our mandate to identify "safer" chemicals through a chemical-to-chemical comparison, focusing on their potential toxicological effects.

We acknowledge that biocide release rates from antifouling paints are crucial for environmental safety assessments. The evaluation of "release fewer toxic chemicals into the environment" is under the special considerations section in the safer criteria. If two chemicals are equal in the hazard assessment, we will further assess the magnitude of exposure potential using parameters like leach rate. As you brought up both leach rate and content, we'd like to clarify that the content and leach rate of active ingredients in antifouling products may not have a direct correlation. When considering exposure potential, we think leach rate can provide more relevant information than content. Currently, copper-based antifouling paints for recreational paints are subject to U.S. EPA's maximal allowance leach rate.

Thank you for recommending the modeling tools for quantifying the risk of biocides in the environments. Ecology has conducted a Marine Antifoulant Model to Predict Environmental Concentrations (MAMPEC) study on biocidal antifouling ingredients. We published these results in a previous report.[11] The report included an estimated allowable leach rate range for copper, Irgarol, Econea, Sea-Nine, and zinc pyrithione. We welcome similar recommendations and will consider other available tools to mitigate toxic threats to the environment.

You suggested we include occupational exposure in the comparative evaluation. In the report, we cited U.S. EPA's risk assessments and recognized the information about inhalation and dermal risks for shipyard painters from certain biocides. In addition, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) label on biocidal paints also provides requirements for the safety of applicators.

Comment B-1-2: Alternative - FRCs

"2. Biocide-free paints for recreational vessels less than 24 metres in length (LOA)

Effective, proven, safer and feasible Biocide-free foul release coatings will be available in Washington State for all types of recreational boats < 24m LOA from 2024.

There are several inaccurate statements made in the draft report regarding biocide-free foul release coatings (FRCs). We therefore provide the information below and request that the section on FRCs is amended:

Biocide free FRCs are commercially available for use on recreational craft. As a market leader in fouling control coatings, Hempel developed and introduced a full range of biocide-free Fouling Release Coating (FRC) prod- ucts based on silicone coating technology which are suitable for use on all types of leisure boats less than 24 meters LOA. First introduced in 2012, over 10 000 successful applications of biocide-free Hempel FRC products have since been made to the hulls of recreational boats across Europe. In September 2023, Hempel announced that it's innovative, proven high-per- formance, copper-free, and biocide-free antifouling coating - Silic One will be available in the United States and Canada, distributed by SeaWide dis- tribution3.

Application and mode of action
Silic One can be applied by consumers and works by providing an amphiphilic surface that microscopic settling stages of fouling organisms can- not strongly adhere to. The amphiphilic surface consists of a low surface energy and elastomeric silicone matrix combined with a superhydrophilic hydrogel microlayer which sets up on immersion, producing a non-stick surface which prevents organisms from attaching firmly to the hull. This technology is described in the presentation attached to this comment 'Fouling control coatings for use on vessels less than 24 meters overall (LOA)'. Any fouling that does weakly attach is removed as the boat gets underway. In the case of slower boats, any loosely adhered fouling can be easily removed by gentle wiping with a soft sponge. The first biocide-free FRC product, Silic One was introduced by

[11] https://apps.ecology.wa.gov/publications/SummaryPages/1904020.html

Hempel in 2012, and is proven to provide effective fouling control on leisure boats less than 24 meters LOA.

Silic One is proven and effective
In independent tests, Silic One has consistently showed performance on pleasure craft <24m LOA that is equivalent or better than copper-based biocidal antifouling products. For example, a study carried out by Chalmers University (Gothenburg) in the Baltic Sea, Kattegat and Skagerrak areas, concluded that Silic One is as more effective against fouling than the commercially available copper-based antifouling paints when immersed for two years[3]. In addition, In addition a UK boating magazine in 2022 also highlighted Silic One performance as 'best in test' when tested in UK waters alongside commercially available biocidal antifouling paints for leisure boats[4].

Mechanical strength of FRC films
If subject to accidental mechanical damage / abrasion from fenders or from unintentional contact with the sea bed, silicone-based coatings may be scraped which may result in release of small fragments of the paint film into water. This is also the case with biocidal antifouling coatings. In general silicone elastomeric foul release coatings have a higher resistance to milder mechanical stresses compared to eroding biocidal antifouling paints due to their elastomeric and crosslinked nature. In the event that a vessel requires underwater cleaning , gentle non-abrasive removal of any fouling should not damage the foul release coating and cause any release of paint film or particles into water.

FRCs are less hazardous than biocidal antifouling paints
Hempel Silic One does not contain fluoropolymer-based binders or oils (PFAS) and does not contain an organotin catalyst. A small quantity of polydimethylsiloxane (PDMS)-based silicone fluid is present in the Silic One paint film to achieve the required non-stick surface properties which prevents adhesion of fouling organisms. The fluid is non-hazardous to the environment4 and is designed to remain within the paint film so that its sur- face properties are retained. PDMS-based silicone fluids are universally recognised as safe and are widely used throughout the world in household products, medicines, medical devices, cosmetics and food. In laboratory tests5, PDMS showed no adverse effects on aquatic species and sediment dwelling organisms at concentrations up to, and exceeding its solubility in water. There is no evidence that it may bioaccumulate or bioconcentrate in the marine environment."

Response

Thank you for sharing this update. We are interested to see more coating options become available in the Washington market, especially those designed to minimize environmental impact. Ecology would like to connect with manufacturers and obtain more information about those products to understand the "environmentally friendly" statement. If you can share product information like ingredients and composition, we will use this information for better decision-making. Please contact us with questions or concerns about sensitive or confidential business information.

We appreciate the most recent product update. We surveyed the market and searched for biocide-free foul release coatings (FRCs) for recreational vessels in 2022 and 2023. At the time our draft report was published, there were no FRCs for recreational vessels in the Washington market. We are aware that many products are available in the European market. In the report, we recognized that "foul-release coatings have started to be available in the market." With the information you shared, we can add more clarification to show that at least one biocidal-free FRC will soon become available in Washington.

With regard to the performance data about Silic One, we also read literature discussing this specific product and the comparison to copper-based antifouling paints. The paper from Lagerström et al. was included in our report. As "safer" and "effective" are the two top priorities in alternatives, our main concerns with FRCs are unknown chemicals and extremely limited safety data. Compared to traditional antifouling, there are no established regulatory measures to assess the risks of these products before they enter the market.

Comment B-1-3: Alternative - FRCs

"The following provide documents that support the comments above:

I. IMO Glofouling report 2022 – summarises antifouling technologies and good management practices for managing the spread of invasive species:

BIOFOULING MANAGEMENT FOR RECREATIONAL BOATING -GEF-UNDP-IMO GloFouling Partnerships Project, 2022. Biofouling Management for Recreational Boating: Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species.

II. Paper from Hempel presented at the International Antifouling Conference Gotenburg 2023

Arias (2023). *Proven,effective biocide-free paint solutions are available to control fouling on the hulls of leisure boats*

III. Information prepared for IMO Glofouling project 2023

Hempel (2023). *Fouling control coatings for use on vessels <25 m LOA*"

Response

Thank you for the documentation.

Comments from: Rushton Gregory Communications

Comment B-2-1: Alternative - FRCs

"My company works with Hempel and Propspeed - producers of biocide-free foul release coatings (FRC) for boat hulls (Hempel) and running gear, underwater lights and transducers (Propspeed). Hempel's Silic One has been proven effective for over 10 years in Europe and Propspeed for over 10-years in Oceana and Europe. Both company's products have been

extensively tested, used on recreational (and commercial) vessels of all sizes including those under 24 meters. For both products, any fouling that does weakly attach is removed as the boat gets under-way. In the case of slower boats, any loosely adhered fouling can be easily removed by gentle wiping with a soft sponge. FRC-based coatings do not contain fluoropolymer-based binders or oils (PFAS) and organotin catalysts, and are less hazardous than biocidal antifouling paints and better for the environment. In addition, by protecting surfaces with Hempel and Propspeed, electrolysis and the degradation of zinc anodes is greatly reduced.

I urge you to look deeper into the benefits and performance of biocide-free foul release coatings that have been proven on thousands of recreational vessels in markets around the world."

Response

Thank you for providing feedback on biocide-free FRCs. We received similar comments, as shown in Comment B-1-2 and B-5-1. Please see the additional information under those comments.

As outlined in our report, there are significant data gaps around FRCs, particularly in toxicological data and risk assessments. Unlike traditional biocidal antifouling ingredients, FRCs are not subject to federal and state pesticide regulations. This contributes to the lack of standardized toxicity tests and safety evaluations for these products. The absence of detailed chemical composition and toxicity data for FRCs limits our ability to conclusively assess whether they are safer than copper-based paints.

In a recent paper, the researcher reviewed seven ecotoxicological studies with commercial silicone FRCs (Lagerström et al., 2022). The toxicity of silicone FRCs appears to be low compared to copper coatings, but some coatings have displayed toxicity to marine organisms, especially during the first months of immersion. The chemical nature of those leachables and the identity of the substances responsible for the observed effects are still unknown.

We agree that FRC-based coatings, especially silicone-based ones, might be made without fluoropolymer-based binders. Products that claim environmental advantages align with our interest in identifying safer alternatives. Ecology welcomes Hempel and Propspeed to share solid scientific evidence with us to support future evaluation.

Your suggestion to dive deeper into the benefits and performance of biocide-free coatings is well taken. We are committed to working with industry stakeholders, researchers, and regulatory bodies to gather and evaluate comprehensive data on FRCs and explore all possible alternatives. For now, without sufficient data, Ecology cannot conclude that FRCs are safer than biocidal antifouling paints and better for the environment.

Comments from: CeRam-Kote Marine Coatings

Comment B-3-1: Alternative – Hard Coatings

" 1. CK-AF is an upgrade to CeRam-Kote Coatings standard CeRam-Kote 54 (CK-54) ceramic epoxy coating which has been applied throughout the military, industrial and marine markets

since 1985. It meets the 'food grade' requirements of FFDCA. CK-54 has been applied to boat bottoms for over 24 years as a 'hard surface treated composite coating.' It is still on boat bottoms after all that time, and environmentally oriented boaters love it. However, it does have to be cleaned one week sooner than copper bottom paint, and if allowed to fall behind a steady cleaning schedule, may require a greater scrubbing effort.

2. CK-AF is CK-54 with Zinc Oxide (ZnO) added as an inert ingredient to ward off marine fouling. It is rated as a 'minimum risk pesticide' by EPA and does not require registration. CK-AF contains no cuprous oxide (Cu2O) and is not a leaching paint as is the case with most bottom paints, which are designed to allow water to penetrate the coating and leach out the toxins contained therein. The high concentration of ceramics prevents water from penetrating. Rather, the ceramic epoxy shell formed upon curing holds the ZnO indefinitely.

3. ZnO is an unbalanced molecule with extra electrons, called an ion. These ions form a self-contained ion field within the ceramic epoxy matrix. It serves as a very strong low voltage shield, which wards off marine microbes that normally attach to boat bottoms to form a biofilm. Algae feed on this biofilm, but without it they search for another surface to feed. Without algae to feed on, barnacles and other hard marine growth also search elsewhere for food, leaving the boat bottom free of marine fouling. The marine 'food chain' has been interrupted. And this process has been repeated throughout nature for thousands of years. CK-AF simply follows nature's own way.

4. To my knowledge, CK-AF is the only bottom paint in the world which uses this proprietary technology. The ZnO is carefully selected to meet specific requirements, and the percentage of concentration is confidential.

5. I believe the frequency of cleaning in the Washington market can stretch beyond the 3-4 weeks cycle as practiced in California. The only substance to clean is occasional seaweed, and this is washed off when a boat is underway. If a boat remains in its slip for long periods, then the seaweed cleaning frequency will be determined by how often a diver cleans the running gear (props and shafts).

6. ZnO in other bottom paint is designed to leach, so that is why performance seemed inhibited in the reported sample. After the 56 days mentioned, it was simply expended.

Additional comments:

a. CeRam-Kote Coatings does plan to introduce CK-AF to the Washington market, and this communication serves to kick it off now. Since copper bottom paint has to be replaced every 2-3 years, over a relatively short period of time, CK-AF could replace all the copper leaching bottom paint and serve to eliminate the high concentration of copper in the water column in Washington State.
b. CK-AF has an expected life span of 10+ years at a minimum, so the cost of frequent copper bottom paint jobs can be greatly reduced for boat owners.
c. Also, CK-AF can be rolled on over old hard (modified epoxy) copper bottom paint without requiring expensive blast removal. The usual cleaning and sanding practice should be followed. The savings to the boat owner is especially beneficial here.

d. I would like to submit a formal public comment with you to the Legislature but am not familiar with the procedure. Perhaps this report can serve that purpose.
e. I trust testing of CK-AF by you can commence soonest, and we look forward to supplying the amount of coating required for the test panels. Please note that I have been testing CK-AF in San Diego Bay for the past 4 years. IT WORKS.
f. The Port of San Diego and the Los Angeles Department of Beaches & Harbors are both in the process of coating boats with CK-AF. Some are from private boat owners, and some are port operation vessels. Such an effort by you would greatly speed up the qualification process."

Response

Thank you for sharing this product information with Ecology. We welcome updates like this, as it keeps our knowledge about future markets up to date. As outlined in our report, typical non-biocidal alternative paints include FRCs, biocide-free self-polishing coatings (SPCs), and hard surface-treated composite coatings. Your ceramic epoxy-based product is classified under hard surface-treated composite coatings. Biocide-free hard coatings have minimal environmental impact. However, it's important to note that such coatings require frequent and regular cleaning.

For guidance on ensuring that antifouling products adhere to state and federal pesticide regulations, we recommend contacting the WSDA Agriculture Pesticide Customer Service desk via email at pestreg@agr.wa.gov or by phone at 360-902-2030.

Again, we appreciate the coating industry's efforts to introduce more products into the Washington market. We welcome information about antifouling paints and ingredients, as well as insights about the future landscape of the coatings market. Please contact us with questions or concerns about sensitive or confidential business information.

Comments from: American Chemet Corporation

Comment B-4-1: Regulation

"Copper-based antifouling coatings are the recognized most universally effective antifouling coatings globally available. It is estimated that 90% of global vessels, including recreational vessels, have copper-based marine antifouling coatings. Globally dozens of risk assessments have been conducted on copper based antifouling coatings and, in all cases, the continued use of these coatings has been approved. Many current regulatory activities and goals are focused on reducing greenhouse gas emissions from commercial and recreational vessels as well as preventing the further introduction of invasive species from hull fouling. This includes the International Maritime Organization's Glofouling Initiative and 2023 Strategy on Reduction of GHG Emissions from Ships, New Zealand's Craft Risk Management Standard for Biofouling, Australia's Biofouling Management Requirements, and California's Biofouling Management Requirement. With the continued regulatory approval of copper based antifouling coatings and the emphasis on the extremely important goal of preventing global warming and reducing the

introduction of invasive species in mind, we provide the following comments that we believe will help DOE improve the report and assist in a reasonable and productive path forward:

On page 4 of the report is mentioned the US EPA leach rate for antifouling paints that contain copper. We believe it should include mention that this only applies to recreational vessels."

Response

Thank you for sharing your observations around trends in antifouling regulatory activities. As part of our review, we are committed to keeping up with new scientific findings and evolving regulations in other states and countries.

We appreciate your recommendation to specify that the U.S. EPA's maximum allowable leach rate for copper in antifouling paints applies specifically to recreational vessels. We incorporated this clarification into the appropriate section of our final report.

Comment B-4-2: Copper

"Also, on page 4 the second paragraph discusses the toxicity of copper. We believe it could more fully express the complexity of this issue by beginning with '*Copper is a micronutrient and is ubiquitous in all aquatic environments. However elevated levels……'.* Bioavailability is a key scientific fact that the audience of this report must understand, or an incorrect conclusion could be drawn that if copper exists in the environment there is a problem, and it is toxic. This also applies to the bioavailability and bioaccumulation discussion on page 14 of the draft. The bioaccumulation of copper has been well reviewed in the EU copper evaluation at the Technical Committee for New and Existing Substances (TCNES) and the Scientific Committee for Health and Environmental Risk (SCHER) and the conclusion was because of the essentiality of copper, an increase in body concentration of copper cannot be considered as "bioaccumulation" as commonly understood for typical organic molecules. To achieve optimum biological efficiency and growth, organisms actively and deliberately accumulate essential metals in nutrient depleted environments using bio-regulatory (homeostatic) mechanisms to ensure body concentration does not become harmful. For this reason, it is not relevant to define an essential metal as bioaccumulative as this has no meaning for homeostatically regulated essential metals.

TCNES and SCHER agreed with the conclusions of the review, which is that from the considerable amount of copper accumulation data available:

- There is an inverse relation between the copper bioaccumulation and copper concentrations in the environment.
- Waterborne exposure is most the critical exposure route in aquatic ecosystems.
- Copper is well regulated in all living organisms and that the concept of bioaccumulation has no meaning for hazard assessment of essential metals such as copper.

On page 14 in the second paragraph, we believe it would be more accurate and thorough if the statement, '*Copper is moderately bioaccumulative and is very toxic to aquatic organisms*' be removed. Instead, we recommend this statement, '*For the naturally occurring substances such*

as essential metals as copper, bioaccumulation is complex, and many processes are available to modulate both accumulation and potential toxic impact.'"

Response

We appreciate the American Chemet Corporation's insights about the complexity of copper's bioavailability and toxicity. We recognize that copper is an essential micronutrient for marine organisms, and the environmental impact of copper depends on its levels. During the process of reviewing and editing our draft report, we simplified this section and removed the extensive discussions on bioavailability, such as copper's speciation and complex organic ligands. Our intention was to ensure that detailed discussion on copper did not distract the audience. We'd kept this report focused on alternatives rather than copper.

However, we recognize the importance of conveying accurate information to both legislators and the general public. We considered the suggested statement and revised relevant sections to reflect the complexity of copper bioaccumulation.

Comment B-4-3: Copper

"On page 5 of the report, it is stated that cupric oxide is a dominant form of copper in antifouling coatings. We believe this is incorrect. Cupric oxide is used in wood treating and agricultural products, but it is not used in antifouling coatings. It is cuprous oxide that is used in antifouling coatings."

Response

Thank you for this comment.

The original statement in the report is, "The forms of copper are dominantly cuprous oxide, followed by cupric oxide, copper pyrithione, and cuprous thiocyanate." We intended to highlight cuprous oxide as the primary form of copper in these coatings. The mention of cupric oxide and others was not to suggest their dominance but rather to list other forms present. We realize the wording may have led to confusion and appreciate your attention to detail. We rephrased this statement to eliminate any ambiguity.

Comment B-4-4: Safer Criteria

"The draft states '*Concerns about salmon In Washington State, one of the motivations to phase out copper in antifouling paints is to protect culturally and ecologically important species, such as salmon. The sublethal effects of copper on Coho salmon, and particularly on the salmon's sensory function, have been well documented (Baldwin et al, 2003; McIntyre et al., 2008, 2012; Sandahl et al., 2007; Hecht et al., 2007).*' (page 12). All five studies cited are freshwater studies. The olfactory effect of copper is significantly reduced in marine water and the emphasis on this project by DOE is focused on marine water environments. It would be appropriate for DOE to mention in this draft that the studies cited are freshwater studies. The salmonid olfactory studies conducted in marine water, i. e. Labenia et al. (2007), Sommers et al. (2016), indicate that the threshold for negative olfactory effects in salt water may be significantly higher than

concentrations found in marinas in Washington. This is a significant fact that greatly calls into question the primary justification for the legislation calling for this potential ban. In addition to mentioning the freshwater issue and the studies citing the lack of effect in salt water, it should be included that of the Hecht 2007 study cited in your draft it states, '*Dissolved copper's effect on salmonid olfaction in saltwater environments remains a recognized data gap and it is presently uncertain whether the BMC thresholds derived in this document apply to saltwater environments*,' (page 16). We believe this should be noted in your report to assist in the direction of the future evaluation of salmonid olfactory effects due to copper."

Response

Thank you for highlighting data gaps regarding the effects of dissolved copper on salmonid olfaction in saltwater environments. This point has also been raised in another comment (Comment O-1-2), and we have provided additional clarification there.

We also acknowledge that the difference between freshwater and saltwater can call into question the primary justification for this potential ban. It's worth noting that recreational boats often move between saltwater and freshwater. It should also be noted that salinity changes at estuaries where these environments are interconnected. In Puget Sound, for example, many boatyards are located along the Lake Washington ship canal, including Salmon Bay (half saltwater, half freshwater), Portage Bay (freshwater), and Lake Washington (freshwater). Lake Washington is also a critical area in the salmon migration route, connecting upstream creeks and the inland sea.

Our report emphasizes marine environments where marine fouling is a concern. This is to exclude inland freshwater settings where antifouling concerns are minimal or different. We aim to provide more clarification that our scope is limited to "marine environment, as well as the closely connected freshwater environments." To this end, we made changes in the section, "Our scope and approach for this study."

Comment B-4-5: Alternative - DCOIT

"The draft states '*DCOIT is a safer antifouling chemical comparing to copper.*' (page 19). We believe that DCOIT is a valuable biocide for use in marine antifouling coatings; however, coatings that only contain DCOIT are not effective coatings. DCOIT is almost exclusively used as a co-biocide with other biocides, most commonly cuprous oxide. In addition, DCOIT is not safer to humans. The US EPA's mandatory label for this active ingredient includes the following:

DANGER
CORROSIVE
CAUSES IRREVERSIBLE EYE DAMAGE AND SKIN BURNS
MAY CAUSE ALLERGIC SKIN REACTION
MAY BE FATAL IF INHALED
HARMFUL OR FATAL IF SWALLOWED OR ABSORBED THROUGH THE SKIN (US EPA pesticide registration #707-175 approved label, 2016)

Also, at this time DCOIT cannot be used in the USA on recreational vessels. The US EPA requires the following statement for this active: "*Paints formulated with this product are intended solely for commercial and military applications adhering to recommended safe handling procedures*." (US EPA pesticide registration #707-175 approved label, 2016). This should be mentioned in the final report to fully state the limits of this alternative."

Response

Thank you for your comment regarding DCOIT's use and safety as an antifouling chemical.

We agree that DCOIT is typically used in combination with cuprous oxide. Based on the safer criteria, DCOIT is a relatively safer antifouling chemical compared to copper. This doesn't contradict the fact that DCOIT still presents toxicity in certain human health endpoints. In the U.S. EPA's latest risk assessment, DCOIT fails both the inhalation and dermal assessments by a wide margin for occupational painters.

Regarding the use of DCOIT in products, Ecology cannot speak for U.S. EPA or interpret the language on behalf of U.S. EPA. Based on the fact that DCOIT is currently registered in antifouling products, we believe there might be misunderstanding on the term "for commercial use" in the comment.

U.S. EPA pesticide registration #707-175 specifies that DCOIT is for commercial use only. In 40 CFR 705.3, commercial use refers to, "the use of a chemical substance or a mixture containing a chemical substance (including as part of an article) in a commercial enterprise providing saleable goods or services."[12] In this context, DCOIT must be applied by a professional painter, but there are no restrictions as to boat length or type (e.g., commercial, recreational, naval, etc.).

In the antifouling market, "commercial use" has a specific meaning for use in commercial vessels or commercial shipping markets. Paints for commercial use, in this case, means those used for large ships and containers. This is compared to "recreational use," where paints are used for yachts and boats with a length shorter than 65 feet.

Comment B-4-6: Performance

"Regarding the efficacy testing, FRC coatings, such as the 1100SR® and Propspeed®, are applied with the expectation of a 7-to-10-year life while biocide coatings generally have a 1-to-3-year life expectation. Therefore a 12-month evaluation of all coatings doesn't give an accurate comparison of efficacy. We recommend you mention this in your report and if possible, continue the panel test beyond 2024."

[12] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-R/part-705/section-705.3

Response

Thank you for your comment.

We agree that biocide-free FRCs have a significantly longer life expectancy. This distinction suggests that a 12-month evaluation may not adequately reflect the long-term performance of these products. We will consider long-term efficacy in our future research.

It's worth mentioning that when we selected products for this test, no FRCs for recreational use were available in Washington market. We still included 1100SR® and Propspeed®, as they are leading products used on commercial vessels and the only FRC products we could obtain. There is a possibility that manufacturers may introduce similar products into the recreational market in the future. We included these two products as an exploratory part of the test and they cannot accurately reflect the efficacy of FRCs for recreational vessels.

Comment B-4-7: Regulation

"This report completes the third review by DOE of this subject with the analyses of alternatives to the use of copper in recreational vessel antifouling coatings. All three have reached the same conclusion. Biocide antifouling actives and coatings are continuously going through regulatory review in jurisdictions around the world. Biocide and biocide-free coatings are continuously going through introduction, evaluation, and use on thousands of vessels. If safer and more effective coatings are found, they will quickly get adopted and manufacturers will be introducing those coatings to markets around the world including Washington state. The use of Washington Department of Ecology resources to repeat this exercise for the fourth time is not necessary or productive. We encourage the Department of Ecology to request the Washington Legislature repeal the Antifouling Paints Law and allow Ecology to pursue more critical environmental and human health issues."

Response

Thank you for sharing your perspective with us. Our draft report, including the review of alternatives to copper antifouling paints, is guided by Legislative mandates. Ecology cannot provide policy recommendations beyond the requirements. We will continue to fulfill our responsibilities and ensure that resources are used effectively.

Comments from: Seawide Distribution

Comment B-5-1: Alternative - FRCs

"Biocide-free paints for recreational vessels less than 24 metres in length (LOA)

Effective, proven, safer and feasible Biocide-free foul release coatings will be available in Washington State for all types of recreational boats < 24m LOA from 2024. Seawide distribution welcome the opportunity to comment on the draft document "Antifouling Paints in Washington State: Third Report to the Legislature". There are several inaccurate statements made in the draft report regarding biocide-free foul release coatings (FRCs). We therefore provide the information below and request that the section on FRCs is amended:

Biocide free FRCs are commercially available for use on recreational craft As a market leader in fouling control coatings, Hempel developed and introduced a full range of biocide-free Fouling Release Coating (FRC) products based on silicone coating technology which are suitable for use on all types of leisure boats less than 24 meters LOA. First introduced in 2012, over 10 000 successful applications of biocide-free Hempel FRC products have since been made to the hulls of recreational boats across Europe. In September 2023, Hempel announced that it's innovative, proven high-performance, copper-free, and biocide-free antifouling coating - Silic One will be available in the United States and Canada, distributed by SeaWide distribution [1]

Application and mode of action Silic One can be applied by consumers and works by providing an amphiphilic surface that microscopic settling stages of fouling organisms cannot strongly adhere to. The amphiphilic surface consists of a low surface energy and elastomeric silicone matrix combined with a superhydrophilic hydrogel microlayer which sets up on immersion, producing a non-stick surface which prevents organisms from attaching firmly to the hull. This technology is described in the presentation attached to this comment "Fouling control coatings for use on vessels less than 24 meters overall (LOA)". Any fouling that does weakly attach is removed as the boat gets underway. In the case of slower boats, any loosely adhered fouling can be easily removed by gentle wiping with a soft sponge. The first biocide-free FRC product, Silic One was introduced by Hempel in 2012, and is proven to provide effective fouling control on leisure boats less than 24 meters LOA. Silic One is proven and effective In independent tests, Silic One has consistently showed performance on pleasure craft.

Response

Thank you for providing feedback on biocide-free FRCs. We received similar comments, as shown in Comment B-1-2 and B-2-1. Please read more information under those comments.

Appendix A. Comments in Original Format

This appendix contains the comments we received in their original format. The comments are summarized in the main body of this document.

Some of the following content is untagged and isn't compatible with screen readers. If you are using a screen reader and would like to receive this entire appendix in an accessible format, please contact us by phone at 360-407-6700 or by email at hwtrpubs@ecy.wa.gov.

UNGENT Formal Public Comment on draft Antifouling Paint

Good Day Ms. Deng,

We attended this morning Zoom-Meeting you hosted and we would like to thank you for the good information that you presented.

Tacoma Youth Marine Foundation has decades of presents here on the Thea Foss Waterway in downtown Tacoma as a youth marine training organization.

We recently acquired the M/V Doolin-Rogers a custom built 110' training vessel to support our program. We have been working with the Science and Math Institute (Tacoma Public Schools) for year as their on the water partner to support their marine and environmental science programs.

We are committed to supporting sound environmental practices with all of our vessels, as we are training the future science and maritime personnel. With our new vessel we choose to use EPaints SN-1 based on its reputation and recommendation of the boat yard that applied it, and that the maker states it is used by the U.S.C.G.

In short this paint has proven to be total ineffective for the waters of Puget Sound based on the rate of growth that started in short order. This is also on a vessel that is used far more that most vessels.

The amount of growth has caused concerns for the safe operation of the vessel due to fouling of sea water intake screens for the main engines and generators. The Doolin-Rogers is a USCG inspect passenger vessel by class of inspection.
We had to involve the USCG because we MUST return to drydock a full year ahead of schedule to correct this issue.

The vessel will be hauled out on 3 January 2024, if you would like to join us to first and look at E-Paints SN-1 in a real-world performance test of how well it performed in one year of service.

I have inserted a link below for you to review the underwater inspection done not too long ago and a write up of the vessels service.

Bottom Job Details:
Vessel: M/V Doolin-Rogers 110' aluminum training vessel
Haul-out date: 30 Dec 2022
Work: Sanded, dewaxing solvent wipe, barrier coat touchup, two coats EPaints SN-1 (Sea-Nine) , new zincs, shaft and prop treatment
Launch Date: 18 Jan 2023
First sign of Issues: Late April growth was noticed at the waterline. Midsummer July 2023 more growth was observed getting a good hold on the stern of the vessel.
Vessel use: Year to date 433 hours underway
Inspection: As the growth was getting alarming by September we had a former USCG inspector dive on the vessel and tape the attached video footage of the bottom in October 2023
Corrective measures: Seawater Intakes are inspected before each use of the vessel and vessel is set for haul-out at Port Townsend for bottom paint service 1 full year early due to poor antifouling paint performance.

Here is a drop Box Link to one of the video files: https://www.dropbox.com/scl/fi/xgi1l323q8vnelgi9tutw/GX010470.MP4?rlkey=pnoytzqjegq2l200dqzzgp99a&dl=0

I you can see we have a vested interest in how well Antifouling paints perform and the environmental impact as well.

Let me know if you would like to view the vessel on haul-out on 3 Jan 2024.

Best Regards,

Vernon Moore
Youth Marine Foundation | Capt. M/V Doolin-Rogers
820 East D Street, Tacoma WA 98421
O 253.572.2666 | Youth Marine Foundation

American Coatings Association

Please see attached for the American Coatings Association's (ACA) comments to the Washington State Department of Ecology (WA DOE) regarding its Draft Antifouling Paints in Washington State: Third Report to the Legislature. Thank you for your consideration of our comments. Please do not hesitate to contact us if you have any questions or require additional clarification. ACA looks forward to working with WA DOE on its continued evaluation of antifouling paints and their ingredients in Washington.

AmericanCoatings
ASSOCIATION℠

January 17, 2024

Ms. Iris Deng
Toxics Researcher / Product Testing Coordinator
Hazardous Waste and Toxics Reduction Program
Washington State Department of Ecology
300 Desmond Drive SE
Lacey, WA 98503

RE: Washington State Department of Ecology Draft Report to the Legislature on Antifouling Paints; ACA Comments

Dear Ms. Deng:

The American Coatings Association (ACA) submits the following comments to the Washington State Department of Ecology (WA DOE) regarding its *Draft Antifouling Paints in Washington State: Third Report to the Legislature*. ACA is a voluntary, nonprofit trade association working to advance the needs of the paint and coatings industry and the professionals who work in it. The organization represents paint and coatings manufacturers, raw materials suppliers, distributors, and technical professionals. ACA serves as an advocate and ally for members on legislative, regulatory, and judicial issues, and provides forums for the advancement and promotion of the industry through educational and professional development services.

ACA appreciates the opportunity to comment on WA DOE's thoughtful and detailed review of biocidal and non-biocidal antifouling paints and ingredients in the state. Notably, the draft report highlights the importance of ensuring that there are safe and efficacious antifouling paint products for sale and use in Washington. ACA agrees with Ecology's recommendation to delay the ban on copper-based antifouling paint and conduct another review of relevant studies and information for inclusion in a follow-up report that will be submitted to the legislature by June 30, 2029. ACA looks forward to continuing to work with WA DOE, industry, and all relevant stakeholders to gather new information and provide resources that will better inform a sound decision on this important matter.

While ACA appreciates the research discussed and conducted in the report, we have a comment on the studies referenced regarding salmon in freshwater environments. The draft report notes on page 12:

> *In Washington State, one of the motivations to phase out copper in antifouling paints is to protect culturally and ecologically important species, such as salmon. The sublethal effects of copper on Coho salmon, and particularly on the salmon's sensory function, have been well documented (Baldwin et al, 2003; McIntyre et al., 2008, 2012; Sandahl et al., 2007; Hecht et al., 2007).*

ACA urges WA DOE to clarify in the report that the studies cited take place in freshwater environments and not marine saltwater. The majority of WA DOE's study is focused on saltwater environments, including three of the four testing sites. This important distinction should be noted because a data gap exists regarding dissolved

copper's effect on salmonid olfaction in saltwater environments.[1] In fact, some studies show that the olfactory effect of copper is significantly reduced in marine saltwater environments.[2] It's critical for WA DOE to include language in its report to the legislature that highlights this distinction, as the current draft implies that dissolved copper has the same effect in marine saltwater. This important distinction will assist in the direction of future evaluations and studies in Washington.

Lastly, the report notes that U.S. EPA's maximum allowable leach rate for antifouling paints that contain copper is 9.5 µg/cm^2/per day (see page 4). ACA encourages WA DOE to clarify in the report that this maximum allowable leach rate only applies to coatings used on recreational vessels.[3]

Thank you for your consideration of our comments and the opportunity to participate in this review process. Please do not hesitate to contact us if you have any questions or require additional clarification. ACA looks forward to working with WA DOE on its continued evaluation of antifouling paints and their ingredients in Washington.

Sincerely,

Rhett Cash
Counsel, Government Affairs
American Coatings Association
rcash@paint.org

Katherine Berry
Director, Sustainability & Environment
American Coatings Association
kberry@paint.org

Submitted via WA DOE's Online Comment Form

[1] Hecht, S. A., Baldwin, D. H., Mebane, C. A., Hawkes, T., Gross, S. J., & Scholz, N. L. (2007). An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. NOAA Technical Memorandum NMFS-NWFSC-83. Page 16.

[2] Labenia JS, Baldwin DH, French BL, Davis JW, Scholz NL. 2007. Behavioral impairment and increased predation mortality in cutthroat trout exposed to carbaryl. Marine Ecological Progress Series 329:1-11. Sommers F, Mudrock E, Labenia J, Baldwin D. 2016. Effects of salinity on olfactory toxicity and behavioral responses of juvenile salmonids from copper. Aquatic Toxicology 175:260-268.

[3] U.S. EPA Interim Registration Review Decision for Copper Compounds (August 2018). Docket Number EPA-HQ-OPP-2010-0212 (page 5).

Julian E Hunter

Please find in the files attached comments and feedback to your draft report from Hempel A/S - a global leader in antifouling paints used on commercial and recreational vessels throughout the world.

Our comments pertain to

(i) the approach used to assess the relative safety of antifouling biocides versus copper oxide and

(ii) the status, performance, track record and safety of biocide-free antifouling paints (Foul release coatings) that will be commercially available for use on recreational boats in WA in 2024.

We hope you find these comments and suggestions useful - we would be happy to discuss further at your convenience.

Sincererely

Dr Julian E Hunter
Consultant to Hempel A/S

Comments from Hempel A/S

Hempel A/S is a world leading supplier of coatings to major markets including the marine and yacht industries and has provided coating solutions to customers across the world for over 100 years. Headquartered in Denmark, Hempel focusses on development and promotion of sustainable products and through our R&D and production centres across the world, we provide high performance sustainable antifouling products for use on all types of commercial and leisure marine vessels.

We welcome the opportunity to comment on the draft document “Antifouling Paints in Washington State, Third Report to the Legislature” and ask that our comments are considered and the points made reflected when finalising the draft report :

Herewith comments on your draft report for your consideration :

1. **Biocidal paints**

The draft report evaluates the comparative safety of antifouling biocides versus copper oxide on the basis of their hazard properties. The approach does not consider environmental or human exposure and is thus incomplete when evaluating safety of antifouling biocides. This may lead to erroneous conclusions about safety and is not aligned with Federal and internationally accepted risk assessment procedures currently used by US-EPA, IMO and other regulatory authorities that evaluate the safety of antifouling biocides.

Furthermore, the draft report (page 8) defines antifouling chemicals as ‘safer’ if they ‘release fewer toxic chemicals into the environment’ – this element is missing from the evaluations in the draft report.

Evaluation of the potential inputs of biocides into the environment and an assessment of exposure to them is an essential part of a comparative evaluation for the safety of antifouling biocides. Consideration of hazard properties in isolation does not take account of the relative content of biocide in the paint film nor the biocide leaching rate when the paint is immersed. The draft report notes contents of non-copper biocides in paints (% w/w wet paint) versus copper are different, i.e. – typically Copper present at 15-40%, typical Tralopyril 6% w/w, ZPT – typically <4-5% w/w,

DCOIT (no specific amount noted), but this is not considered in the evaluation of their relative safety.

Recognised tools are available to determine biocide release rates and to model their fate and concentration in the environment
Biocide release rates from immersed paint film is a key element of an environmental safety assessment. Biocide leaching rates can be calculated for typical products using ISO methodologies, e.g. ISO 10890:2010 which specifies a method for estimating the mean release rate of biocide from an antifouling paint over its entire lifetime (in-service period) using a mass-balance calculation[1]. Biocide release rates can then be used as inputs internationally accepted environmental emission models such as MAMPEC[2]. Which can predict the environmental concentrations of biocide in marinas and harbours.

Predicted environmental concentrations (PEC) for antifouling biocides can then be compared with no-effect concentrations (PNEC) derived from substance hazard data, and a PEC/PNEC ratio derived to determine environmental safety. This is a scientifically recognised approach used by regulatory authorities throughout the world when evaluating the safety of antifouling biocides.

The potential for exposure of biocide to applicators containing the biocide is also an essential part of a comparative evaluation of biocides.

We suggest that the evaluation of the biocides in the report is expanded to include an evaluation of relative safety for each biocide using the approach above for antifouling products containing a 'typical concentration' of biocide.

[1] https://www.iso.org/standard/46281.html#:~:text=ISO%2010890%3A2010%20specifies%20a%20method%20for%20estimating%20the,the%20specified%20paint%20lifetime%20can%20also%20be%20calculated.

[2] https://www.deltares.nl/en/software-and-data/products/mampec

2. Biocide-free paints for recreational vessels less than 24 metres in length (LOA)

Effective, proven, safer and feasible Biocide-free foul release coatings will be available in Washington State for all types of recreational boats < 24m LOA from 2024.

There are several inaccurate statements made in the draft report regarding biocide-free foul release coatings (FRCs). We therefore provide the information below and request that the section on FRCs is amended :

Biocide free FRCs are commercially available for use on recreational craft
As a market leader in fouling control coatings, Hempel developed and introduced a full range of biocide-free Fouling Release Coating (FRC) products based on silicone coating technology which are suitable for use on all types of leisure boats less than 24 meters LOA. First introduced in 2012, over 10 000 successful applications of biocide-free Hempel FRC products have since been made to the hulls of recreational boats across Europe. In September 2023, Hempel announced that it's innovative, proven high-performance, copper-free, and biocide-free antifouling coating - *Silic One* will be available in the United States and Canada, distributed by SeaWide distribution[3].

Application and mode of action
Silic One can be applied by consumers and works by providing an amphiphilic surface that microscopic settling stages of fouling organisms cannot strongly adhere to. The amphiphilic surface consists of a low surface energy and elastomeric silicone matrix combined with a superhydrophilic hydrogel microlayer which sets up on immersion, producing a non-stick surface which prevents organisms from attaching firmly to the hull. This technology is described in the presentation attached to this comment "Fouling control coatings for use on vessels less than 24 meters overall (LOA)". Any fouling that does weakly attach is removed as the boat gets underway. In the case of slower boats, any loosely adhered fouling can be easily removed by gentle wiping with a soft sponge. The first biocide-free FRC product, *Silic One* was introduced by Hempel in 2012, and is proven to provide effective fouling control on leisure boats less than 24 meters LOA.

[3] https://www.marinebusinessworld.com/news/267185/SeaWide-launches-Hempels-Silic-One

Silic One is proven and effective

In independent tests, *Silic One* has consistently showed performance on pleasure craft <24m LOA that is equivalent or better than copper-based biocidal antifouling products. For example, a study carried out by Chalmers University (Gothenburg) in the Baltic Sea, Kattegat and Skagerrak areas, concluded that Silic One is as more effective against fouling than the commercially available copper-based antifouling paints when immersed for two years[3]. In addition, In addition a UK boating magazine in 2022 also highlighted Silic One performance as 'best in test' when tested in UK waters alongside commercially available biocidal antifouling paints for leisure boats[4].

Mechanical strength of FRC films

If subject to accidental mechanical damage / abrasion from fenders or from unintentional contact with the sea bed, silicone-based coatings may be scraped which may result in release of small fragments of the paint film into water. This is also the case with biocidal antifouling coatings. In general silicone elastomeric foul release coatings have a higher resistance to milder mechanical stresses compared to eroding biocidal antifouling paints due to their elastomeric and crosslinked nature. In the event that a vessel requires underwater cleaning , gentle non-abrasive removal of any fouling should not damage the foul release coating and cause any release of paint film or particles into water.

FRCs are less hazardous than biocidal antifouling paints

Hempel *Silic One* does not contain fluoropolymer-based binders or oils (PFAS) and does not contain an organotin catalyst. A small quantity of polydimethylsiloxane (PDMS)-based silicone fluid is present in the Silic One paint film to achieve the required non-stick surface properties which prevents adhesion of fouling organisms. The fluid is non-hazardous to the environment[4] and is designed to remain within the paint film so that its surface properties are retained. PDMS-based silicone fluids are universally recognised as safe and are widely used throughout the world in household products, medicines, medical devices, cosmetics and food. In laboratory tests[5], PDMS showed no adverse effects on aquatic species and sediment

[3] https://doi.org/10.1016/j.marpolbul.2022.114102

[4] Best antifouling paint: 8 leading options in head-to-head test (pbo.co.uk)

[4] Not classified as hazardous under EU (CLP) and global (GHS) rules for classification and labelling of chemicals.

[5] 1 (ecetoc.org)

dwelling organisms at concentrations up to, and exceeding its solubility in water. There is no evidence that it may bioaccumulate or bioconcentrate in the marine environment.

3. Attachments to this submission

The following provide documents that support the comments above :

I. IMO Glofouling report 2022 – summarises antifouling technologies and good management practices for managing the spread of invasive species :

BIOFOULING MANAGEMENT FOR RECREATIONAL BOATING - GEF-UNDP-IMO GloFouling Partnerships Project, 2022. Biofouling Management for Recreational Boating: Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species.

II. Paper from Hempel presented at the International Antifouling Conference Gotenburg 2023

Arias (2023). *Proven,effective biocide-free paint solutions are available to control fouling on the hulls of leisure boats*

III. Information prepared for IMO Glofouling project 2023

Hempel (2023). *Fouling control coatings for use on vessels <25 m LOA*

We thankyou in advance for consideration of our comments to your draft report and would be happy to discuss them further at your convenience.

Dr Julian E Hunter , Consultant, Hempel A/S

Email : juhuxx@hempel.com

15th January 2024

Proven, effective biocide-free paint solutions are available to control fouling on the hulls of leisure boats

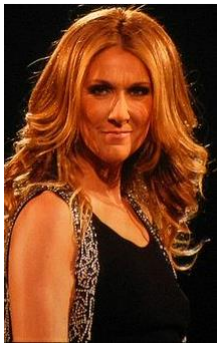
Santiago Arias
12 September 2023

Agenda

- 1989
- Technology
- History of biocide free yacht solutions
- Results in Raft
- Results in boats
- External recognitions
- Recommendation

1989

- ✓Council Directive 89/677/EEC of 21 December 1989
- ✓Organostannic compounds may not be used on the hulls of boats of an overall length, of less than 25 metres
- ✓One of my first projects in Hempel R&D to work on alternatives



1970

Baier publish the curve

1972
Fouling release invented by Hempel

1980

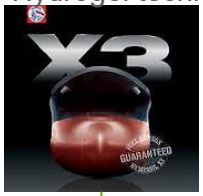
1990

1990'ies
Fouling release R&D takes off due to increasing concern with TBT

2000: 77500 & 77100

2000

2008
Hydrogel technology in FR



2010

2015:
Improved hydrogel

2020

HEMPASIL 77500

- Low surface tension
- Flexibility
- Poor wettability
- Little to no adhesion strength of biofouling adhesives

29 19 August 2015 HEMPEL

Critical surface tension of substratum (mN/m)

HEMPEL

The Hydrogel's impact on performance

2000

Hydrophobic
HEMPASIL 77500

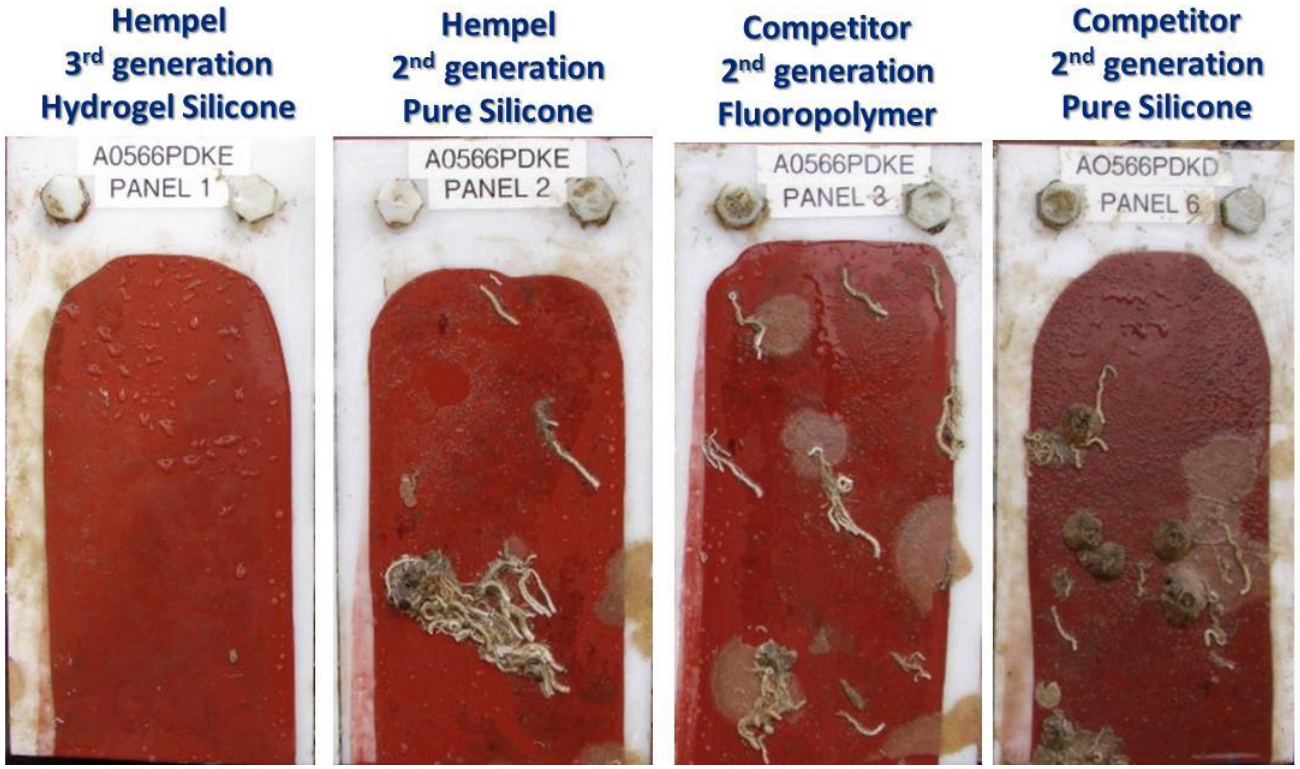
2008

Hydrogel technology
HEMPASIL X3

2015- Today

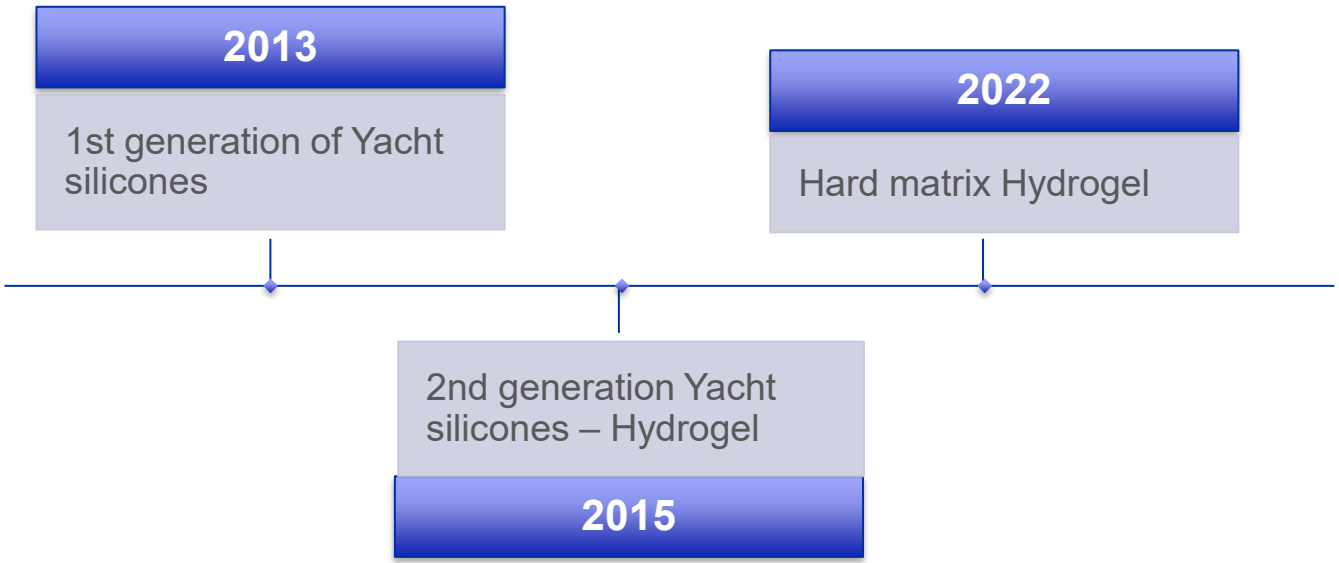
Improved hydrogel
technology

8 months static Singapore



Non biocidal antifouling for Yacht.

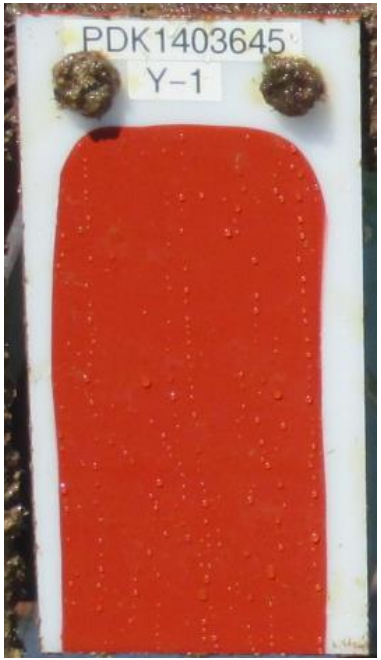
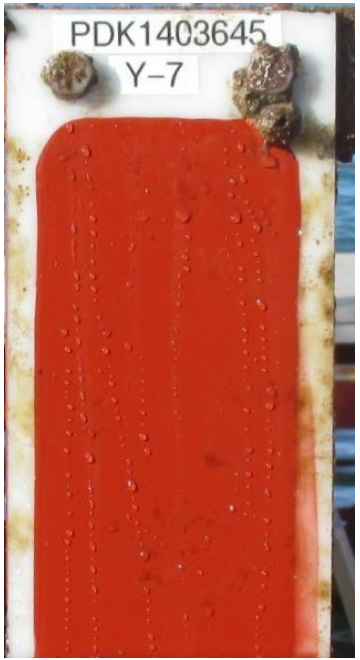
Different generations



After 80 weeks in Singapore – Silic One

HEMPEL

Silic One 2015 in Mediterranean up to 80 weeks

Silic One 2nd generation	Silic One 2nd generation	Silic One 2nd generation	Silic One 2nd generation
			

HEMPEL

Silic One – after 1 season in Baltic sea

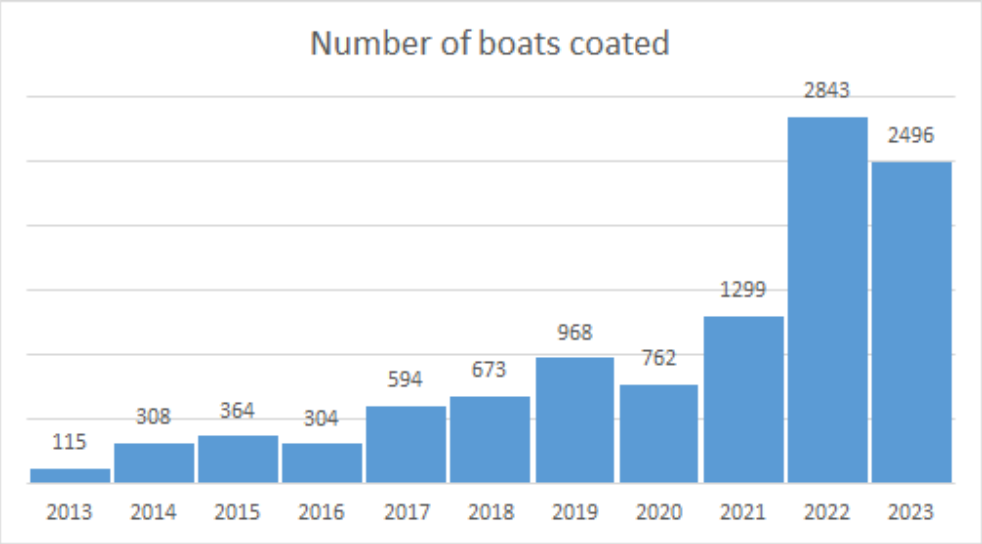
(Lynæs)

(Lynæs)

HEMPEL

Yacht biocide free references

More than 10,000 applications in the last 11 years



8 months

Types of waters

- Mediterranean
- Atlantic
- Baltic Sea
- North Sea
- Brackish waters

HEMPEL

Hempel’s biocide-free solutions

3rd partie recognitions

2023

Chalmers University research (2022)

CHALMERS
UNIVERSITY OF TECHNOLOGY

Miljövänlig båtbottenfärg mest effektiv mot påväxt

- ✓ This study shows that an environmentally friendly antifouling paint is **more effective** against fouling than a traditional copper-based paint
- ✓ The study was carried out at **three sites** in the **Baltic Sea** region and the Skagerrak and the results have been published in the scientific journal *Marine Pollution Bulletin*

Research done by Maria Lagerström from Chalmers University together with colleagues from the University of Gothenburg and the Swedish Environmental Institute IVL

Photo *taken after 2 years of sea exposure*:

- **black** surfaces coated with biocide-free silicone-based paint
- **red** surfaces coated with copper-based paint
- white surfaces (full of fouling) have no antifouling treatment

HEMPEL

Vene magazine (2023), Finland

- ✓ Independent biocide-free antifouling test
- ✓ **Hempel's Silic One positioned on the first, Hempaspeed TF the second place, outperforming all other biocide containing products**

Practical Boat Owner magazine UK(2022), UK

- ✓ Big independent antifouling test included 8 antifouling products
- ✓ The aim of the test was to compare traditional copper-based annual antifoulings with innovative, longer lasting and more environmentally sensitive alternatives
- ✓ Hempel's Silic One rated **BEST ON TEST**

Hempel Silic One

TYPE Biocide-free medium term antifoul
PREPARATION Hempel Light Primer 4 coats, Silic One Tie-Coat 1 coat
INITIAL COST £1,045
ANNUALISED COST £233

Silic One had the most stringent set of application instructions of our group. It's strongly advised to apply it on to a stripped hull but, if the existing coating is in good order, a barrier coat of Hempel's Silic Seal will enable the switch.

Commencing with Hempel's two-component Light Primer, the bare surface must be built up with a minimum of four thin layers. Next, a tie-coat must be applied while the last coat of primer is still tacky. After two hours the first of two coats of Silic One can be applied with a minimum of eight hours in between, the last of which has a 16-hour minimum drying time before immersion.

If it sounds like an involved process that's because it is, taking nearly three days from start to finish once drying intervals have been factored in. However, the results speak for themselves. After seven months, Silic One has performed the best of all our group, with no signs of weed or shell growth and the least amount of surface slime. It also wiped off exceptionally easily. An impressive result for a biocide-free antifouling.

Because it has a recommended lifespan of two years before topping up with one fresh coat of Silic One, the high initial application cost is offset over time.

Its six-year annualised cost comes in lower than all other products on test except Hempel Tiger Xtra 7100 and Coppercoat if you exclude the cost of shotblasting.

2022 Practical Boat Owner BEST ON TEST

HEMPEL

BÅD Magasinet (2020), DK

TEXT & PHOTO TORSTEN RASMUSSEN

ANTIFOULING TEST

With focus on the environment

The vulnerability of the marine environment cannot be ignored. It needs to be cared for in order for plants and spieces to survive. Action needs to be taken now by shifting to environmentally friendly systems as regards to antifouling. With the focus on the environment, we will show you the results from tests done thoughout season 2019 of the most environmental friendly antifoulings.

Spring is the busiest time for treating the hull of the boat. Through force of habit, one will choose the same antifouling as previous years.

This antifouling test is made once a year. The test helps us navigate the market of antifoulings and in which direction the paint producers are heading in their research. Demands and regulations from the Ministry of Environment and EU need to be followed. They especially address type and amount of pollutants. At the same time, the paint producers and environmental engineering institutions are collaborating to meet their demands and approval procedures.

This close collaboration is important for the development of new biocides. The long-term effect of these biocides is tested in several environmental conditions. All this research and developent is being done to prepare for May 1st 2021, when the EU's biocidal product regulation comes into full force.

PURPOSE

The Danish magazine BÅD has throughout season 2019 monitored the most environmental friendly antifoulings and treatment products. The products have been rated with respect to the level of fouling over the sailing season of seven months. The test boat has sailed approx. 200 nautical miles and anchored in stream-filled waters over 30 days. The test boat has also been into habour and used for weekend trips and activities which represent the main sailing bahaviour of a Danish sailor.

CONCLUSION

For the test period, 12 test areas on the boat have been exposed to the environment of the marina. Several of the polishing products had similar fouling results as previous seasons tests have shown. The product Aero G showed in test season 2018 a heavy fouling, which according to the producer was due to a manufacturing defect. The product has in the test 2019 shown to have a antifouling effect similair to the other tested biocidal products. The more environmental friendly treatments consisted primarily of biocide free foil and biocide free paint based on hydrogel. As a result of new foil technology, silicone based foil can be an alternative to biocidal antifouling paint. Although, the new blue Silic One coating should be emphasised as a product with the same antifouling effect as the test's biocidal products.

- ✓ Independent biocide-free antifouling test
- ✓ 12 test areas, 7 months
- ✓ Proved that biocide-free paint can be an alternative to biocide containing antifoulings
- ✓ Silic One has the same antifouling effect as the tested traditional antifoulings

HEMPEL

Sweboat Award (2023) - Hempaspeed TF

- ✓ Awarded as a **new sustainable coating solution** with patent-pending technology for Yacht segment during **Goteborg Boat Show 2023**
- ✓ ***Sweboat's Environmental Award i****s awarded annually to a person, organization or company that has made a good and significant contribution to the environment linked to boating*

HEMPEL

Recommendations

There is technology available with proven / demonstrated performance to fulfil performance demands on Fouling control solutions for Yachts in Europe.

There is legislation experience on how to do it

We just need to do it

Fouling control coatings for use on vessels <25 m LOA

HEMPEL
Trust is earned

The need for biofouling management on vessels

Control of fouling of immersed areas of ships and boats is **essential** for safe and sustainable operation of all vessels :

A fouled hull is an economic and environmental disaster :

- Loss of manoeuvrability / speed
- Increases fuel consumption , GHG and SOx/NOx emissions
- Requires reactive hull cleaning / dry-docking

and

- **Increases risk of translocation and spread of invasive species leading to loss of biodiversity in sensitive aquatic environments**

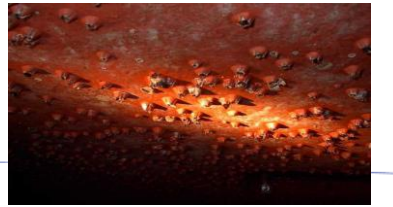
Image source : British Coatings federation

HEMPEL

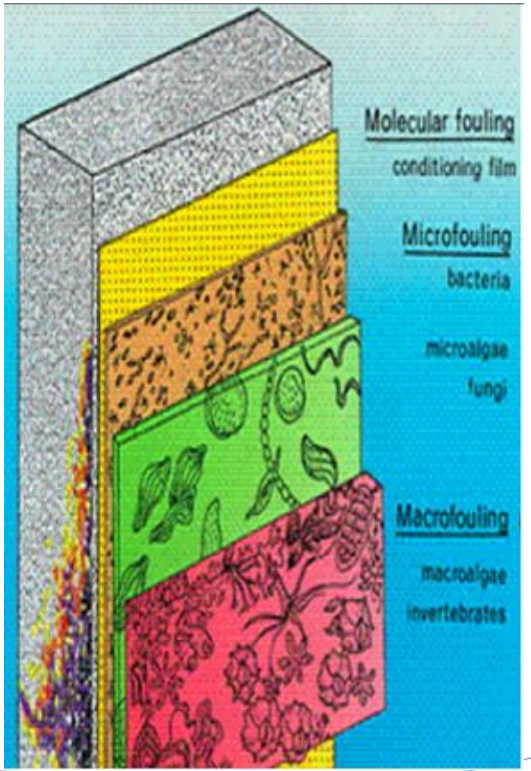
Colonization of the outer hull increases surface roughness (AHR)

Slime : 250 - 400µ AHR

Weed : 400 - 650µ AHR

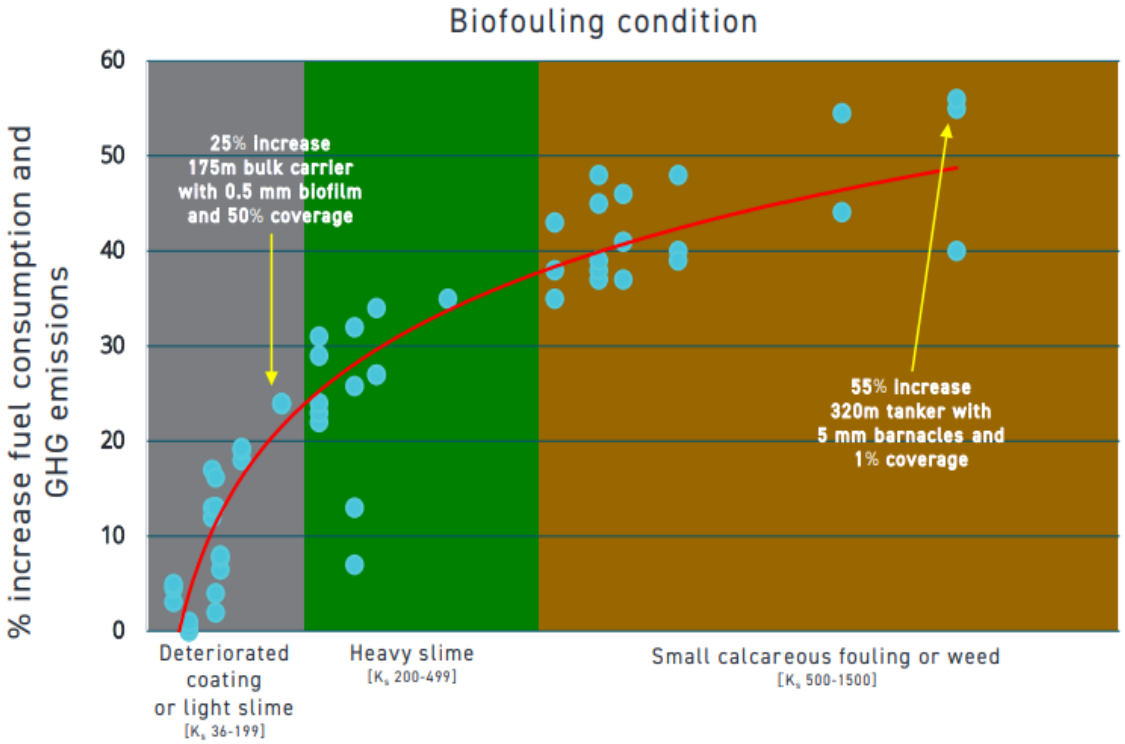


Shell Fouling : > 650µ AHR



Time

Colonization of the outer hull increases GHG emissions



175 m Bulk Carrier
Increase in GHG emissions :

Light slime – up to 25%
Shell fouling – up to 55%

Source : IMO Glofouling (2022) : Analyzing the Impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures

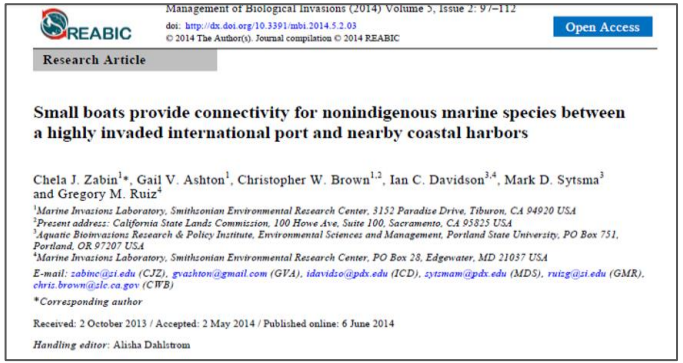
HEMPEL

Colonization of immersed surfaces risks translocation of invasive aquatic species

Effective antifouling systems are essential to protect biodiversity

Fouling on immersed areas of leisure craft can translocate and spread invasive aquatic species in Marine Protected Areas (MPA) disrupting biodiversity*

The use of effective antifouling systems on boats and ships is recognized as key in the prevention and spread of invasive aquatic species and protection of bio-diversity in coastal marine environments.



REABIC

Management of Biological Invasions (2014) Volume 5, Issue 2: 97–112

doi: http://dx.doi.org/10.3391/mbi.2014.5.2.03

© 2014 The Author(s). Journal compilation © 2014 REABIC

Open Access

Research Article

Small boats provide connectivity for nonindigenous marine species between a highly invaded international port and nearby coastal harbors

Chela J. Zabin[1]*, Gail V. Ashton[1], Christopher W. Brown[1,2], Ian C. Davidson[3,4], Mark D. Sytsma[3] and Gregory M. Ruiz[4]

[1]*Marine Invasions Laboratory, Smithsonian Environmental Research Center, 3152 Paradise Drive, Tiburon, CA 94920 USA*

[2]*Present address: California State Lands Commission, 100 Howe Ave, Suite 100, Sacramento, CA 95825 USA*

[3]*Aquatic Bioinvasions Research & Policy Institute, Environmental Sciences and Management, Portland State University, PO Box 751, Portland, OR 97207 USA*

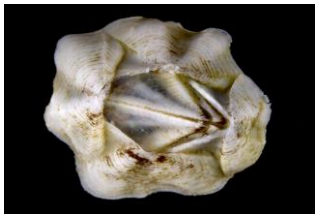
[4]*Marine Invasions Laboratory, Smithsonian Environmental Research Center, PO Box 28, Edgewater, MD 21037 USA*

E-mail: zabinc@si.edu (CJZ), gvashton@gmail.com (GVA), idavidso@pdx.edu (ICD), sytsmam@pdx.edu (MDS), ruizg@si.edu (GMR), chris.brown@slc.ca.gov (CWB)

**Corresponding author*

Received: 2 October 2013 / Accepted: 2 May 2014 / Published online: 6 June 2014

Handling editor: Alisha Dahlstrom



Darwin's barnacle Austrominius modestus (UK)

Australian tubeworm (UK)

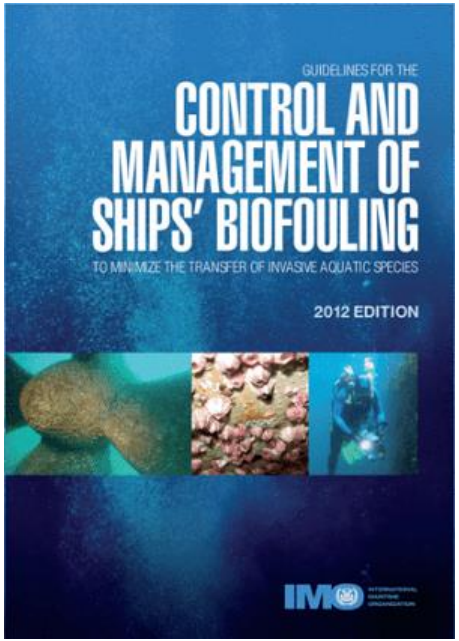
* Ulman, A., et al Alien species spreading via biofouling on recreational vessels in the Mediterranean sea. Journal of Applied Ecology https://doi.org/10.1111/1365-2664.13502 (2019)

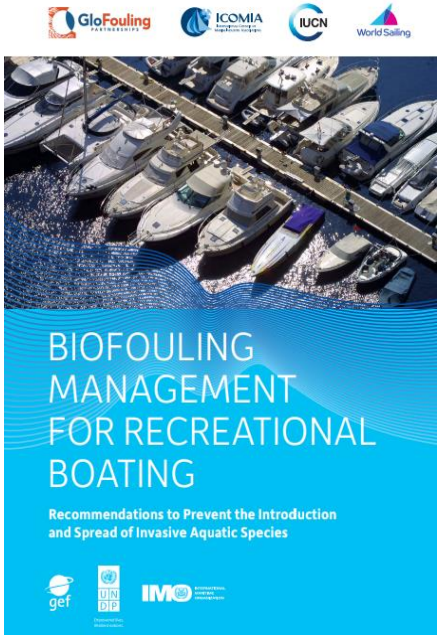
Guidance on biofouling management

IMO Guidance promotes importance of effective management of biofouling

IMO is promoting biofouling management on all vessels :

- Revising guidelines on control and management of ships biofouling (2023)
- IMO Glofouling project published guidance on Biofouling Management for recreational boating (2022)



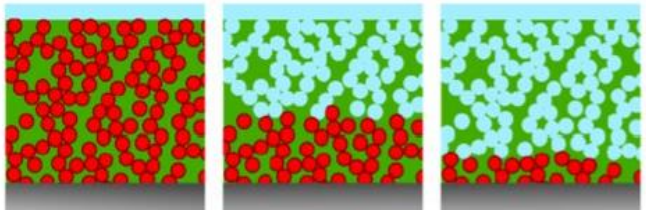


HEMPEL

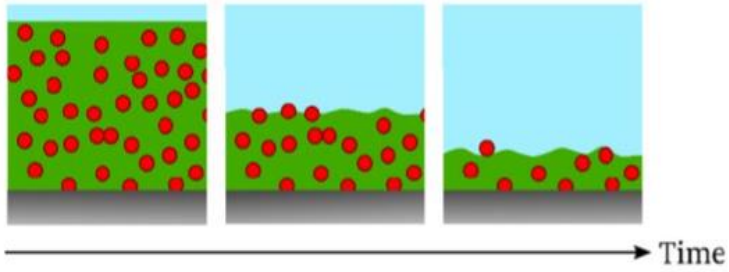
Antifouling systems - Biocidal Antifouling paints
Product types

biocide

resin



Conventional insoluble matrix



Self-polishing co-polymer (hydrolyzing paint matrix)

Modified from Lagerström et al 2021

HEMPEL

Biocidal antifouling paints are closely regulated

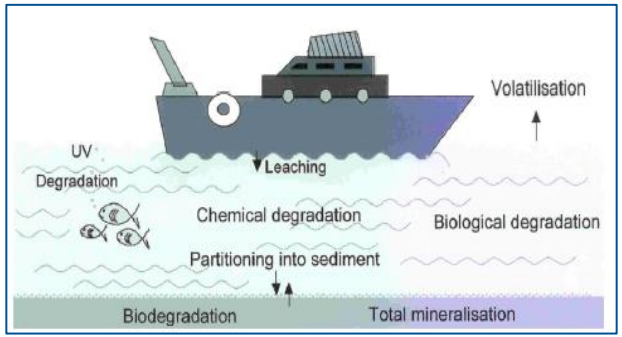
EU policy is to drive for a toxic free environment

In EU countries biocidal antifouling paints must be registered prior to sale and use by law

Similar registration schemes for biocidal antifouling paints exist in USA, Australia, NZ, Turkey, Hong Kong China

In order to be registered a product must not have a negative impact on human health or the environment where it is used

All biocidal antifouling products on the market in the EU are currently under review.



HEMPEL

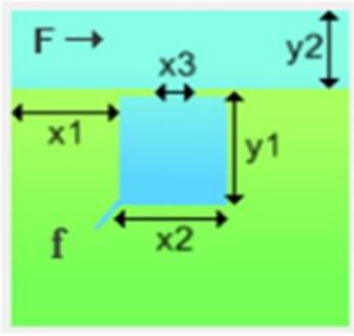
Concern over use of biocidal antifouling paints

To get approval products must be proven safe by environmental risk assessment.

Environmental exposure to biocide released from products in scenarios such as marinas is derived using modelling - MAM-PEC

Concern is that biocidal antifouling products may not be proven as safe in some marinas when they are used on small boats (<25 M LOA), in Particularly Marine Protected Areas such as the Baltic Sea

Future for biocidal antifouling products used on vessels <25 LOA is uncertain



Scenario	Length (m)	Width (m)	Depth (m)	Volume (m^3)	No. of boats[a]
OECD Marina	141.5	141.5	4.0	80089	276
Regional Atlantic Marina	436.0	215.0	5.0	468700	403
Atlantic Marina 1(ES1)	645.0	300.0	8.0	1548000	1000
Atlantic Marina 2(ES2)	525.0	327.0	7.0	1201725	500
Atlantic Marina 3(ES3)	288.0	215.0	15.0	928800	180
Atlantic Marina 4(PT1)	449.0	251.3	7.0	789644	650
Atlantic Marina 5(PT10)	1036.1	809.3	3.5	2934640	240
Atlantic Marina 6(PT3)	663.6	236.0	4.0	626484	620
Atlantic Marina 7(PT4)	520.0	480.0	4.0	998400	1000
Atlantic Marina 8(PT5)	977.2	185.9	3.0	544908	462
Atlantic Marina 9(PT7)	366.3	181.3	6.9	458168	250
Atlantic Marina 10(PT8)	365.0	111.5	15.0	610648	150

HEMPEL

Concern over use of biocidal antifouling paints

Industry has responded by developing and introducing non-stick Fouling Release Coatings that are biocide-free

Several products are now available which have a significant track record of performance on boats (<25 M LOA)

Performance is equivalent to biocidal antifouling paints

Biocide-free = lowest possible environmental impact in MPAs

HEMPEL

HEMPEL
Trust is earned

Biocidal antifouling paints vs. Fouling Release Coatings

How it works?

Biocidal Antifouling

- ✓works by releasing biocides.
- ✓prevents fouling from attaching to the boat with controlled biocide release
- ✓Concerns over environmental impact

Fouling Release System

- ✓biocide free
- ✓Prevents fouling organisms from attaching firmly to the hull
- ✓easy removal of any fouling when the boat is in motion or with soft sponge
- ✓Safer for the environment

How it works?

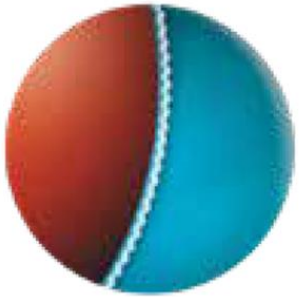
What is the technology behind Fouling Release System?

- It is a biocide-free solution to prevent fouling
- It is a “non-stick paint”
- Biocide-free

What is hydrogel?

Hydrogel is based on unique, non-reactive polymers that are added to the paint, creating an invisible barrier between the hull surface and the water

Fouling organisms perceive the hull as a liquid and are consequently attaching to a much lower extent



Unique, non-reactive polymers form a hydrogel layer between the substrate and water

Fouling organisms perceive the hull as a liquid and consequently have difficulty in attaching

HEMPEL

Cost difference:

Biocidal Antifouling

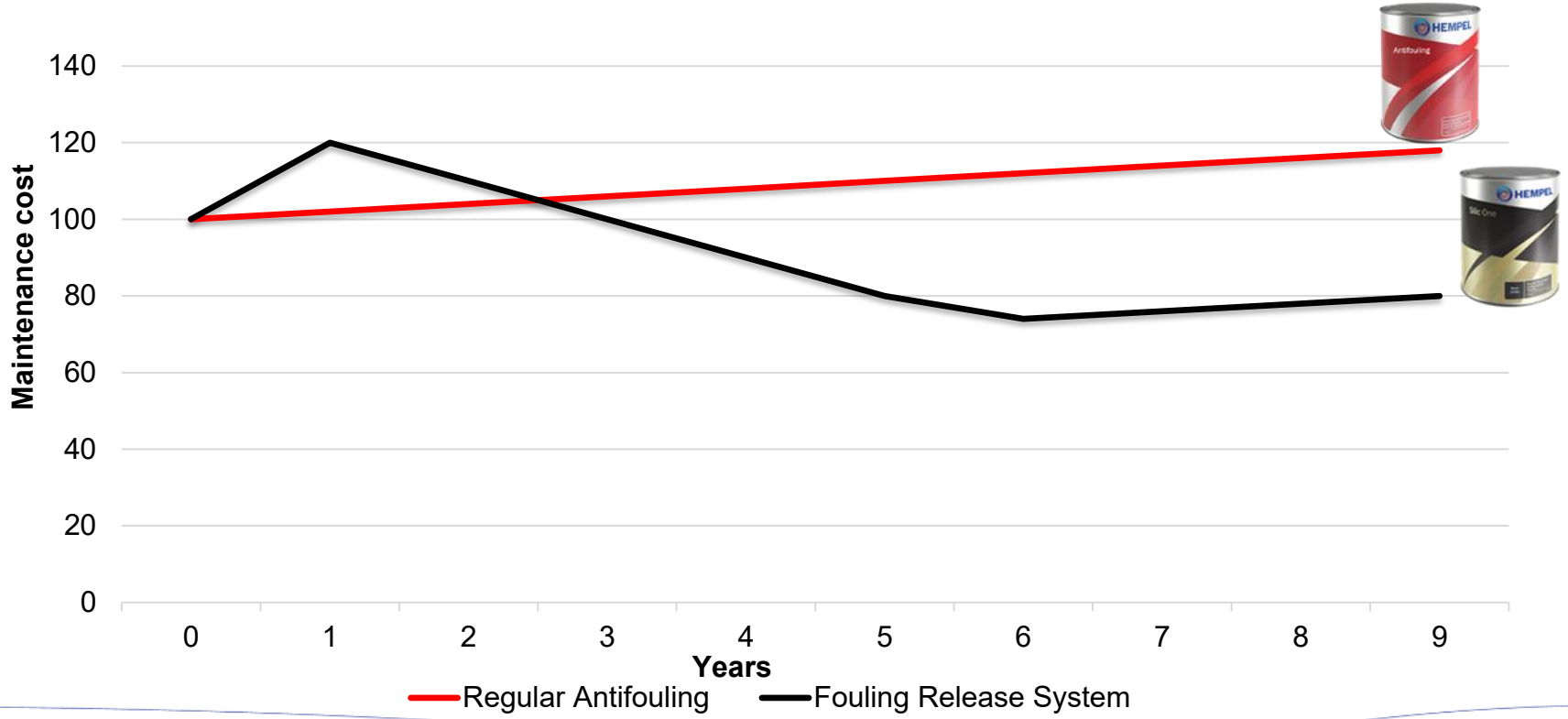
Year 1
lower application cost
Year 2
higher maintenance cost

Fouling Release System

Year 1
higher application costs
Year 2 & 3
lower maintenance time and cost

✓ reduces the friction
✓ increases speed
✓ saves fuel.

Cost difference scheme:



Types of boat:

Biocidal Antifouling

Before choosing the right product consider:

- boat type
- boat substrate
- sailing pattern & speed
- geographic location
- characteristics of the mooring
- existing coating
- environmental and legislative rules in the area where the product is applied and used
- type of water and sensitivity of the environment

Fouling Release System

- ✓Ideal for use in sensitive environments such as PSSAs
- ✓for all types of boats
- ✓ for all types of substrates, except wood
- ✓ for all types of water
- ✓ the best performance proven on motorboats*
- ✓on slow sailing boats* a small amount of fouling may occur – but easy to clean

**the frequency of usage and speed can influence amount of fouling*

Fouling Release System – example : Silic One

Hempel's Silic One → Our most efficient antifouling solution

Available in shades:

- Red
- Black
- Blue

- 2 year — Fouling protection
- Biocide and copper free
- Easy to apply & maintain
- Works on propellers
- Fuel saving

HEMPEL
Trust is earned

Systems & application

Systems and application

Primers

or

Tiecoat

Final coat

Hempel's Light Primer

High build epoxy primer and undercoat. For use above and below the waterline.

Hempel's Silic Seal

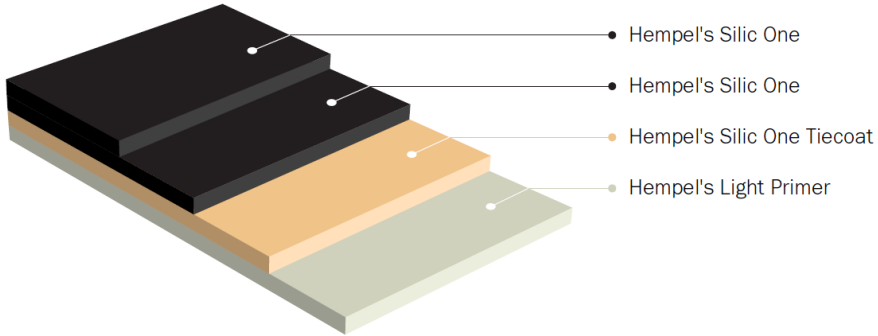
For easy conversion from Antifouling to Silic One on previously painted antifouling in good condition.

Hempel's Silic One Tiecoat

Silicone-based curing tiecoat, secures adhesion between primers and Hempel's Silic One.

Application - Previously coated boats

CASE 1 – Removal of old antifouling and application of full system



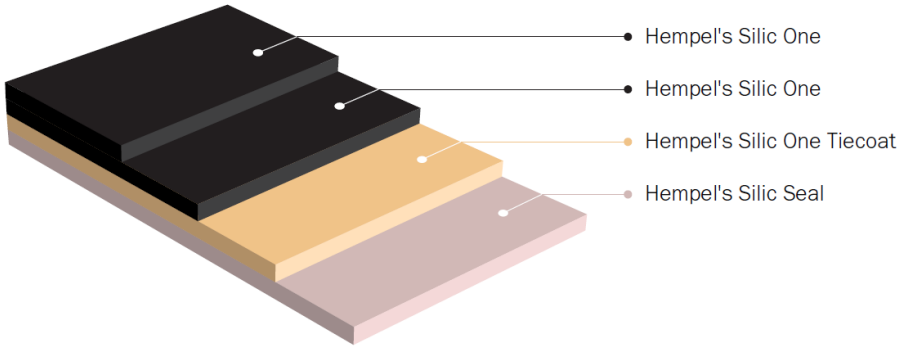
Overcoating intervals:

Layers	Hempel's	20°C		10°C	
		Min	Max	Min	Max
1st	Light Primer	1,5h	4h	3h	8h
2nd	Silic One Tiecoat*	8h	48h	16h	48h
3rd	Silic One	8h	indefinite	16h	indefinite
4th	Silic One	-			
To be immersed after final coat		24h	4 weeks	36h	4 weeks

* The Silic One Tiecoat must be applied to full coverage to ensure adhesion.

Application- Previously coated boats

CASE 2 – Application on top of old antifouling in good condition, easy switch to Silic One System

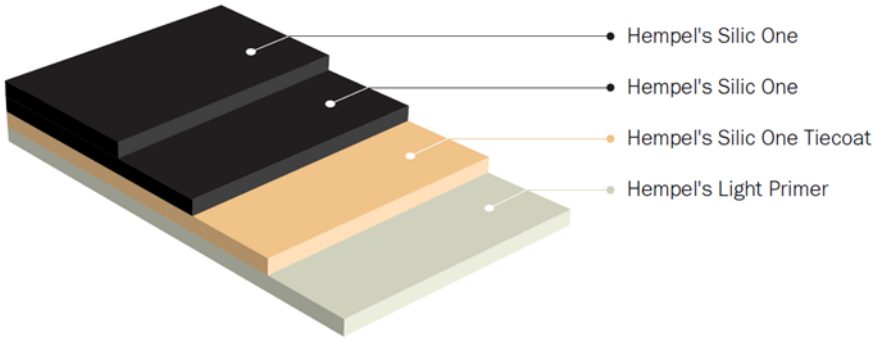


Overcoating intervals:

Layers	Hempel's	20°C		10°C	
		Min	Max	Min	Max
1st	Silic Seal	1,5h	4h	3h	8h
2nd	Silic One Tiecoat*	8h	48h	16h	48h
3rd	Silic One	8h	indefinite	16h	indefinite
4th	Silic One				
To be immersed after final coat		24h	4 weeks	36h	4 weeks

* The Silic One Tiecoat must be applied to full coverage to ensure adhesion.

Application – New boats
CASE 3- New boat with epoxy

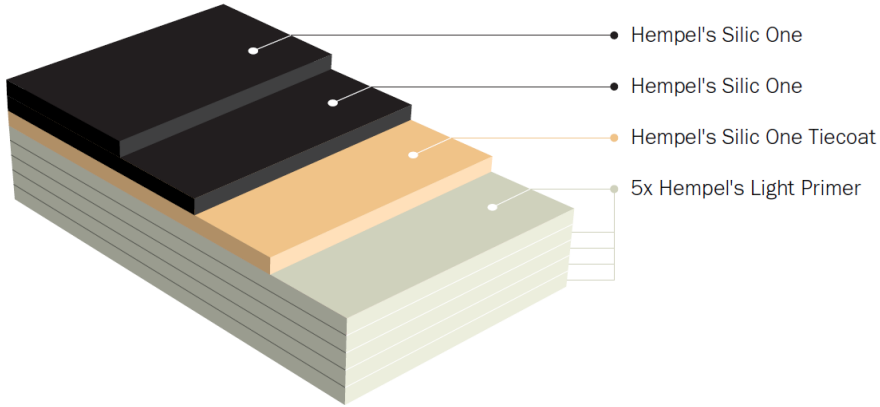


Overcoating intervals:

Layers	Hempel's	20°C		10°C	
		Min	Max	Min	Max
1st	Light Primer	1,5h	4h	3h	8h
2nd	Silic One Tiecoat*	8h	48h	16h	48h
3rd	Silic One	8h	indefinite	16h	indefinite
4th	Silic One	-			
To be immersed after final coat		24h	4 weeks	36h	4 weeks

* The Silic One Tiecoat must be applied to full coverage to ensure adhesion.

Application – New boats
CASE 4 - New boat without epoxy



Overcoating intervals:

Layers	Hempel's	20°C		10°C	
		Min	Max	Min	Max
1st	Light Primer (thinned 20%)	4h	30d	8h	60d
2nd	Light Primer	4h	30d	8h	60d
3rd	Light Primer	4h	30d	8h	60d
4th	Light Primer	4h	30d	8h	60d
5th	Light Primer	1,5h	4h	3h	8h
6th	Silic One Tiecoat*	8h	48h	16h	48h
7th	Silic One	8h	indefinite	16h	indefinite
8th	Silic One	-			
To be immersed after final coat		24h	4 weeks	36h	4 weeks

* The Silic One Tiecoat must be applied to full coverage to ensure adhesion.

Application process example:

1.

Hempel's Silic Seal

2.

Hempel's Silic One Tiecoat

3.

Hempel's Silic One

4.

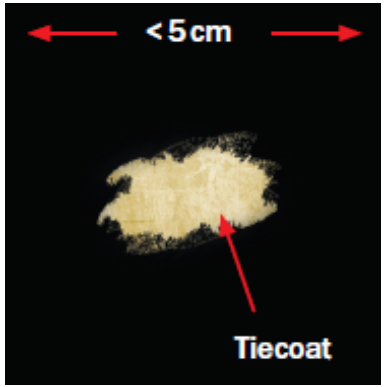
Repair of damages

Repair of damages

The most important is to distinguish:

HEMPEL

Light damage below 5x5 cm

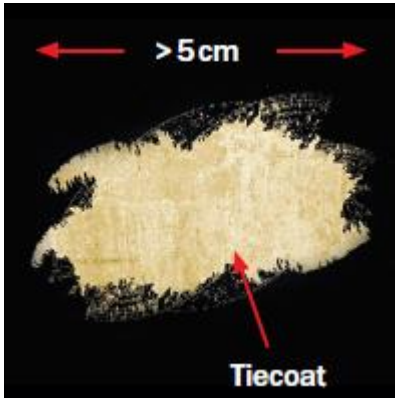


Silic One (topcoat) is damaged and Silic One Tiecoat (yellow coat) is visible. The tiecoat may also be slightly damaged, but you cannot see through it.

Solution:
Put 1 layer of
Silic One (topcoat) on the damage (and complete underwater boat surface when re-painting).

HEMPEL

Light damage above 5x5 cm



Silic One (topcoat) is damaged on a larger area than 5 cm and Silic One Tiecoat (yellow coat) is visible. The tiecoat may also be slightly damaged, but you cannot see through it.

Solution:

1. Carefully remove all loose coating.

2. Clean the damaged area with boat shampoo.

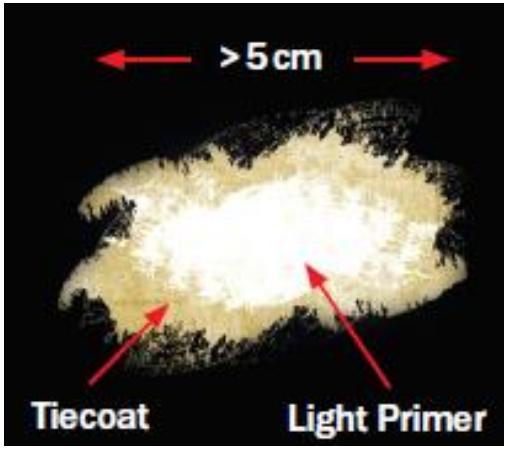
3. Rinse with clean water and let dry.

4. Put on the clean and dry damaged area 1 layer of yellow Hempel's Silic One Tiecoat on a slightly larger area than the damaged area.

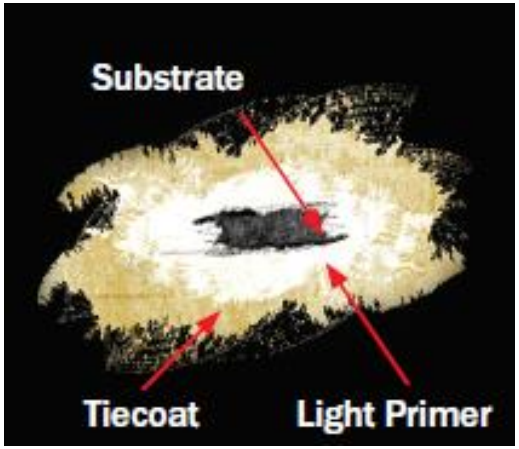
5. Put 1 layer of Hempel's Silic One (topcoat) on the damaged area slightly larger than the area with Hempel's Silic One Tiecoat (Apply one coat of Silic One to entire underwater surface.)

HEMPEL

Medium & heavy damage above 5x5cm



Medium damage
Silic One (topcoat) is completely gone, the Silic One Tiecoat (yellow coat) is damaged, and the white epoxy primer is visible. The epoxy primer might also be slightly damaged, but you cannot see through it.

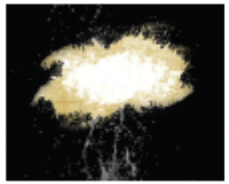


Heavy damage
You can see all the way through the coating system to the substrate underneath.

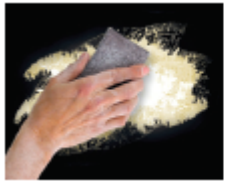
Medium & heavy damage above 5x5cm

1. Carefully remove all loose coating.

2. Clean the damaged area with boat shampoo.

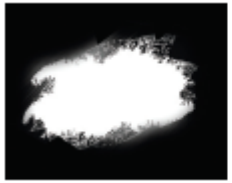


3. Rinse with clean water and let it dry.



4. Sand the damaged area with the sand paper and remove any remaining dust with a cloth.

5. Apply 1 layer of Hempel's Light Primer* on the damaged area on a slightly larger surface than the damaged area.



6. After drying, the paint that has been applied next to the repair area and upon needs to be loosened and cut off.

7. When the surface is dry, apply 1 layer of Hempel's Silic One Tiecoat (yellow coat) on a slightly larger area than the applied primer area.

8. Apply 1 layer of Hempel's Silic One (topcoat) on the damaged area slightly larger than the area with Hempel's Silic One Tiecoat (Apply one coat of Silic One to entire underwater surface.)

***heavy damage above 5×5 cm** apply 5 layers of Hempel's Light Primer.

HEMPEL

HEMPEL
Trust is earned

Cleaning and Maintenance

Cleaning of fouling

- **Fast motorboats**
  - ➢ self-cleaning on fast motorboats

- **Slow speed boats – sailboats**
  - ➢ can be cleaned as frequently as required to maintain a perfectly clean surface even with low friction

✓ Easy to clean:

Option 1
Use a high pressure, fresh water wash to clean the surface.
Option 2
Use a dense sponge or a cloth and then rinse with a hose. Be careful not to scratch the surface while cleaning.

Do not use hard brush, bristles or similar.

Cleaning

Watch the video

Antifouling systems – non-biocidal (I)

not regulated under Biocidal product rules

Technology	Pros	Cons
Ultrasound Ultrasonic transducers emit multiple bursts of ultrasonic sound waves alternating positive and negative pressure	Can be used with other antifouling systems Effective in niche areas.	Initial outlay for installation. Longer vessels require more transducers. Requires reliable power source. May require occasional lift outs and cleaning.

HEMPEL

Antifouling systems – non-biocidal (2)

not regulated under Biocidal product rules

Technology	Pros	Cons
Boat wrap. Biomimetic surface - simulates sea urchin surface	Can be cleaned with pressure washer or mechanical in-water systems.	Needs to be professionally applied. Needs occasional cleaning.
In-water dock / slip liner External liner covers the hull at birth. Organisms enclosed in the wrap are non-viable	Available for power boats and yachts with keels.	Only available at 'home' berth. Liner requires regular cleaning.
Floating docks Modular dock lifts hull clear of the water.	Periods with hull completely out of water avoids biofouling.	Requires fixed berth for attachment. Only available for use at home berth. High initial cost. Not suitable for keeled vessels
Dry-stacking Boat stacked in secure area	Avoids biofouling	Cost / logistics

Hull Cleaning – key part of biofouling management

Technology	Pros	Cons
Reactive in-water hull cleaning Mechanical cleaning of hull when boat is at anchor or at mooring by diver or autonomous robot *or* Drive-in boat washing station removes fouling by brushing , jetting or robotic cleaning system.	Can be completed mid-season or before setting sail to increase hull efficiency.	Coatings must be hard enough to withstand physical cleaning (brushes, jetting etc). Generates biological waste that must be collected/managed to prevent release of potentially invasive species. If not captured paint particles (microplastics) may be released into surrounding water during hull cleaning.

HEMPEL

Hull grooming – proactive in-water cleaning

Technology	Pros	Cons
Hull grooming Gentle brushing of hull when boat is at anchor or at mooring by diver or autonomous robot.	Hull grooming removes surface biofilms as a proactive measure to prevent further fouling.	Works on soft fouling only so must be carried out regularly in order to remove biofilms before hard fouling settles. Commercial systems available for larger vessels. Less for smaller boats /craft. Non capture cleaning systems release biofilm material into water.

HEMPEL

Conclusions /take home

Effective antifouling systems are essential for biofouling management of vessels

At present Biocidal antifouling paints are the ‘go to antifouling system solution’ for the majority of vessels and are highly regulated

Biocide-free systems are available but currently not suitable for all vessels in all environments

The safety and environmental impact of all Antifouling systems should be assessed fairly and in the same way to avoid ‘regrettable substitution’

Hull cleaning (reactive and proactive) is a key part of effective biofouling management

Currently there is no one size fits all solution for all vessels

HEMPEL

Conclusions / take home

Effective antifouling systems are essential for biofouling management of all vessels, including small boats (< 25 M LOA) as they can translocate and spread invasive species in Marine Protected Areas and disrupt diversity

Proven and effective biocide-free fouling control coatings which have a low environmental impact are suitable and available for use.

HEMPEL

Reference

Lagerström et al (2022) : Are silicone foul-release coatings a viable and environmentally sustainable alternative to biocidal antifouling coatings in the Baltic Sea region?

https://www.sciencedirect.com/sciehnce/article/pii/S0025326X22007846

GloFouling PARTNERSHIPS

ICOMIA International Council of Marine Industry Associations

IUCN

World Sailing

BIOFOULING MANAGEMENT FOR RECREATIONAL BOATING

Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species

gef

UNDP

Empowered lives.
Resilient nations.

IMO INTERNATIONAL MARITIME ORGANIZATION

BIOFOULING MANAGEMENT FOR RECREATIONAL BOATING

Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species

Published* in 2022 by the
GloFouling Partnerships Project Coordination Unit
International Maritime Organization
4 Albert Embankment
London SE1 7SR
United Kingdom

Design by Missing Element

Photo and infographic credits: © Adobe stock (cover); © Adobe stock (pages 6, 9 and 10); © Biofouling Solutions PTY Ltd (page 11); © LimnoMar (Wiki Commons) (page 11); © GEF-UNDP- IMO GloFouling Partnerships (Adapted from Nurioglu et al, 2015), PLOS, CSIRO, creative commons, Biofouling Solutions PTY Ltd, CZM at Rowes Wharf (Figure 1); GEF-UNDP- IMO GloFouling Partnerships (adapted from K.B. Schimanski et al., 2015) (Figure 3); © Jasmine Ferrario (page 14); © Aylin Ulman (page 15); © Emilio Macuso, Townepost Network (Flickr) and Aylin Ulman (Figure 4); © Wikimedia Commons (page 18); © D.Minchin and CZM at Rowes Wharf (page 19); ©NOAA Great Lakes Environmental Research Laboratory (Wikimedia Commons) and Fisheries and Oceans Canada (page 20); © Hans Hillewaert, Duane Cox, Museum Victoria (Wikimedia Commons) and NMNH Smithsonian (page 21); © Hans Hillewaert and NOAA Great Lakes Environmental Research Laboratory (page 22); © Nick Hobgood (page 23); © Dr David Aldridge (page 24); © Mark S. Hoddle, University of California - Riverside, Bugwood.org (page 25); © Adobe stock (pages 26 and 30); © Aylin Ulman, Peter Griffin and a_rockaphotography (page 32); © Adobe stock (page 34); © driveinboatwash.com page (41); Adobe stock (pages 42, 44, 49, 55 and 69);

Please cite this document as: GEF-UNDP-IMO GloFouling Partnerships Project, 2022. Biofouling Management for Recreational Boating: Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species.

---

* Electronic version available for download at https://www.glofouling.imo.org/publications-menu

GloFouling Partnerships

Building Partnerships to Assist Developing Countries to Minimize the Impacts from Aquatic Biofouling (GloFouling Partnerships) is a collaboration between the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the International Maritime Organization (IMO). The project aims to develop tools and solutions to help developing countries to reduce the transfer of aquatic invasive species through the implementation of the IMO Guidelines for the control and management of ships' biofouling.

www.glofouling.imo.org

Funding Agency:

GEF - the Global Environment Facility - was established on the eve of the 1992 Rio Earth Summit to help tackle our planet's most pressing environmental problems. Since then, the GEF has provided over USD 21.1 billion in grants and mobilized an additional USD 114 billion in co-financing for more than 5000 projects in 170 countries. Today, the GEF is an international partnership of 184 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues.

www.thegef.org

Implementing Agency:

UNDP – the United Nations Development Programme – partners with people at all levels of society to help build nations that can withstand crisis, drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in nearly 170 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations.

www.undp.org

Executing Agency:

IMO - the International Maritime Organization – is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships.

www.imo.org

ICOMIA

The International Council of Marine Industry Associations – ICOMIA, is the international trade association representing the global marine industry since 1966. ICOMIA brings together national marine industry associations in one global organisation, presenting a strong and united voice when dealing with issues challenging the industry. Nearly 40 national associations across the world are full members covering most of the industrial world, from North America across to Japan and from Finland to New Zealand.

ICOMIA collaborates internationally with authorities and major organizations, publishes documents and guidelines while also producing tools to facilitate the growth of the industry.

www.icomia.org

IUCN

International Union for Conservation of Nature – IUCN, is a membership Union composed of both government and civil society organisations. It harnesses the experience, resources and reach of its more than 1,400 Member organisations and the input of more than 18,000 experts. IUCN is the global authority on the status of the natural world and the measures needed to safeguard it.

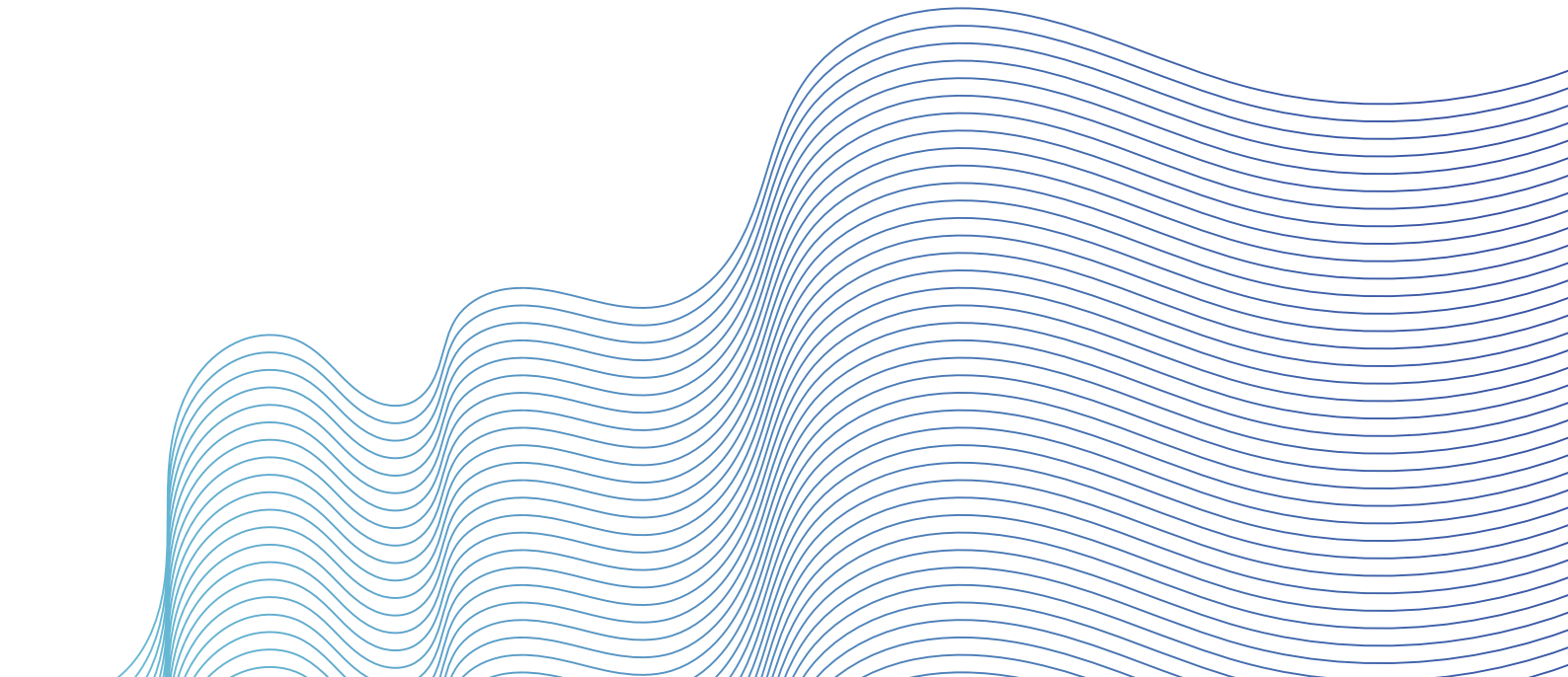
www.iucn.org

World Sailing

World Sailing is the world governing body for the sport of sailing, officially recognised by the International Olympic Committee (IOC) and the International Paralympic Committee (IPC). Founded in 1907, World Sailing's vision is for a world in which millions more people fall in love with sailing. Inspired by the unique relationship between sport, technology and the forces of nature we all work to protect the waters of the world. World Sailing is made up of 146 Member National Authorities, the national governing bodies for sailing around the world and 119 World Sailing Class Associations.

www.sailing.org

TABLE OF CONTENTS




1809
1809
SA

ACKNOWLEDGMENTS

This Guide is the product of the GEF-UNDP-IMO GloFouling Partnerships Project.

Empowered lives.
Resilient nations.

The report Biofouling Management for Recreational Boating: Recommendations for improved biosecurity to prevent the introduction and spread of Invasive Aquatic Species was written by William Jonathan Michael Yonge, Senior Consultant, Earth to Ocean, with contributions, editorial review, comments and inputs from Udo Kleinitz, Secretary General and Julian Hunter, Head of Sustainability, ICOMIA; Kevin Smith, Senior Programme Officer Biodiversity Data Impact and Influence, IUCN; Dan Reading, former Head of Sustainability and Alexandra Rickham, Head of Sustainability, World Sailing; Lilia Khodjet El Khil, Project Technical Manager; John Alonso, Project Technical Analyst, GloFouling Partnerships Project, the Department of Partnerships and Projects, IMO; and Teo Karayannis, Head of Marine Biosafety, Marine Environment Division, IMO.

Great thanks are also due to Violeta Luque, Senior Project Assistant; and Jurga Shaule, Project Assistant, GloFouling Partnerships project, the Department of Partnerships and Projects, IMO, who provided coordination and editing support to produce this report.

For further information please contact:

GloFouling Partnerships Project Coordination Unit
Department of Partnerships and Projects
International Maritime Organization
4 Albert Embankment
London SE1 7SR
United Kingdom

www.glofouling.imo.org

EXECUTIVE SUMMARY

Oceans are home to a large variety of species such as plants, algae, fish and microorganisms, that have evolved in their habitats, separated by natural barriers. Some species have always moved about the planet through the oceans. Whether by swimming or hitching a ride on a log, leaf, or other debris, organisms have found new worlds in which to thrive. Until recently, this process has been moderate, limited by differences in water temperature and salinity, sea currents and other natural barriers. But an increasing number of species have been moved, intentionally or not, as a result of increased human activity since the mid-20th century.

There is clear scientific evidence that biofouling on immersed areas of recreational vessels can and does enable the translocation of non-native species between bodies of water and along coastlines, and that they can become invasive. In some countries, notably New Zealand and Australia, biosecurity risks from Invasive Aquaic Species (IAS) to biodiversity and the local economy and culture are understood and actively managed by regulatory authorities. However, in other parts of the world there is less awareness and proactive management of these risks.

Anti-fouling coatings are the main tool to prevent biofouling of immersed areas of recreational vessels. At present, anti-fouling coatings that contain a toxin or biocide are the dominant system used. However, ongoing concerns over their environmental impact of some biocides means that they are closely regulated, often presenting a dilemma of balancing the risks from IAS against the risks from control measures for anti-fouling coatings which reduce their efficacy. Another aspect is the irregular performance of anti-fouling coatings over time, on many occasions impaired by poor selection of the coating or deficient application on the surface that needs to be protected.

Other options are available to the wider public, and these include non-biocidal surface effect (non-stick) coatings, devices such as ultrasound systems, mechanical cleaning and several other technologies that are under development, although for some of the latter further research is required to assess their efficacy and impact on the environment.

But in general, anti-fouling systems operate in difficult and ever-changing habitat conditions and their performance is further impaired by the wide range of characteristics and adaptability presented by some biofouling species and the high variability of boat types, materials and usage. Therefore, when it comes to prevent biofouling growth, there is no “one size fits all” solution. Boat users need to apply a combination of anti-fouling systems, based on an analysis of the specific characteristics of the environment where they operate and the type of vessel they have. Through the reduction of biofouling, the boating community can:

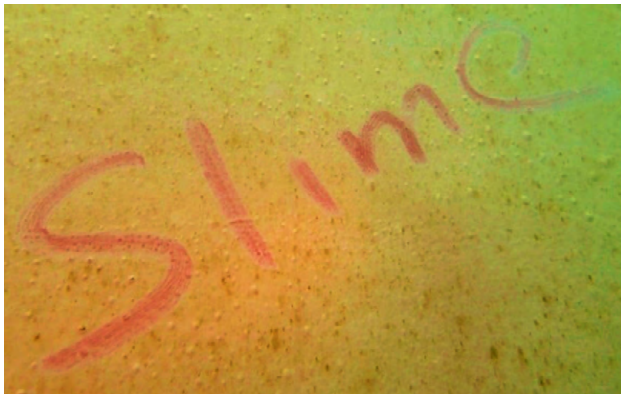
- Protect the biodiversity of the waterways and waterside environments that are visited by recreational vessels;
- Maintain performance when under sail;
- Optimise fuel consumption and reduce air pollution from motorised craft ;
- Avoid damage to hulls and equipment;
- Avoid damage to infrastructure including marina locks and pumping equipment;
- Avoid economic harm to local businesses, aquaculture, fishing and tourism.

This report makes specific recommendations for practical prevention and management of marine biofouling for all types of recreational craft, highlighting key areas and equipment that need to be considered. Guidance has been tailored to different types of vessels and uses, including trailered craft, local or estuary cruising vessels and long-distance cruising. In addition, there are recommendations for marinas and port-based management of biofouling.

To facilitate promotion of the information contained in this report, each chapter provides information that can be used for awareness-raising purposes to understand the issue. Chapter 1 explains what is biofouling, the environmental issues, notably the transfer of IAS, to which it is associated, and the role played by recreational boating in spreading or introducing IAS to new environments. Chapter 2 provides examples of IAS and their environmental, and socioeconomic impacts. Chapter 3 gives an overview of the regulations related to biofouling, with a more in-depth analysis available in Chapter 9. Chapter 4 highlights the key areas that need to be taken into account for managing biofouling. Chapter 5 gives an overview of current and upcoming anti-fouling and biofouling management solutions and technologies available to recreational boaters. Chapter 6 is focused on recommendations on how to manage biofouling, each section with a one-page infographic leaflet that can be used to raise awareness and communicate recommendations tailored to each type of recreational vessel or user profile. Chapter 7 includes links to further resources and information that are available worldwide. Finally, chapter 8 includes a brief analysis of the gaps and challenges detected in the development of this report and some recommendations on how to promote solutions and increase awareness of the issue.


1

BIOFOULING AND ITS ROLE AS A PATHWAY FOR INVASIVE AQUATIC SPECIES



Slime layer on the surface of a hull

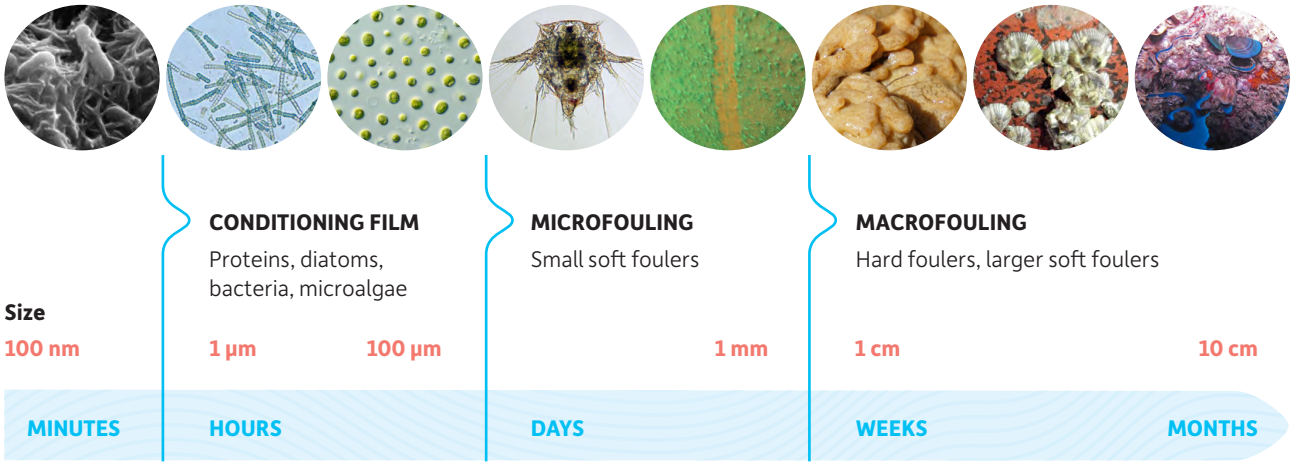
Macrofouling on a motor vessel

Biofouling starts as soon as a hull is placed in the water and its surface is rapidly colonised by a variety of marine species such as diatoms, bacteria and microalgae that create a biofilm commonly called a slime layer. This is followed by a gradual succession and growth of larger macro Fouling species, such as other algae, sessile animals (sponges, anemones), mobile benthic animals (worms, shrimps, crabs), and parasites. **Figure 1** gives an approximate idea of how the process evolves through time.

WHAT IS BIOFOULING?

The International Maritime Organization (IMO) defines biofouling, often referred to as a hull fouling, as the undesirable accumulation of aquatic organisms such as micro-organisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment. Biofouling can range from a thin slime layer to more noticeable growth that may include hard encrusting animals, algae tufts or mobile shrimp-like amphipods and, in cases of extensive biofouling, mussels, seaweed, sponges and crabs.

Figure 1: How fast biofouling organisms can grow on a surface



Most boat users know that a fouled hull affects performance, increasing fuel consumption and air pollution from motorboats and slower passage time for yachts when under sail. What is less well known, is the risk of spreading Invasive Aquatic Species (IAS) via biofouling attached to the hulls or to immersed equipment of recreational craft. This is now recognised as one of the key pathways for local spread of IAS.[1]

WHAT ARE INVASIVE AQUATIC SPECIES?

The oceans are home to a large variety of species (plants, algae, fish, microorganisms, etc.) that have evolved in their habitats, separated by large distances and natural barriers. But some species have been moved, intentionally or not, as a result of human activity. When the adopting habitat has similar characteristics, the introduced non-native species have a good opportunity to adapt and thrive. Due to some competitive advantage such as the absence of natural predators, some non-native species have become dominant and disrupted the biodiversity of their newly adopted habitat. It is these species that are generally referred to as Invasive Aquatic Species (IAS). IAS range from fish, crabs and mussels, seaweeds and plants, to microscopic pathogens. This vast diversity can make it difficult to identify invasive species.

The accidental introduction of IAS can cause havoc to the environment, coastal industries and local livelihoods. As this all takes place underwater, the effects are not seen until the invasive species have become established and caused a disturbance.

Eradication of IAS has proven difficult in most cases and any chance of success normally goes hand in hand with early detection - further arguing for the need of a preventive approach. There are very few confirmed cases of successful eradication. On most occasions, discovery happens too late to act, or eradication attempts fail. Due to the wide range of vectors and pathways that can result in the introduction and establishment of IAS, containment options are difficult to implement successfully.

1.1 Recreational vessels and local spread of IAS

The islands, waterways and coastal areas that recreational boat users visit are of great ecological, social and economic importance. The rich biodiversity of marine life is one of the many reasons we enjoy and value travelling and spending time in these spaces. As recreational boats move between areas, a variety of marine life can hitch a ride as biofouling on a hull, in the niche areas of water intakes, on anchors and chains, in bilge water or on equipment[1], and even clothing.

Whilst the translocation of many IAS across oceans is probably caused by large commercial ships either as biofouling or in their ballast water, it is biofouling on the smaller, recreational boats that risks spreading IAS from ports to smaller harbours, anchorages, islands, and inland between lakes, catchments and reservoirs.

In some areas, marinas have proven to host a larger variety of Invasive Aquatic Species than commercial harbours[1]. This can be explained by the longer length of idle time a recreational boat stays in a marina or harbour compared with a commercial ship. For sailing vessels and slower motorboats the slower speed of travel through the water, is another factor that creates more opportunities for IAS to remain attached to the hull and successfully hitch a ride to colonise new areas with similar climatic conditions. As scientific studies work on improving knowledge of IAS distribution and their impacts, recreational boat users can help prevent the spread of IAS and prevent further ecological damage of freshwater and marine environments.

Figure 2

RECREATIONAL VESSELS ACTING AS 'HUB & SPOKE' VECTOR

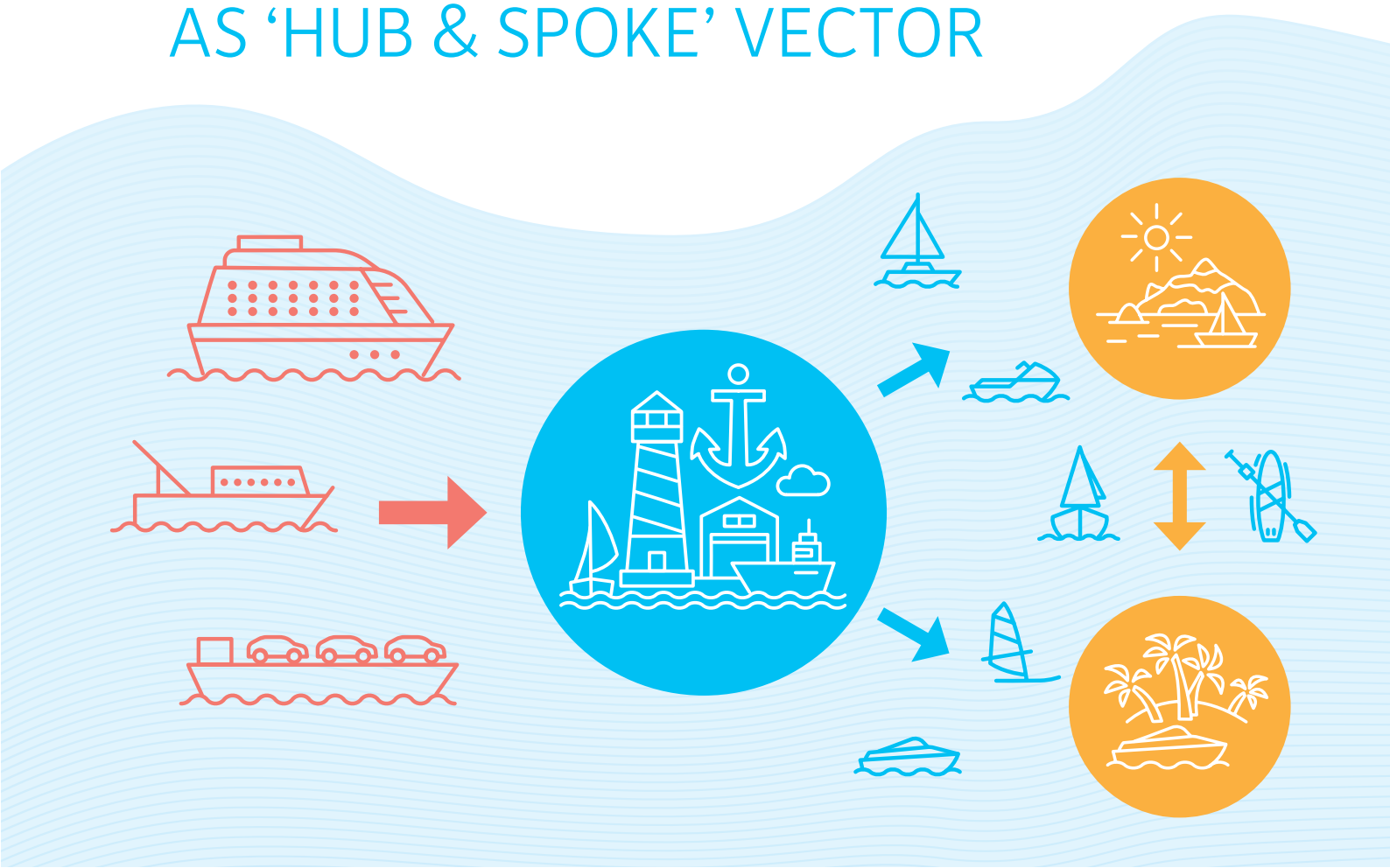
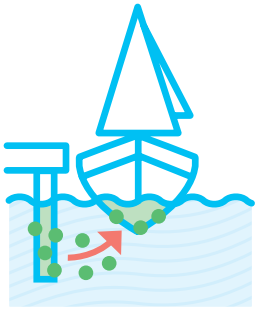


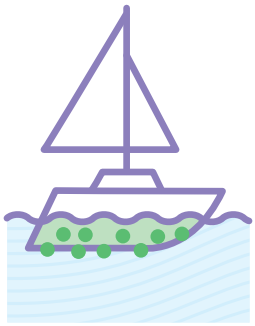
Figure 3: Typical stages in the transfer and establishment of Invasive Aquatic Species through hull biofouling

PORTS AND MARINAS "HOT SPOTS" FOR INVASIVE SPECIES

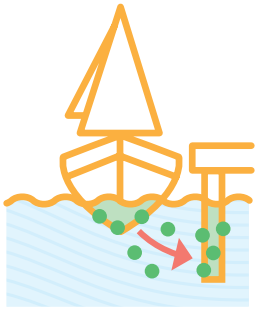
STAGE 1:
Recruitment to boat hull



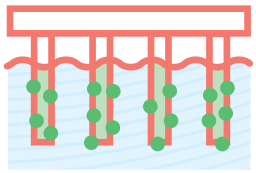
STAGE 2:
Translocation as biofouling on hull



STAGE 3:
Transfer from hull and colonization



STAGE 4:
Establishment and spread



Key factors that determine potential success during each stage

Donor port
- Residency period
- Type of antifouling coating
- Condition of antifouling coating
- Propagule supply

Voyage
- Voyage speed duration and route
- Location of biofouling on the hull
- Type of antifouling coating

Recipient port
- Environmental conditions
- Residency period
- Space availability
- Biotic resistance

Recipient location
- Environmental conditions
- Space availability
- Biotic resistance
- Additional introductions

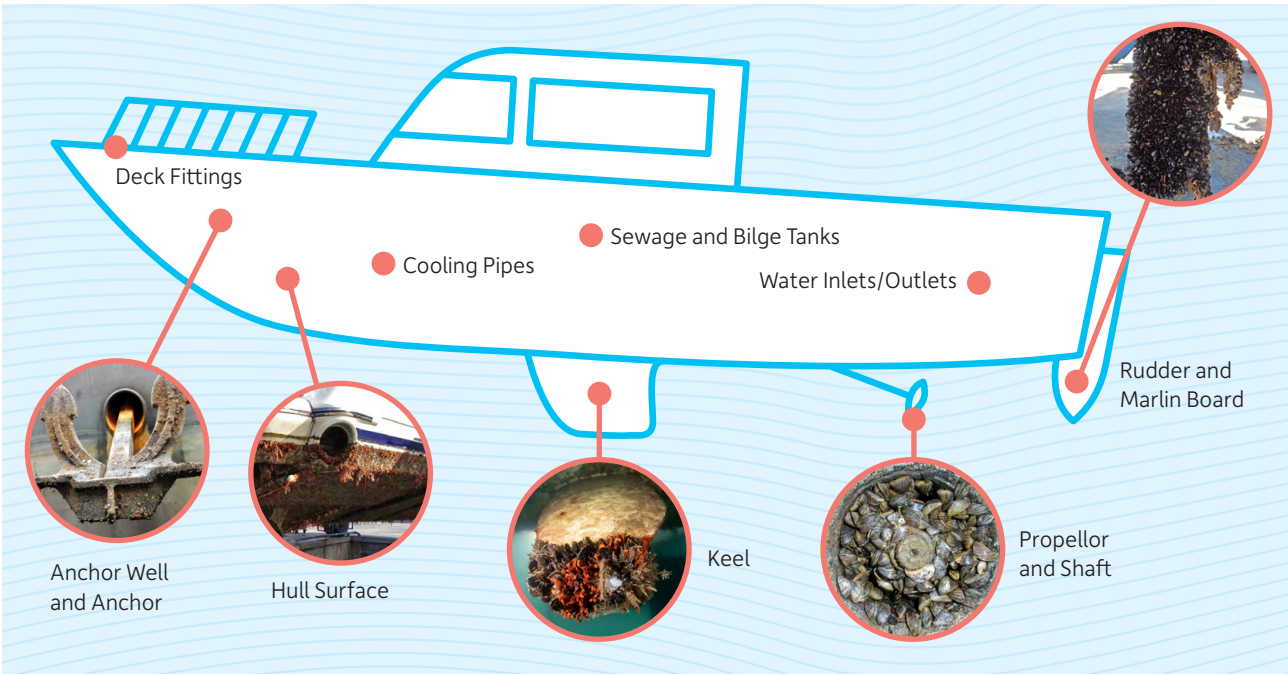
The vast diversity of IAS can make them difficult to identify, especially for non-experts. However, recreational boat users can, and should, play an important role in preventing the spread and translocation of IAS through regular and proactive steps to prevent biofouling on and in their vessels and equipment.

1.2 Niche areas

Niche areas on a hull pose an additional challenge in relation to biofouling. As defined by the International Maritime Organization (IMO), niche areas are *'Parts of a craft that are particularly susceptible to biofouling growth due to different water flow conditions, the exposure of the anti-fouling coating system to wear or damage, or areas that may be inadequately coated'*.[2] Niche areas include propellers, thrusters, rudder stocks and hinges, anodes, outlets, inlets, anchors, chain and anchor wells. These areas are less accessible, usually made of a different material, or in the shadow of water flow when underway. Although they comprise a small percentage of the total hull area, these niche areas are hotspots for biofouling accumulation, and therefore an opportunity for transport of non-native species which may be introduced, establish, and become invasive.

Fouling on propeller

Figure 4: Typical niche areas prone to additional biofouling



1.3 Hull and propeller performance

The immediate impact of biofouling on recreational vessels is well known to all boat owners: it slows the boat, increasing fuel costs for powerboats, and increasing passage time for sailing boats, who may revert to using the engine sooner, leading to increased air pollution.

A recent study focused on commercial ships showed that a thin layer of slime covering up to 50% of a hull surface can trigger an increase of fuel consumption and greenhouse gas emissions in the range of 20 to 25%. For more severe biofouling conditions (for example, barnacles, tubeworms or algae) the increase could be as high as 55%.[3]

Mussels and barnacles can grow on static propellers, at best reducing performance at worst preventing the use of the boat, with immediate costs involved to clean the

propellers. Less well-known, biofouling can also block water intakes, leading to damage to the engine from overheating if not noticed in time.

These effects are sufficient incentive in themselves for vessel owners to manage biofouling. However, there are further environmental, social and economic impacts from biofouling that are not so readily apparent to recreational boat users.

1.4 Marine environment and biodiversity

The marine environment is made of a delicate balance of interconnected relations between all the species and their habitats in an ecological community. Invasive Aquatic Species (IAS) are considered among the five greatest threats to the world's oceans and marine biodiversity (the other four being overexploitation of resources, pollution, habitat destruction and ocean acidification) (IPBES, 2019). The introduction of IAS can disrupt the balance of nature by affecting many different species in its interconnected web, both directly and indirectly. IAS can affect the local food web, lead to loss of indigenous species and affect the cleanliness of water. However, whereas the reduction in hull performance is immediately apparent to a boat user, the impact of IAS on the marine environment and its biodiversity can take several years to detect, by which time an IAS may already be establish

1.5 Social and economic impacts of invasive aquatic species

The natural environment provides many services that are often under-appreciated, particularly in financial terms. Examples of these include:

- provisioning services such as food and water,
- regulating and maintenance benefits such as shelter and wave attenuation from storms, and
- cultural enhancement such as recreational and spiritual benefits.

The economic impacts of IAS are a result of their interference with biological resources that support fishing and coastal aquaculture (e.g. collapse of fish stocks), interference with fisheries (e.g. fouling of gears), disruption to tourism, damage to infrastructure (e.g. through fouling) and costs of treatment, clean-up or control. All these types of impacts are interconnected, tending to influence and exacerbate one another. IAS damage their adopting habitat mainly by consuming native species, competing with them for food or space, or introducing disease.

If the role of recreational vessels in the transfer of IAS is not reduced, this could force some authorities to restrict access to high value marine areas. Thus, boaters would see a limit in their access to nature and all the cultural benefits, sport and well-being that this entails. For example, in the United Kingdom, a water company and reservoir owner had to impose strict Clean Check Dry conditions on boats arriving and leaving a reservoir to prevent the spread of the Killer Shrimp, after an initial ban.

IAS impacts aquaculture by competition for food, fouling of shells, or introduction of disease damaging shellfish. This affects the viability of local business, and prosperity of the local economy, which then may be less able to provide supporting services for visiting sailors, such as shops, marine services (fuel, repairs) and transport links.

Along shorelines, windrows of Zebra mussels can litter beaches and the decaying mussels produce an extremely foul smell[4]. The sharp shell of the *D. polymorpha* is razor-like and is a hazard to barefoot swimmers and beachcombers. This combination spoils the most pristine of locations affecting tourism, which impacts the local economy. One study[5] considered the US Great Lakes region and focused on commercial fish landings, sportfishing participation, wildlife viewing, and raw water usage for power stations and water treatment plants. This study determined that the impacts from IAS cost $138 million per year.

Darwin's barnacle, A. *modestus*, can negatively affect aquaculture and fisheries by competition for space with cultured bivalves (mussels and oysters) causing a reduction of production, additional costs for sorting and cleaning fouled shells, and leading to extra costs for maintenance of fishing gear or aquaculture equipment[6].

The Department of Agriculture in Australia looked at the costs of containing or eradicating the invasive black striped mussel in three Australian ports[7]. The report said that costs of successful ongoing containment include traffic inspection, vessel cleaning, ongoing infrastructure and facility maintenance, all undertaken at the port of infestation. Other costs include maintenance

and clearing mussel from slipways, hoists and lock gates. These costs are likely to be borne by industry, government and even individuals.

In another example, directly related to recreational boating, many marinas have lock gates and other equipment, and invasive species infestations can cause delays in operation; ultimately costs of maintenance will be passed on to recreational users of these facilities.

The next chapter gives some examples of Invasive Aquatic Species and their environmental and economic impacts.


2

EXAMPLES OF INVASIVE AQUATIC SPECIES

Carpet sea squirt *Didemnum vexillum*

Native to Japan but has been transported around the globe causing a range of issues in ports and marinas. It forms pale orange, cream or off-white colonies of extensive thin (2-5 mm) sheets and can form long pendulous outgrowths.

Impact: As the colony grows, the sea squirts smother local marine life and become a serious threat to biodiversity. On offshore banks in the USA, it has shown very extensive coverage of the seabed, potentially out competing species living in gravel and affecting shellfish aquaculture for species such as mussels and oysters. In the Netherlands, it seems to have caused decreases in the numbers of brittle stars and sea urchins. In the United Kingdom, the Carpet sea squirt has been included by the government's "alert" list of non-native (alien) species.

Spread: *D. vexillum* is likely to originate from Japan and is now found in the northeast Pacific (British Columbia to Southern California, northeast of the USA, New Zealand, the Netherlands, north-western France, Ireland, and the United Kingdom (England and North Wales). Hitchhiking on the biofouling of boats is the sea squirt's preferred mode of transportation.[8]

As is the case for many invasive species, eradication is extremely difficult. In the case of *D. vexillum*, some attempts ultimately failed. In New Zealand, the attempt to eradicate *D. vexillum* from a mussel farm in cost $650,000 but failed. In the United Kingdom, an attempt to eradicate *D. vexillum* at Holyhead Marina cost £400,000 but failed.

Spiny water flea
Bythotrephes longimanus

First detected in 1984 in North America and is thought to have arrived in ballast water from Eurasia. But the spiny water flea is now spreading via biofouling on trailered small craft and even fishing gear from the Great Lakes to other inland lakes.

Impact: The voraciousness of this species outcompetes native species for food, posing a threat to the biodiversity of native zooplankton communities. Additionally, its long tail means that small fish choke when trying to eat the spiny water flea, which further disrupts the food web and ecosystem. The spiny water flea forms large, jelly-like masses on commercial and recreational fishing equipment, affecting livelihoods.

Spread: reproduction is rapid with asexual females producing approximately 10 offspring every two weeks[9]. Transmission between waterbodies is on boats and fishing gear.

Leathery sea squirt
Styela clava

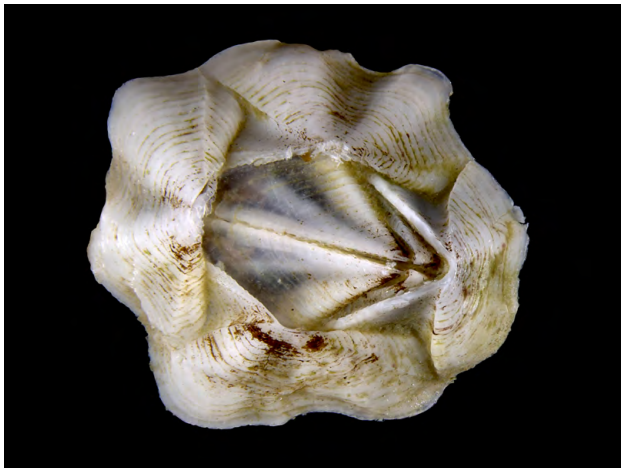
Native to the Pacific Coast of Asia but is now known to be in Australasia, Pacific, Europe and North America. As a fouling species, it is common on rocks and pylons and can reach densities of 500-1500 individuals per square metre. It can attach itself to concrete, wood, vessel hulls, pontoons and reefs.

Impact: it competes for space and food with local species and predates on the larvae of native species causing population decline. It creates dense fouling on aquaculture and fishing equipment, moorings, ropes and hulls. It affects human health through an asthmatic condition in oyster shuckers (Japan).

In Canada, the economic damage to shellfish aquaculture is estimated as high as CAD 88 million per year. In NZ this affects 22% of production areas, with a cost to green mussel producers estimated $23.9 million

But in South Korea, Styela clava is eaten as seafood.

Spread: *S.clava* has low natural dispersal ability, therefore its global spread is thought to be due to human-aided dispersal on vessels, and a high tolerance to changing environmental conditions.



Darwin's barnacle *Austrominius modestus*

Native to Australasia, has been in the UK since the 1940's, and has now spread to Europe, Ireland and the Mediterranean. This fast-growing species occurs in estuaries and harbours and attaches to and then dominates hard surfaces including rocks and hulls displacing native barnacle species and oyster spat.

Impact: This is a fast-growing species that is quick to reach maturity, which, combined with its high reproductive output in water temperatures above 6°C, gives it a competitive advantage over native species. This barnacle has largely displaced native barnacles in estuaries in southwest England. It has an economic impact on oyster industries through fouling (making oysters less valuable) and by competition for space and food.[10]

Spread: Its spread has been facilitated by its ability to attach to a range of substrates, including hulls and in ballast water, and its ability to tolerate a wider range of salinity and turbidity than native species.

Australian tubeworm *Ficopomatus enigmaticus*

It thrives in estuarine and coastal environments within sub-tropical and temperate areas throughout the world. This worm builds and inhabits white calcareous tubes. It grows very fast and abundantly on all surfaces. It forms dense reefs, scattered over hundreds of hectares, which has major impact on power station cooling systems, marinas and operation of channel locks. It increases ship drag through hull fouling.

Impact: The UK power industry spends more than USD 10 million annually to prevent clogging of cooling system water intakes. A marina in UK had to reduce berthing fees to prevent loss of clients.

Spread: The Australian tubeworm is spread on hull fouling and ballast water. It is the small recreational vessels that are important vectors on a regional scale. The worms can attach to the bottoms of vessels or ropes attached to small fishing boats or canoes, and can survive a long period of desiccation.

European green crab *Carcinus maenas*

It has spread far beyond its native Atlantic Europe. It is now found in waters off North and South America, Asia, South Africa and Australia. It is a voracious omnivore which can consume species from at least 104 families, 158 genera so food is not a limiting factor.

Impact: C. maenas causes an economic impact to crab and shellfish industries, with estimates of US$22.6 million of damage per year in predation on shellfish alone on the east coast on USA. It can degrade habitats, and it has been suggested it has decreased abundance of eelgrass in the Gulf of St Lawrence.[11]

Spread: Although primarily introduced through ballast water, it can be transported on hull fouling, within niche areas.

Killer Shrimp *Dikerogammarus villosus*

It originates in the Black Sea and Caspian Sea regions and were found in Grafham Water, UK, in 2010. As a result, sailing events were cancelled for a short time and then restricted, having a direct impact on the local sailing community. It is fast growing, reaching sexual maturity in 4 to 8 weeks. Up to 30mm in length, it is larger than the local UK shrimp and is an aggressive hunter, feeding on native freshwater shrimp, damselflies, water boatmen as well as small fish and eggs.

Impact: For a short time sailing events were cancelled and then restricted, as local guidelines / regulations were agreed to prevent further spread of *D. villosus.* The introduction of *D. Villosus* negatively affects the local ecosystem, as the native shrimp help improve water quality by breaking down leaf litter, but the foreign invaders have the opposite effect, by eating many of the species that keep water clean and clear. Whilst this does not affect drinking water quality, the murky water could have an economic effect on tourism[12]. The killer shrimp D. villosus sometimes kills prey but does not eat it and its ability to attack and feed on a range of species could cause the local extinction of some species.

With a link to other IAS, it is thought that zebra mussels change habitats by increasing the amount of benthic organic matter, which benefits *D. villosus* helping them to outcompete other species. When given a choice, *D. Villosus* spend more time feeding around zebra mussel shells than a bare substrate[13].

Spread : It is thought they were introduced into Grafham Water and then Barton Broad via a boat, windsurfer or even angling gear. The shrimp can live outside the water in damp conditions - for instance, in waders, fishing nets, engine cooling systems - for up to 14 days, but they cannot tolerate dry conditions. That is why “Check, Clean, Dry” has become the mantra in preventing their spread (refer to chapter 5 for more information on this)

Green algae *Caulerpa*

It is a fast growing and attractive species for adding to aquaria. However, in the open waters, this very fast-growing species can quickly attain plague proportions. It rapidly overgrows corals, slower growing macroalgae, seagrass and other benthos in coastal locations, quickly smothering them.

Impact: Economic and social impacts are due to the reduction in catches of fish by commercial fishermen due to the reduction of fish habitats by Caulerpa, and the weed becoming entangled in boat propellers and fishing nets. Economic impacts resulting from the cost of eradication of C. Taxifolia included approx. US $6 million spent in southern California in 2000-04[14] and estimated AUS $6-8 million in southern Australia.

Spread: Although the initial spread is by release from aquariums, vessels' anchors remove fragments of Caulerpa from estuaries, and conditions inside anchor lockers may enhance fragment survival. This means that boats may be an important vector for dispersal of Caulerpa within and between estuaries[15] across and around the Mediterranean. Sport fishing can also aid local movement of Caulerpa in Italy, with algae attached to fishing equipment[16]. For these reasons, new infestations tend to occur in ports, harbours and marinas.

Within the Caulerpas, Caulerpa taxifolia or Killer Algae is notoriously invasive and has been publicized widely by the Media. In California it was eradicated at considerable cost using toxic chemicals. This has led to some US States banning the use of some Caulerpa in aquaria, to prevent their spread to open waters and damage to local ecosystems. However, later studies seem to indicate a reduction of the growth and spread of *C.taxifolia* and a reduction of its potential impacts. Whereas, other members of the genus, such as *Caulerpa racemosa* and *Caulerpa cylindracea*, where, together or in combination with other species, Caulerpas have proven to negatively impact meadows of *Posidonia oceanica*, the main seagrass in the Mediterranean.

Zebra Mussel *Dreissena polymorpha*

It is a bivalve mollusc native to the Caspian Sea, is possibly the most aggressive freshwater invader worldwide. It has spread through canals and river estuaries, was in London docks in 1820's, in Sweden in 1920's, in Alpine lakes in 1960's and by 2010, zebra mussels were found in more than 600 lakes and rivers across 26 U.S. states. These are one of the world's most economically and ecologically damaging aquatic invasive species. Once introduced their populations can grow rapidly, and the total biomass of a population can exceed 10 times that of all other native benthic invertebrates.[17]

Impact: The mollusc has blocked water intakes for power plants, water treatment plants and ships. Large populations have devoured plankton affecting local biodiversity and disrupting aquatic food webs. Along shorelines, windrows of mussels destroy beaches, and the decaying mussels produce an extremely foul smell.[18] The sharp shell of the *D. polymorpha* is razor-like and is a hazard to barefoot swimmers and beachcombers. This combination spoils the most pristine of locations and prohibits recreational activities.

Spread: Whilst the initial spread has been in ballast water in commercial vessels, the microscopic larvae can continue to be spread between smaller bodies of water by recreational vessels in bilge water, bait buckets, equipment, biofouling or anything else that moves from one body of water to another. Also, adult and juvenile mussels can move on boat hulls, and buoys as they move between areas.

Quagga Mussel *Dreissena rostriformis bugensis*

It is similar to the zebra mussel, originating in Ukraine, and is now in North America. This species was identified as the top-ranking invasive species threat to the UK in a study of almost 600 non-native species.[19]

Impact: The dreissenids, including *D. rostriformis bugensis*, are sessile filter-feeders capable of reaching extremely high densities, negatively affecting the environment, food webs and biodiversity of the ecosystems they invade[20], and causing tremendous economic damage in raw water-using industries, potable water treatment plants, and electric power stations.[21]

Spread: Shipping is considered to be the primary pathway of quagga mussel introductions into new areas located far outside its native range[22]. The mussels can travel with a vessel either as adults attached to the biofouling on the hull or as planktonic larvae within ballast water. Accidental introductions of quagga mussels at local and national levels often happen due to overland transportation of recreational boats and fishing gear, which is especially popular in North America.

Rock snot or "Didymo" *Didymosphenia geminate*

It was considered a widely distributed, yet uncommon single-celled algae (diatom) native to the cool, running freshwaters of the northern hemisphere, including northern parts of North America, Europe, and Asia. However, within the last two decades, didymo blooms have been reported with increasing frequency and intensity across the globe, starting with Vancouver Island, Canada in 1990's, spreading across North America, and in the South Island, New Zealand in 2004.

Nicknamed "rock snot" for its gooey appearance, didymo secretes massive amounts of branching stalks, creating dense mats that cover the bottoms of streams and rivers.

Impact: Didymo can alter the diversity and distribution of native stream species and may have negative consequences on how stream ecosystems function. By covering and dominating the substrate, didymo may alter habitat and available food resources for bottom-dwelling stream invertebrates, potentially affecting the fish that feed on them. Didymo invasions, although unsightly, do not produce an odour or threaten human health. However, infestations do have significant negative impacts on all water-associated recreational activities, particularly sport-fishing. Floating didymo stalks tangle up lines, flies and lures. Additionally, didymo blooms have blocked water intake pipes and canals. Consequently, didymo remains a serious economic concern for fisheries, tourism, irrigation, and hydropower.[23]

Spread: most likely spread by moving boats and equipment between waterways. Water recreationists must take great care to inspect, clean, and dry all equipment, especially waders and boots when leaving an infested stream or river, following the Check, Clean, Dry principle.

3

EXISTING REGULATIONS APPLICABLE TO BIOFOULING

In 2012, IMO published its circular MEPC.1/Circ.792: Guidance for Minimizing the transfer of Invasive Aquatic Species as Biofouling (Hull fouling) for Recreational Craft[24]. This guidance document is specifically aimed at recreational vessels less than 24 metres in length and provides information consistent with the IMO Biofouling Guidelines for ships, published in 2011.[25]

There are currently only a few countries that have specific regulations applicable to biofouling as a vector for IAS transfer through recreational boating. There are, however, many regulations in other countries that, while not mentioning specifically biofouling, are nevertheless applicable, such as regulations addressing Invasive Aquatic Species (irrespective of vectors and pathways), biodiversity protection, Marine Protection Areas (MPAs) and controls on anti-fouling coatings, their toxicity and chemicals and waste management.

The prime example of national regulations addressing specifically biofouling as a vector for introducing IAS is New Zealand. The country has strictly enforced biosecurity controls on recreational vessels, with the Craft Risk Management Standard (CRMS*) for Biofouling and it effectively enforces its biosecurity regulations for visiting vessels. The New Zealand CRMS for Biofouling includes a definition of acceptable biofouling (just a slime layer) providing a risk-based reference point for the level of action to be taken. Even with a strong public acceptance and clearly defined controls, this level of biosecurity control requires considerable commitment by the authorities.

Many countries have regulations on the disposal of wastewater and solid waste from onshore pressure washing of vessels coated with antifouling coatings, to prevent this 'trade effluent' entering controlled waters, such as rivers and estuaries. The wash-down controls to prevent potential IAS being discharged back into the water are the same as preventing the discharge of antifouling paint residues in the wash water. However, these are not always fully enforced, leading to concentrations of heavy metals near marinas, and the potential escape of IAS back to the water.

Many inland waterways around the world have effective controls as access can be controlled by the 'owners' or local authorities, such as Anglian Water controlling the Killer Shrimp at Grafham Water, (Grafham Water SC Non-native species**) and the American guidelines to stop aquatic hitch-hikers*** between the many inland lakes.

The Galapagos Marine Reserve, in Ecuador, and the Papahānaumokuākea Marine National Monument (PMNM) in Hawaii, USA, are examples of enforcing strict standards on biofouling before entry to marine parks or protected areas.

* https://www.mpi.govt.nz/dmsdocument/11668-Biofouling-on-Vessels-Arriving-to-New-Zealand-Craft-Risk-Management-Standard
** https://www.grafham.org/on-the-water/non-native-species.html
*** https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_029120.pdf

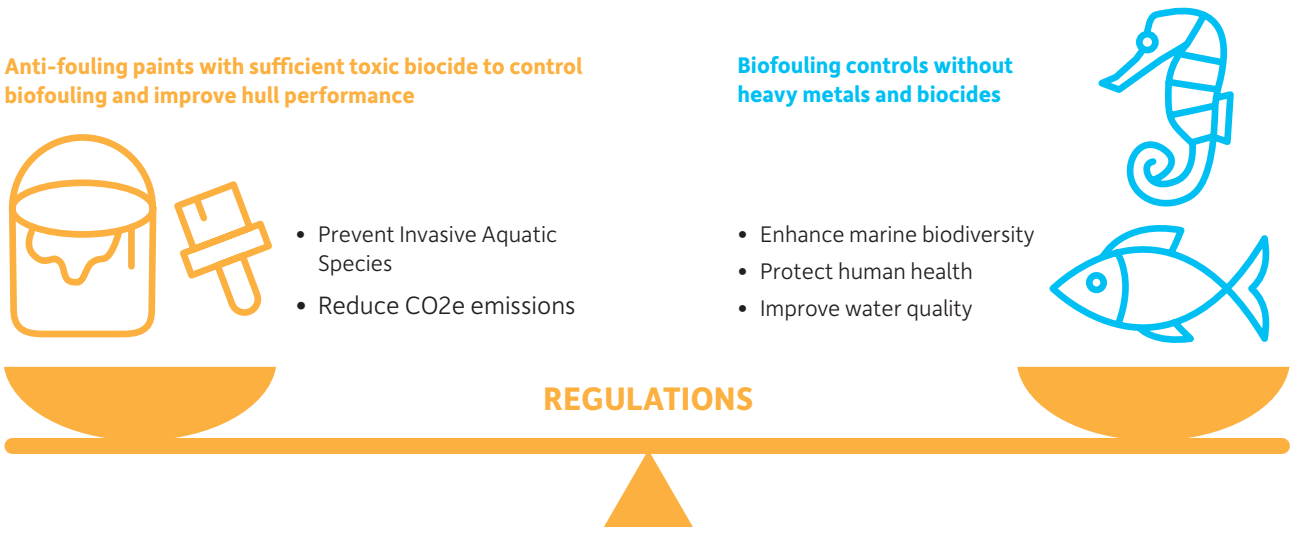
3.1 Anti-fouling paints and the control of IAS

The use of anti-fouling paint is the most widely approach taken to prevent biofouling on boats and ships. It works by releasing biocides into the surrounding water, thereby killing or deterring the microscopic settling stages of organisms at the paint surface, preventing them from making the vessel's hull their new home. However, there is ongoing concern from marine scientists that some of these biocidal paints may have adverse effects on non-target marine species and that they may be hazardous to humans during application and removal if the correct precautions are not taken. This means there is often a balance between keeping hulls clean with biocidal anti-fouling paint to maintain performance of the boat and preventing the spread of IAS to protect the local marine environment, especially in congested or popular areas.

To be successful, an anti-fouling coating needs to tick many boxes: it should be durable, reliable, easily applicable, stable, cost-effective, cause minimal harm to environment, and be substrate independent. Taking also into account the highly varied characteristics of fouling species and the different environmental conditions where vessels operate, it is a considerable challenge to design a versatile, efficient and durable anti-fouling coating. To date, no single chemistry has been identified as the universal anti-fouling strategy to meet all these requirements and trying to develop one universal coating strategy is likely to be an unreachable goal.[26] Instead, industry and boat owners should make use of synergetic strengths by combining several anti-fouling strategies into one multifunctional system.

In countries such as USA, EU countries, UK, Australia and New Zealand, biocidal anti-fouling products must be approved before they can be commercialised. Products and the biocides used in them are regulated

Figure 5: Balance between Performance and Biodiversity



in the same way as insecticides, wood preservatives and disinfectants. To grant approval for a product, regulators in the jurisdiction evaluate the risk to the environment and human health from using the product and determines if they can be used safely.

When preparing the hull of a boat for application of an anti-fouling paint, before washing or scraping the hull is attempted, care should be taken to ensure wastewater contaminated with biofouling and/or paint flakes is not released to water. Personnel applying the coating should use protective equipment and follow technical and safety instructions on the product label or on the product safety data sheet (usually available online). Where possible, all work on the hull should be carried out in within areas designated for maintenance within ports or marinas, where wastes generated can be collected and disposed of safely and in accordance with local regulations.

Boaters and service providers using anti-fouling paints on their vessels should carefully check the information on their selected product(s) to ensure it is approved under applicable legislation and that is fit for purpose for where the boat will operate. Before paint application, the technical and safety instructions on the label of the product should be read, understood and followed carefully. Care should be taken during application to ensure paint or paint particles are not spilled in the marine environment.

Boat owners, marina operators and boatyards need also to be careful when cleaning hulls either ashore or afloat to prevent the biocides from their anti-fouling paint entering the marine environment.

It should be noted that some biocides previously used in biocidal anti-fouling paints are now banned internationally by the International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS Convention), specifically organotin tributyltin (TBT) and cybutryne.

With the need to prevent biofouling and the translocation of IAS, as well as to reduce emissions from vessels, the use of biocidal anti-fouling systems is a delicate balance between competing environmental risks. This is an ongoing dilemma for regulators, boat owners and the manufacturers of anti-fouling coatings alike. Biocide-free alternatives are discussed in chapter 7.


4
frogg toggs

KEY AREAS FOR MANAGING BIOFOULING, BY TYPE OF VESSEL OR EQUIPMENT

Recreational vessels can start to collect biofouling on their hulls within hours of being in the water (refer to **Figure 1** (see page 12) for a description of this process). Dry-sailed craft, such as trailered boats, dry-stacked craft or portable craft rely on dry storage to avoid the accumulation of biofouling on their hulls, whereas vessels that stay afloat will have some form of anti-fouling coating as protection. The hull is the obvious area where biofouling is seen, and therefore cleaned.

However, there are many other areas on vessels and equipment where biofouling can occur, and therefore be a source of transporting IAS, particularly if they are not readily visible or known areas on a boat, such as bilges, lockers or cooling systems. These so-called niche areas are therefore a key point to consider for biosecurity when moving a boat from one area to another. Refer to **Figure 4** (see page 15) for a description of typical niche areas prone to additional biofouling.

4.1 Long term afloat vessels

Larger recreational vessels are usually kept afloat for the boating season, or longer. Recreational boats kept afloat pose a high risk of transporting biofouling as they have long periods when left unused, undertake slow and itinerant voyages, are not restricted to ports and frequent in-service maintenance is of marginal benefit to the owner. Additionally, if a vessel moves at slow speeds (typically less than 14 knots) to get to its destination, the biofouling species are unlikely to become dislodged during travel.

Generally, the hull and underwater appendages will have been painted with an anti-fouling coating (or an alternative anti-fouling system will be installed) when launched. Biofouling pressure will be variable: some areas will be more prone to biofouling due to less flow when under way, allowing biofouling to build. The opposite can also happen where there is very high flow, which can increase wear depending on the anti-fouling coating that has been applied. In addition, some niche areas may be missed due to poor access when applying anti-fouling paint, or during any in-season cleaning, either in-water or with a mid-season lift and hull clean.

Niche areas to consider on vessels kept afloat for the season (refer to section 1.2 for a description of niche areas) include:

- Hull openings – engine water intakes, impellers, bow thrusters.
- Propeller and shaft – often metallic and fast spinning so increased wear on anti-fouling coating, so different anti-fouling paints and/or alternative systems could be required.
- Rudder and keel(s), anodes.
- Bilges, holding tanks (sewerage), 'heads' (toilets).
- Anchors with mud, seaweed, mooring lines if 'fouled', deck fittings, anchor well.

Any fouling other than a slime layer has the potential to provide a home for a species that may survive a voyage to a different area and become invasive. The more biofouling is found on a boat, the more likely the presence of IAS.

4.2 Blue water cruising

Sailors who travel the open oceans tend to pay close attention to the performance of the hull coatings, to avoid biofouling. Nonetheless, a report on visitors to Hawaii examining the extent and diversity of biofouling on overseas vessel arrivals to remote islands suggests that the risk of introduction of IAS is real[27]. These vessels are likely to stay for a significant period of time and are not restricted to ports. This gives the opportunity for any IAS to transfer to the local environment.

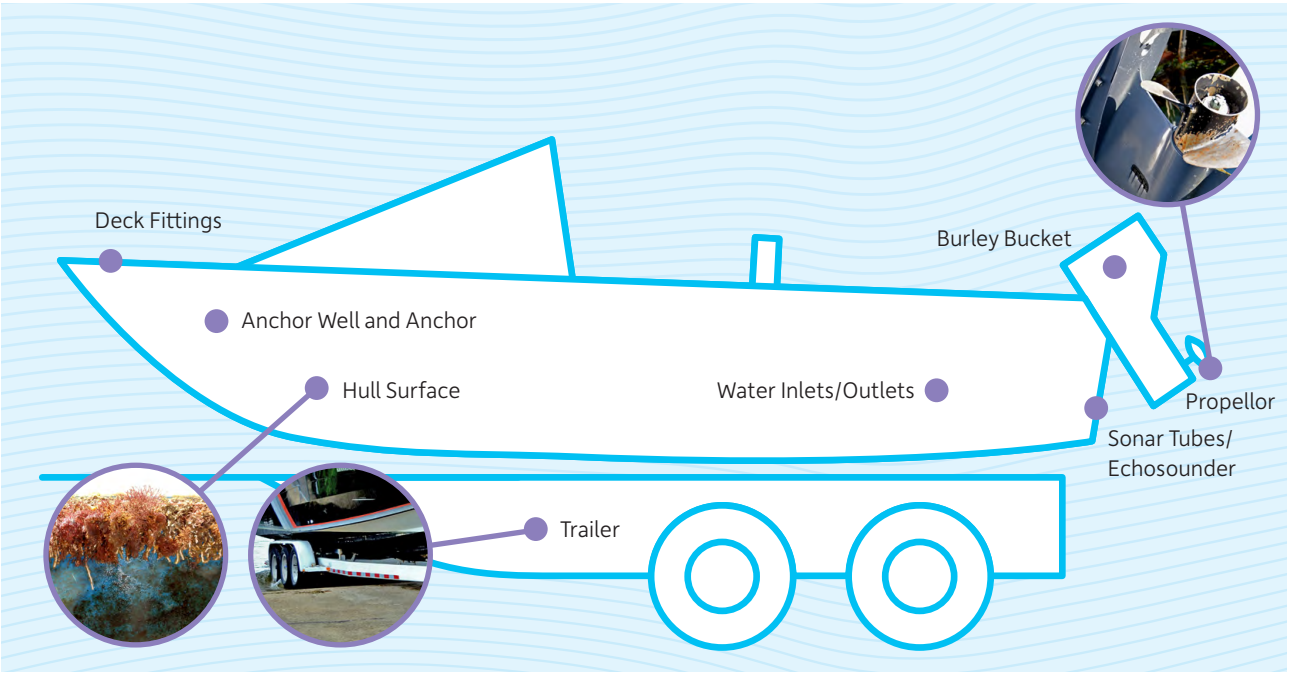
4.3 Trailered boats

These are typically used on freshwater areas, with the ability to easily move from one isolated water body to another, meaning this is the most likely pathway for transporting IAS between inland lakes and rivers.

Niche areas to consider on trailered boats include:

- Engine water cooling, bait well, bilges, ballast tanks.
- Equipment including skis / boards, fishing rods, buckets, anchors, mooring lines.
- Sailing dinghies – built-in buoyancy tanks, residual water in masts / boom.
- Clothing – wetsuits, shoes, buoyancy aids, waders.
- Trailer itself if immersed in water.

Figure 7: Niche areas on trailered boats

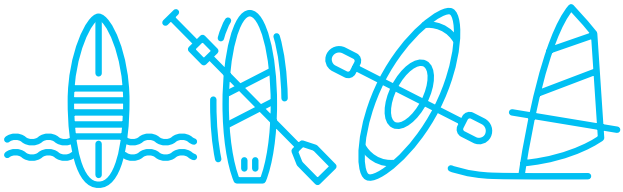


On fishing boats, niche area such as bilge systems, bait wells, live wells can hold possibly up to 200 litres. Wake boats ballast tanks can hold between 470 and 1420 litres; and both wake boats and ski boats have swimmers climbing into boat with water getting into bilges[28].

The killer shrimp D. villosus can live outside the water in damp conditions - for instance, in waders, fishing nets, engine cooling systems - for up to 14 days, but they cannot tolerate dry conditions[29].

Aquatic hitchhikers generally do not survive the change between freshwater and seawater due to the difference in salinity that makes it difficult for species from sea to tolerate freshwater and vice versa.

4.4 Portable craft

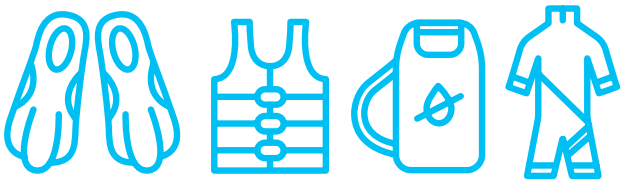


Windsurfers, kite boards, canoes, Stand Up Paddle boards (SUPs) are very portable and nearly always stored ashore.

Niche areas to consider are:

- Boards, hollow sections of paddles, hollow spars, dry bags.

4.5 Clothing



After a day on the water, it can be tempting to leave cleaning of items of clothing until 'next time'. Wetsuits, waders, spray tops, can all remain damp if not washed and dried, which can retain live larvae or other IAS for several days.

Niche areas to consider are:

- Wetsuits, waders, shoes, buoyancy aids, spray tops.

See image of Killer Shrimp on waders on page 22[30].

HIDDEN DANGERS

Breeding-sized quagga or zebra mussels and their veligers (larvae) are known to survive an extended amount of time during transit on or within a boat. Adult mussels are known to live as long as 30 days out of water when humidity and temperature conditions are ideal. This is a real threat as demonstrated when live veligers were recovered from the engine cooling system of a boat traveling from Lake Mead to Lake Powell (approx. 575 miles) in March 2011, where 19 confirmed veligers were found in the 0.47 litres of water recovered. This proves that normal boat operations are a viable pathway to inadvertently move some veligers via raw water circulation into boat motors, wells (bait, transom, and live) or ballasts.Splashed water or drippings from swimmers flowing into the bilge is another potential source for veligers to enter a boat.

4.6 Shore based infrastructure

As vessels are hauled out and washed on slipways or at marinas, there will be a concentration of biofouling waste (and toxic anti-fouling paints) in wash water. Where there is a risk of an IAS being present or the release of paint chips, wash water should be captured to prevent residues returning to the waterway. Where the same slings are being used between vessels, this should be washed off to prevent cross-contamination.

Niche areas to consider are:

- Slipways.
- Straddle carrier slings.
- Water capture containment.

5

OVERVIEW OF BIOFOULING MANAGEMENT SOLUTIONS AVAILABLE

5.1 Examples of different systems and resources available to prevent biofouling

Effective anti-fouling systems are essential to prevent translocation of non-indigenous fouling species growing on immersed areas to waters where they may become invasive. Anti-fouling systems must provide stable and effective prevention of fouling in all locations where the boat travels throughout the complete boating season. They must be cost effective and not result in harmful effects on the environment. They must also be safe to install / apply and be robust and durable.

When selecting an anti-fouling system, boaters should consider:

- Location of mooring and operation of their boat (tropical vs temperate, salt vs fresh water);
- Type of boat / construction materials; and
- The anticipated voyage profile for the season (frequency and pattern of use, speed and activity).

It is useful for fellow boaters to share and advise on which products are effective in the area they are moored and where they operate. Anti-fouling system providers also give advice through their websites and product literature.

WHAT IS AN ANTI-FOULING SYSTEM?

Any coating, paint, surface treatment, surface or device that is used on a ship or vessel to control or prevent the attachment of unwanted organisms as biofouling. While anti-fouling coatings are the most common system in use, there are other options, either alternative or that can be used together with the coating. Examples of this are anodes, ultrasonics, UV protection, hull wraps, marine growth prevention systems. **Table 1** further below provides an overview of anti-fouling systems.

If the anti-fouling paint is biocidal, it is important to check that it can be legally applied and used in your area.

In addition to protecting the hull, it is important to protect all immersed niche areas such as propellers, propeller shafts, sail drives and water inlets from biofouling.

Boaters have a range of options when selecting an anti-fouling system suitable for their vessel, as described in the table below.

Table 1: Biofouling prevention and management solutions

Anti-fouling system	How it works	Pros	Cons
Biocidal anti-fouling systems			
Biocidal antifouling paints (General)[31]	The paints work by slowly releasing biocide from the dry paint film on the surface of the hull to prevent the settlement of fouling organisms. Products contain a copper biocide with or without an organic co-biocide ***or*** organic biocide(s) which are active against fouling organisms. Typically there is less biofouling growth in fresh water than in salt water, therefore biocidal anti-fouling paint used in fresh water usually has a lower biocide content and release rate to prevent growth.	Products available that provide full or multi-season protection against fouling. Easy to apply by boaters themselves or by professional applicators. Cost effective vs alternative technologies. Known products with established supply chains. Products on the market must be reviewed and registered as biocidal products / pesticides under federal and national laws in countries including USA, Canada, EU member states, UK, Australia, New Zealand, Republic of Korea and Turkey.	Products leach biocide and metals to the marine environment when immersed which has caused ongoing concern over effects on non-target marine life. Always read and follow safety advice on the product label and safety data sheet. Hazardous products may be harmful to humans during application & removal if personal protective equipment is not used. Surface preparation and application can result in paint residue / flake residue in wash water which must be collected and disposed of in accordance with waste management rules. Majority of products result in emission of VOCs to air during application
Soft biocidal antifouling paints (self-polishing, ablative)	Surfaces of soft/ ablative or self-polishing paint films erode or polish slowly as biocide is released when the vessel is in-service.	Coated surface of the hull smooths in service, optimising hull performance by reducing drag. Self-polishing effect maintains constant biocide release rate throughout the specified lifetime. Soft paints are suitable for all craft except high performance boats where the hull is regularly polished / burnished for optimum performance.	Soft anti-fouling paints release biocide and metals when cleaned underwater, so abrasive in water cleaning of this type of coatings is a concern in many locations (See Chapter 9) on in-water cleaning). Concern that ablative paints may release microplastic when in service.

Table 1: Biofouling prevention and management solutions - continued

Anti-fouling system	How it works	Pros	Cons
Hard biocidal anti-fouling paints	Hard paints release biocide from the insoluble paint film that does not wear away in-service.	Hard paints are suitable for performance craft operating at 30 knots and can be used on propellers and outdrives. Hard finish anti-fouling paints release less toxicant than soft paints when subject to abrasive underwater cleaning, or jet washing prior to dry storage.	Not self-polishing / ablative, so may need regular cleaning to maintain efficacy Biocide release rate less controlled compared to self-polishing / ablative anti-fouling paints Build-up of insoluble layer (leached layer) depleted in biocide at the paint surface when in service which may reduce efficacy over time.
Hard epoxy resin with copper*	Copper embedded in epoxy resin prevents fouling	Can be specified for multi-season performance	Precise application required for system to be effective. Initial application relatively expensive. Uses copper up to the maximum allowed by law. Not effective against copper tolerant fouling species. May require pressure washing /brushing in-service.
Non biocidal anti-fouling systems			
Biocide free antifouling paints.	Hard and eroding film versions available	Hard film products -can also be used on propellers.	Less well-known products with corresponding lack of experience of efficacy – especially in higher fouling waters.
Silicone elastomer based fouling release coatings.**	Foul release coatings are non-biocidal and function by generating a 'non-stick surface' effect at the coated surface preventing fouling organisms from attaching and maintaining adhesion once the boat is underway. Also generate a smooth surface optimising hull performance. *(Note: Fouling release coatings are also now available that contain biocide).*	Smooth surface that is copper and biocide free. Suitable primarily for higher activity, faster boats or where the hull can be regularly cleaned. Products are available that are suitable for propellers, propeller shafts, sail drives and other immersed niche areas Can be specified for multi-season performance More complex to apply than traditional anti-fouling paints. Versions available that can be applied by boaters themselves and by professional applicators	Requires regular use of vessel at higher speeds (typically > 8 knots) to encourage the fouling to release, therefore generally not suitable for little used boats, or slower vessels (e.g., non-racing yachts and motor cruisers). Can be damaged by abrasion and physical contact (such as fender damage and abrasive hull cleaning). Use in boatyards must be carefully managed to avoid contamination of other coatings with overspray containing silicone. Typically, silicon elastomer coatings contain oils which may leach from the coating into water when in service. Majority of products result in emission of VOCs to air during application
Note: Always read and follow safety advice on the product label and safety data sheet. Non-biocidal anti-fouling paints / coatings may be harmful to humans during application and removal if personal protective equipment is not used. Surface preparation and application can result in paint residue / flake residue in wash water which must be collected and disposed of following waste management rules.			

* https://coppercoat.com/

** https://doi.org/10.1021/acs.langmuir.9b03926

Table 1: Biofouling prevention and management solutions – continued

Anti-fouling system	How it works	Pros	Cons
Ultrasound*	Ultrasonic transducers emit multiple bursts of ultrasonic sound waves in multiple frequencies, creating a pattern of alternating positive and negative pressure. Microscopic bubbles are created from the negative pressure, while the positive pressure implodes them due to cavitation. This deters settlement of microscopic settling stages of fouling organisms and destroys single cell organisms such as algae, stopping further growth of biofouling organisms.	Physical mechanism - no chemicals are used. Does not harm non-target marine life. Can be used with other anti-fouling systems to prevent fouling of all immersed areas to keep the hull clean for extended periods, including when the boat is in static conditions, without the need for regular mid-season cleaning. Effective in niche areas.	Initial outlay for installation. Longer vessels require more transducers. Requires reliable power source. May require occasional lift outs and cleaning.
Boat wrap. Adhesive film applied to boat hull (like wallpaper).**	The surface of the film / wrapping mimics the 'sea-urchin' principle with an artificial spiney surface with very fine flexible plastic fibres that stand out vertically from the surface. Microfouling organisms find it difficult to attach to these spines.	Biocide free. Robust and can be cleaned with pressure washer or mechanical in-water systems. Provides additional protection to the hull	Needs to be professionally applied. Needs occasional cleaning. Concern that microplastic maybe released when in service and during cleaning.
In-water dock / slip liner***	The boat is stored at berth in an external liner which covers the hull. Water inside the liner is completely enclosed and isolated from external water, excluding settling stages of biofouling organisms from entering. Any biofouling organisms enclosed in the wrap as the vessel enters the liner are starved of oxygen, light and nutrients, thus do not settle.	Available for power boats and yachts with keels. Avoids need for anti-fouling paint. No hazardous chemicals needed. Can be used in a marina or swing mooring. Does not require boat to be lifted out of the water	Cannot use through hull inlets / outlets whilst in the wrap. Only available at 'home' berth. Liner requires regular cleaning.

* A complete guide on yacht ultrasonic antifouling | Yachting Pages (yachting-pages.com) https://yachting-pages.com/articles/a-complete-guide-on-yacht-ultrasonic-antifouling.html

** https://materialdistrict.com/article/antifouling-wrap-sea-urchins/

*** http://armoredhull.com/

Table 1: Biofouling prevention and management solutions - continued

Anti-fouling system	How it works	Pros	Cons
Reactive in-water hull cleaning	Approaches: Mechanical cleaning of hull when boat is at anchor or at mooring by diver or autonomous robot. Drive-in boat washing station (similar to car wash) removes fouling by brushing , jetting or robotic cleaning system.	Quick operation, without lifting vessel, can be completed mid-season or before use of vessel to increase hull efficiency.	Coatings must be hard enough to withstand physical cleaning (brushes, jetting etc). Generates biological waste that must be collected/managed to prevent release of potentially invasive species. If not captured paint particles (microplastics) may be released into surrounding water during hull cleaning. Commercially available systems primarily suitable for boats without keels (powerboats).
Proactive in-water cleaning* (hull grooming)	Gentle brushing of hull when boat is at anchor or at mooring by diver or autonomous robot. Hull grooming removes surface biofilms as a proactive measure to prevent further fouling.	Relatively quick to carry out, without lifting the boat from the water. Can be completed mid-season or before use of vessel to increase hull efficiency. Can be carried out on immersed anti-fouling paint films without significant biocide or microplastics release.	Works primarily on soft fouling. Therefore, must be carried out regularly in order to remove biofilms before hard fouling settles. Commercial systems more available for larger vessels than for smaller boats /craft. Non capture cleaning systems release biofilm material into water.
'Out of water solutions' to manage biofouling			
Floating docks (form of dry sailing)**	Different types: Modular dock made of floating polypropylene blocks which the boat drives up onto using own outboard / outdrive, lifting hull clear of the water. Lift systems, using air or hydraulics to lift vessel clear of the water.	Available for vessels typically up to 3 tonnes, such as ribs, personal watercraft and power boats with inboard outdrives. Prolonged periods with hull completely out of water avoids biofouling. Other systems available for heavier boats. Also protects vessel from waves and currents.	Requires fixed berth for attachment. Only available for use at home berth. High initial cost. Requires power to operate. Not suitable for vessels with keels.

* https://marineindustrynews.co.uk/hull-cleaning-drive-in-boatwash-scoops-prize-in-paris/

** https://www.dockmarine-europe.com/en/news/428_everything-you-need-to-know-about-boat-and-jet-ski-drive-on-docks

Table 1: Biofouling prevention and management solutions - continued

Anti-fouling system	How it works	Pros	Cons
Storage ashore / dry sailing / stacking / trailer boats*	Boats are taken out of the water and stored /stacked in secure areas when not used. Suitable for many boat types including motorboats, racing yachts, sailing dinghies, ribs, portable canoes, paddle boards and personal watercraft.	Avoids need for anti-fouling paints completely for some vessels. Avoids build-up of slime layer / biofouling. Clean hull optimises fuel efficiency / performance Trailer boats / portable craft can be transported to multiple locations during the season and stored on shore when not in use.	Dry stack / dry sailing can be expensive. Trailer boats and portable craft need to be cleaned and dried between water bodies to prevent transport of Invasive Aquatic Species (refer to section 6.2).

5.2 Recommended precautionary actions

Biofouling management, and preventing the translocation of IAS, requires planning ahead. The choice of a biofouling management system will depend on the type of vessel and its intended use, including location, frequency of use and potential for mid-season cleaning.

Regular use – commercial vessels are used all the time which makes it more difficult for fouling organisms to attach to the hull. In contrast, recreational vessels are often used infrequently, typically remaining stationary for weeks at a time, allowing biofouling organisms to attach and develop on the hull, and for invasive species to 'jump ship' (See **Figure 3** in section 1.1). Additionally, many recreational vessels, especially sailing boats, move at lower speeds reducing the displacement of biofouling on the hull.

Regular use will therefore reduce the growth of biofouling.

Selection of anti-fouling system - With the variety of anti-fouling systems available, it can be a challenge to select the most suitable. Coatings suitable for use in fresh or brackish water will be different than those used in sea water. There will naturally be less biofouling in colder water than in the tropical areas, so in general lower strength paints can be used. The speed of the vessel will affect choice between hard or soft, self-ablating or foul-release coatings. Niche areas are likely to require a different coating / system to the main hull. It is best to review and discuss the choice of anti-fouling system with a local expert based on the expected use of your vessel.

Correct application of anti-fouling coating: all paint manufacturers provide detailed instructions, including surface preparation and appropriate conditions for applying the paint on the product label and in technical data sheets available online, particularly with the initial application. For subsequent applications, the paint must be compatible with previous coatings, and the surface must be prepared and be clean and dry. Incorrect application of the paint can affect performance.

As these paints are potentially hazardous to humans as well as marine life due to the chemicals they contain, it is important to apply them with caution and to wear the correct protective equipment. Safety information on the label should be read and followed during application.

Niche areas on a hull pose specific challenges, as they are often inaccessible, made of different material (e.g., metal propeller) and also in the shadow of water flow when the vessel is moving. These may require a different coating type than the main hull.

When hauling or lifting the vessel out, **select a wash-down facility** that has a water capture or treatment process. This will prevent any IAS present on the hull from re-entering the local environment, as well as capturing any toxic biocides as the hull is washed off.

Clean the hull - The most effective way to prevent the spread of IAS is to clean the hull before you leave and travel to another destination. This applies to trailer boats as well as boats permanently moored afloat.

* https://www.metstrade.com/news/marina-and-yard/drystacking-sustainability-marines/

5.3 In water cleaning – risks and benefits

In water cleaning has been developed to address vessel performance and reduce fuel consumption as an alternative to drydocking or lifting the vessel out of the water along with associated costs and time.

There are typically two types of in-water cleaning:

Proactive cleaning (commonly called in-water grooming) means regular cleans of microfouling growth with softer types of cleaning methods. This can prevent the biofilm from developing into hard fouling with associated marine growth.

Reactive cleaning which is likely to include the use of brushes that can remove (some) macrofouling. This can be carried out by a diver using some mechanical system with brushes or water jets.

Depending on the level and type of biofouling, both types of cleaning can be conducted through divers or remotely operated vehicles (ROVs). However, if not performed correctly or in adequate circumstances, in-water cleaning can result in several unintended consequences, including:

(a) increased discharge of coating biocides to ambient waters.

(b) increased biosecurity risk through the active release of live biofouling species to local habitats; and

(c) diminished coating condition that reduces anti-fouling performance in subsequent months and years[32].

In-water cleaning can be suitable for removing light fouling (e.g. the slime layer) with gentle techniques that minimize both the release of toxic substances from the anti-fouling and the degradation of the anti-fouling coating system. A light sponge or brush of a biofilm should remove the biofilm which will have limited IAS

and should not remove any anti-fouling paint or release biocides. Before undertaking any in-water cleaning, local authorities should be consulted for regulations regarding the in-water cleaning of boat hulls and/or the discharge of chemicals into the water column. If possible, appropriate technology that captures biological, chemical and physical waste should be used so that it can be disposed of to an appropriate onshore facility. When cleaning an area coated with a biocidal anti-fouling coating system, cleaning techniques that minimize the release of biocide into the environment should be used.

In-water scrubbing of large and distinct biofouling (e.g. barnacles, tubeworms or fronds of algae) generates waste or debris that may create a pulse of biocide that could harm the local environment. As the fouling increases, the level of abrasion required will increase, together with the release of biocides, paint chips and/or fouling organisms into the local water and reducing the effectiveness of the remaining antifouling coating. Biocide in the sediments could affect future applications by the port authority for the disposal of dredge spoil.

Vessels with biocide-free anti-fouling coating systems are likely to require regular in-water cleaning. It is important to use cleaning techniques that do not damage the anti-fouling coating and impair its function. In-water scrubbing may prematurely deplete the anti-fouling coating system which would then rapidly re-foul.

In-water clean and capture systems are increasingly appearing in the market[33], including some that physically filter waste to remove potential IAS, paint chips and other potential contaminants. If operated correctly, these systems are very beneficial, as they allow more frequent cleaning, preventing the build-up of micro and macro fouling, and make the hull more fuel efficient.

As for other types of in-water cleaning, it should only be undertaken when removal of biofouling does not harm the coating and presents an acceptable biosecurity or contaminant risk as determined by the relevant authority[34]. In general terms, if there is a biosecurity risk or danger of releasing paint chips or other contaminants, in-water cleaning should not be conducted without waste

capture. In the latter case, recreational craft should be removed from the water for cleaning and maintenance in preference to in-water operations, where this is operationally practicable. In-water cleaning should not be considered a replacement for coating maintenance and renewal at shore-based maintenance facilities[35].

In addition, it should be noted that in-water cleaning often does not guarantee the total removal of viable fouling organisms, particularly from niche areas. When carried out in marinas without capture of biofouling waste, in-water cleaning may even induce or trigger a spawning event for some organisms, presenting additional risks to biosecurity[36].

A further concern with in-water cleaning, beside the release of biocides and potential IAS, is that many existing anticorrosive and anti-fouling marine coatings use synthetic polymers as binding agents[37] and are a potential source of microplastic pollution which is another reason for capturing and treating the debris from in-water cleaning.

For this reason, some areas have banned in water cleaning for recreational boats (for example, Washington State, USA*) whereas others have strict guidelines for divers carrying out in-water cleaning.

COPPER LEACH

Whilst copper occurs naturally in the oceans, it is the concentrations of metals in marinas, basins that are not naturally 'flushed' and popular boating areas that is proving toxic to mussels, oysters, scallops, crustaceans and sea urchins. Responding to growing concern regarding the amount of copper contributed by underwater hull cleaning, the San Diego Unified Port District implemented a Diver Licensing program that requires licensing of divers, continuing education, and hull cleaning according to Best Practices set forth in the SDUPD Ordinance 2681. This includes the instruction that "No Person shall perform In-Water Hull Cleaning that results in visible paint plume or cloud".

5.4 Control by design

With a greater understanding of the link between IAS and niche areas, it is possible to design vessels in a way that minimizes niche areas and their potential for accumulation of biofouling. For example, the American Boat and Yacht Council (ABYC) have issued design criteria for new boats, trailers, components and accessories to minimise the spread of IAS[38] (ABYC; 2018).

This includes the instruction to manufacturers to support the ABYC Clean Drain Dry requirements with drain plugs at lowest points, standardised engine flushing hose connections and suitable access for inspection. It may be possible for owners to modify existing designs to facilitate inspection, cleaning and minimising niche areas if it is safe to do so without affecting the integrity of the vessel.

* https://ecology.wa.gov/DOE/files/9f/9f9f5b86-865a-431c-9254-1216cf5bba49.pdf


6

BEST PRACTICES

6.1 Biofouling management practices

Biofouling management practices can be broadly categorized as proactive and reactive:

- Proactive (or preventive) measures include applying biocidal anti-fouling coatings or silicon-based formulas that resist attachment of organisms, using ultrasound-based technologies and conducting proactive inspection of the hull and cleaning to minimise the attachment and accumulation of biofouling.

- Reactive (or corrective) measures are essentially focused on cleaning after the detection of biofouling growth.

A complete biofouling management strategy should include both the use of adequate anti-fouling systems (be it an anti-fouling coating, ultrasonics or by any other means) to protect the hull and niche areas, supplemented with appropriate monitoring and cleaning (if needed) to prevent translocation of IAS and to maintain fuel efficiency. These proactive and reactive measures will vary according to the type of vessel, and how often or where it is used.

As a general recommendation, when selecting the anti-fouling system, recreational boat users should gather information to answer a series of questions that could help them to choose the adequate solutions, ensure the optimal performance and minimise their overall maintenance costs. For example:

- What have been my boat use patterns in the previous years? What are my plans for the coming years?

- What is the biofouling pressure in my harbour/marina?

- Have any invasive species been identified in my harbour/marina? Have any invasive species been identified in the areas where I am planning to sail in the future?

- What facilities are available in my harbour/marina in relation to biofouling management and boat storage?

The next pages provide guidance for the different categories of vessels and equipment and their intended use.

6.2 Guidance for all users of trailer boats, including equipment, and personal kit

Includes ski and wake boats, fishing boats, sailing dinghies, canoes, kayaks, windsurfers and SUPs.

AIM:

Prevent the transfer of Invasive Aquatic Species from one waterway to another.

WHY?

The introduction of Invasive Aquatic Species to a new area can cause significant harm to other marine life, threaten local species and biodiversity, as well as incur costs for boat owners, local business and affect livelihoods.

KEY MESSAGE:

Check, Clean, Dry.

Check – most boats / craft have niche areas where water, and therefore marine species can remain out of sight, unless checked.

Clean – the best control is to ensure your vessel is free of all water (other than potable), slime, weed and marine life.

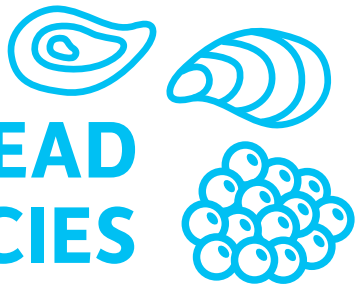
Dry – marine species need water to survive, therefore ensuring all parts of your boat are completely dry for at least 48 hours will prevent the spread of live species.

If your time on the water starts and finishes at a different location or your equipment is not stored in the same outdoor location, after every trip, **CHECK, CLEAN and DRY** the equipment/hull at the location you have been on the water:

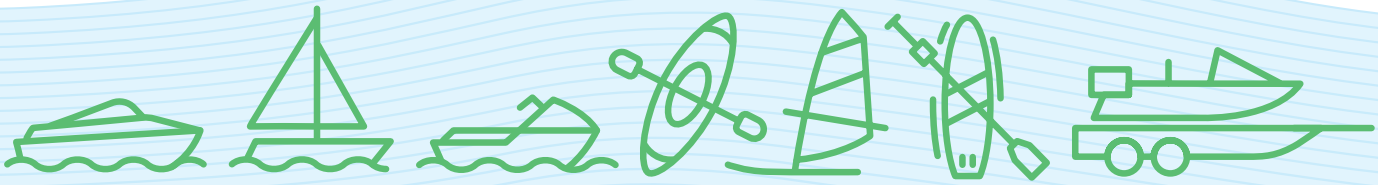
- **check** and **clean** any attached biofouling and seaweed from your vessel, anchor, anchor well and trailer, and put in a bin, not back in the water.
- **check** and **drain** outboard and hull fixtures for water that could harbour potential marine pests (including trimming outboard down to let water out of the gearbox housing)
- **check** all niche areas – hull fittings, propeller, propeller shaft, deck fittings, any cavities in hull and trailer, especially if changing location.
- **clean** / rinse the boat inside and out with fresh water, check lockers, bilges, ballast tanks (on wake boats) and drain, especially if changing location. Flush engine cooling system with fresh, clean water and clean strainers.
- **check**, **clean** and **dry** any equipment used on board such as fishing rods, paddles, lifejackets, hollow masts / boom, sails, covers.
- **dry** all equipment, the hull and trailer before moving to a different waterway.
- **dispose** of any biofouling and wastewater, including known Invasive Aquatic Species, in bins or to landfill, in accordance with applicable rules and regulations so that it cannot be returned to the water.
- For fishing boats – **drain** and **dry** the bait well and live well.

Avoid and reduce: if possible, and without affecting the integrity of the craft, improve access to niche areas to make cleaning and drying easier, and improve drainage.

TRAILERED BOATS: HOW TO PREVENT THE SPREAD OF INVASIVE AQUATIC SPECIES

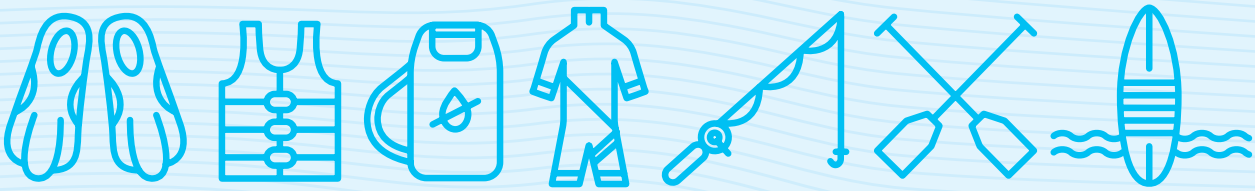


INCLUDES SKI AND WAKE BOATS, FISHING BOATS, SAILING DINGHIES, CANOES, KAYAKS, WINDSURFERS AND SUPS



After every trip:

- Clean and remove weed, biofouling
- Flush and drain engine
- Clean and rinse hull
- Clean, rinse and drain all lockers, bilges, ballast tanks (wake boats)
- Clean all hull and deck fittings



Check, Clean and Dry Equipment:

- Paddles, fishing rods, hollow masts and booms
- Sails, covers
- Wetsuits, spray tops, lifejackets, shoes
- Skis, boards
- Trailers

Fishing boats:

- Bait and live wells

Aim to have containment around these activities to contain Invasive Aquatic Species

Keep the local species local, stop aquatic hitchhiking Contain the spread of invasive species – **CHECK CLEAN DRY**

6.3 Guidance for yachts and motorboats – local coastal / estuary cruising

Includes boats of all sizes stored afloat for the season, in marinas, harbours or moorings.

AIM:

Prevent the spread of Invasive Aquatic Species along coastlines, rivers, harbours and between islands.

WHY?

The introduction of Invasive Aquatic Species to a new area can cause significant harm to other marine life, threaten local species and biodiversity, as well as incur costs for boat owners, local business and affect livelihoods.

KEY MESSAGE:

Avoid, Reduce, Contain

Avoid - the best control is to avoid the growth of biofouling through an effective anti-fouling system appropriate for the area and expected use of the boat.

Reduce – use the vessel regularly to reduce growth of biofouling.

Contain – when cleaning the vessel, contain and safely dispose of any biofouling following applicable rules and regulations.

Start of the season (or before launching)

Avoid or reduce the growth of biofouling by selecting a suitable anti-fouling system that is appropriate to the area and the operating profile of your boat. Consider:

Biocidal anti-fouling paint, a biocide-free coating or other anti-fouling system:

- If using biocidal anti-fouling paint:
  - > Use hard coatings for racing or high-performance hulls, or that are regularly cleaned/burnished hulls.
  - > Soft, self-polishing or ablative paints can be used on hulls that are not cleaned or burnished or for lower performance hulls.
- Select an appropriate anti-fouling system for fresh or salt water, and temperature of water.
- Select an appropriate anti-fouling system for niche areas such as propellers, propeller shafts, sail drives and water inlets.
- When opting for Biocide-free systems – research and select the most suitable method for your boat, such as ultrasound, wraps, silicone (non-stick) coatings.

Seek advice from local chandlery, boat clubs or manufacturers.

During the season afloat:

Reduce the growth of biofouling throughout the season through:

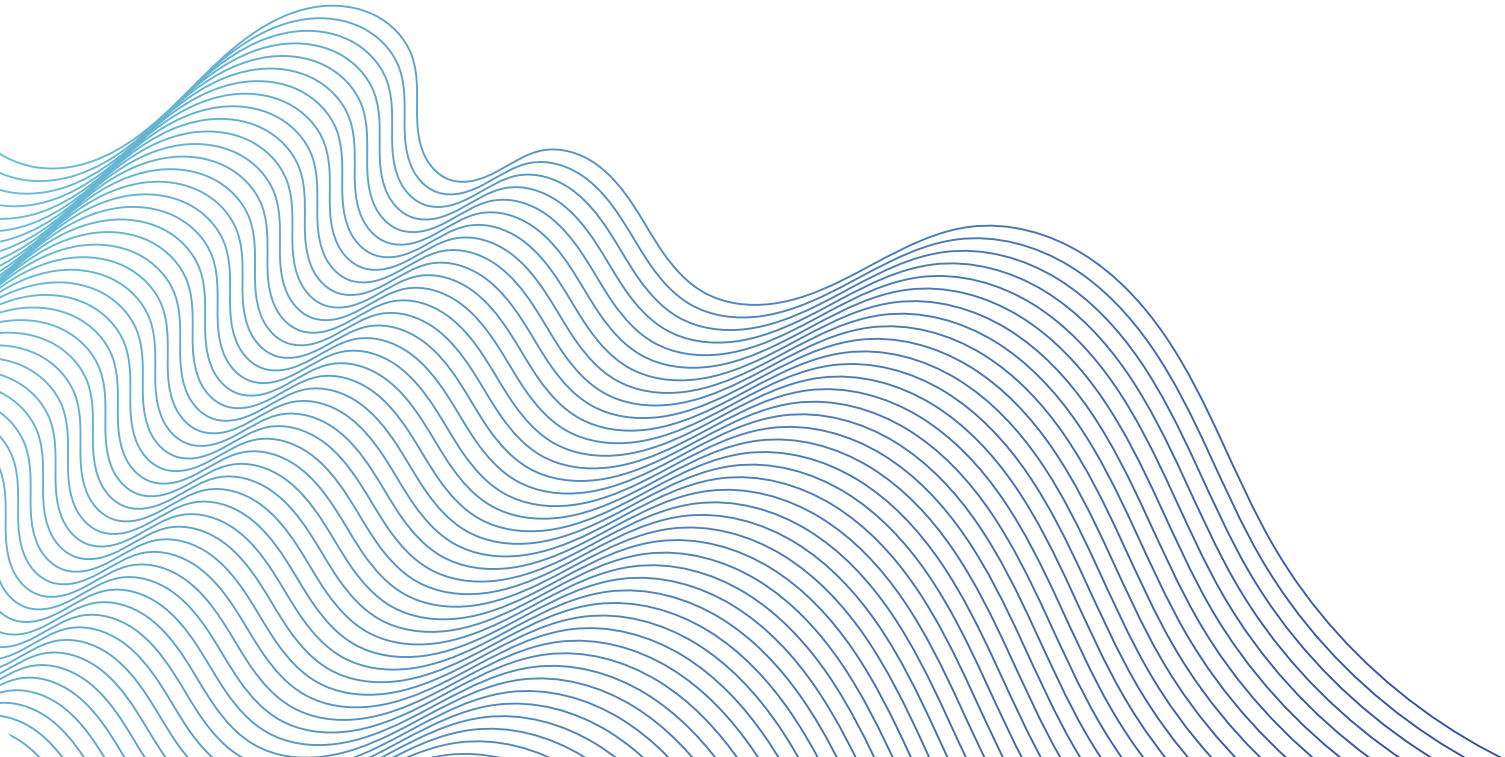
- Regular use – this will reduce the opportunity for biofouling to develop on the hull and keep propellers clean. If an anchor has been used, always wash off both the anchor and chain before stowing.
- If carrying out a mid-season clean, take the boat out of the water and remove any biofouling by water jetting, by using a brush or cloth. Avoid harsh scraping that removes or damages the paint film. Do not allow paint or biofouling residues to enter the water.

- Always **contain** and dispose of any biofouling:
  - > at a marina or yard with wash-water containment facilities.
  - > Air-drying will kill most small pest species in about 48 hours.
  - > Remove the biofouling on land to **contain** scrapings and wastewater to prevent potential Invasive Aquatic Species from getting back into the waterways or stormwater drains.
  - > Inspect raw water systems in your engine and clean if needed.
  - > For in-water cleaning see separate guidance section 5.3 (In water cleaning – risks and benefits).
- If cruising to new areas, clean the hull and niche areas before setting off. This has the benefit of faster passage time, reduced fuel use and minimises the risk of aquatic hitchhikers on your boat.
  - > Especially important if IAS are known or suspected at your current location or departure point, or if cruising to a sensitive area.

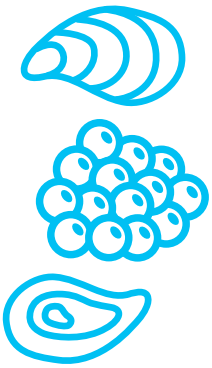
End of season

Contain any biofouling to prevent return of potentially Invasive Aquatic Species to the water.

Select a marina / yard with wash-water containment facilities. Always follow local regulations and rules of the marina / yard.



LOCAL & COASTAL CRUISING: A GUIDE TO PREVENT THE SPREAD OF INVASIVE SPECIES



Pre-season – AVOID

Plan to avoid biofouling

Select anti-fouling system based on:
- Vessel
- Location/local waters
- Expected type of cruising
  - Fast/slow, hard/soft paints
  - Non-toxic anti-fouling system

Preparation

Apply anti-fouling coating according to manufacturers instructions:
- Hull preparation
- Number of paint coats
- Temperature

Records

- Retain records of biofouling management, what product used, when applied

Cruising season – REDUCE

Reduce

Use boat regularly to reduce build up of biofouling.

For longer trips, Clean before you leave:
- Lift and clean – contain and treat any biofouling

Stop the spread of invasive species **AVOID REDUCE CONTAIN**

End of season – CONTAIN

Contain biofouling at end of season

Select lift-out facility with containment for wash-water

6.4 Guidance for longer distance cruising or deliveries - Yachts and motorboats

Includes extended cruising and delivery trips between countries and continents, organised rallies and solo adventures.

AIM:

Prevent the spread of Invasive Aquatic Species (IAS) between countries and continents.

WHY?

The introduction of Invasive Aquatic Species to a new area can cause significant harm to other marine life, threaten local species and biodiversity, as well as incur costs for boat owners, local business and affect livelihoods.

KEY MESSAGE:

Clean before you leave.

Clean before you leave – starting with clean hull and niche areas and cleaned raw water systems will prevent aquatic hitchhikers and ensure a more efficient passage.

Planning: Decide on area to visit, and potential stopovers.

Consider the environment, and biodiversity of your destination and potential stopovers and the potential impact of IAS on these.

Plan and align your biofouling management system with the requirements of your destination and potential stop-over points.

- Check local regulations for:
  - > Biocidal anti-fouling coatings – are there any local regulations or restrictions on types of anti-fouling paint that can be used?
  - > Biofouling limits – are there any clean hull requirements required on arrival or documentation required to prove your biosecurity controls?
  - > Cleaning restrictions – are there any local restrictions on where and how hull cleaning can take place, in-water cleaning or if only at specified locations.
- Allow sufficient budget to maintain your biofouling management system – anti-fouling coatings and treatments may not be as readily available or affordable as in your home port.

Clean before you leave at:

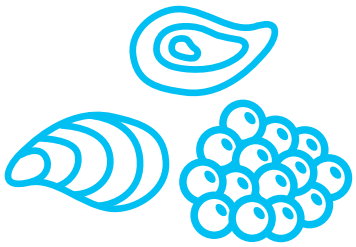
- Initial departure from home port.
- Each significant departure on the trip.

The added benefits include faster passage time, optimum boat performance, reduced fuel consumption and greenhouse gas emissions, minimized risk of transport of invasive species, and the added pride of a well-maintained vessel.

On the Water:

- Avoid sailing or motoring through water plants and weed if possible. This can chop up plants and can spread them further, especially if caught up on the hull or propeller.
- If the boat is on the water but not in use and stationary for a period of time, if possible, raise propellers out of the water to minimise the risk of species entering the engine.
- If an anchor has been used, wash off both the anchor and chain before stowing.

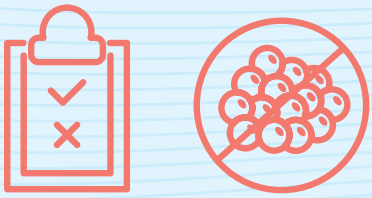
LONG DISTANCE CRUISING: A GUIDE TO PREVENT THE SPREAD OF INVASIVE AQUATIC SPECIES



Dreams and plans

- Decide where to visit
- Consider attractions of local biodiversity, industry/ trades and people

Stop aquatic hitchhikers **CLEAN THE HULL BEFORE YOU LEAVE**



Discovery

- Research local biosecurity requirements
- Consider impact of Invasive Aquatic Species on local environment, society and economy
- Determine suitable biofouling prevention and management system

Preparation

- Apply anti-fouling coating and/or install other biofouling prevention system
- Retain documentation of what anti-fouling system used, when applied

Set sail

- Enjoy the journey
- Monitor biofouling level

Stop-overs

- Monitor biofouling on hull and niche areas and determine if cleaning is necessary

Clean before you leave

- To prevent transfer of Invasive Aquatic Species

6.5 Guidance for Marinas, sailing clubs, boat wash down and slipways

Operators of these facilities have a crucial role to play in preventing the arrival and spread of Invasive Aquatic Species (IAS) by promoting good biofouling management practices.

AIM:

Prevent the introduction or spread of IAS by promoting good biofouling management practices.

WHY?

The introduction of Invasive Aquatic Species to the local area can cause significant harm to local marine life, threaten local species and biodiversity, as well as incur costs for boat owners. It can also damage local infrastructure, businesses and livelihoods.

KEY MESSAGE:

Contain and treat all biofouling.

Provide and maintain facilities where removed biofouling and other solid and liquid residues from boat cleaning and washing can be contained, treated, disposed of, or discharged correctly.

Contain

- Ensure that the hull and niche areas of boats taken out of the water at the facility are cleaned and pressure washed with fresh water. Removed biofouling and other debris should be contained, treated and disposed of in accordance with local regulations and rules of the marina.
- Scrapings and debris should be contained, for example by skirting the hull and using a tarpaulin. Wash down water should not be allowed to return into the environment unless filtered and treated.
- No biofouling is left on slings and on fenders, ropes, chains and anchors of boats. All equipment and clothing that has come into contact with the water should be thoroughly washed with tap water (including trailer and trolley/vehicle tyres).
- Outboard engines are flushed with clean fresh water before leaving the site using appropriate equipment.
- Any biofouling removed should not be allowed to enter any body of water or stormwater; and should not come into contact with any land that is below the high-water mark. Many organisms can remain viable even in small (sometimes microscopic) quantities.

Treat

- Treat and dispose of biofouling waste safely. Fresh water, dry conditions and heat will all kill sea water Invasive Aquatic Species. Avoid using chemical treatments. In freshwater use dry conditions and/or heat to neutralise any potential species.
- All residues should be collected and stored for disposal in line with the requirements of local legislation and/or operation rules that may have been established by the marina or port authority.

Educate

- Raise awareness in the marina using signage highlighting dos and don'ts.
- Provide information (e.g. leaflets, etc) during the booking and checking-in processes to educate berth-holders and visitors to the marina about the need

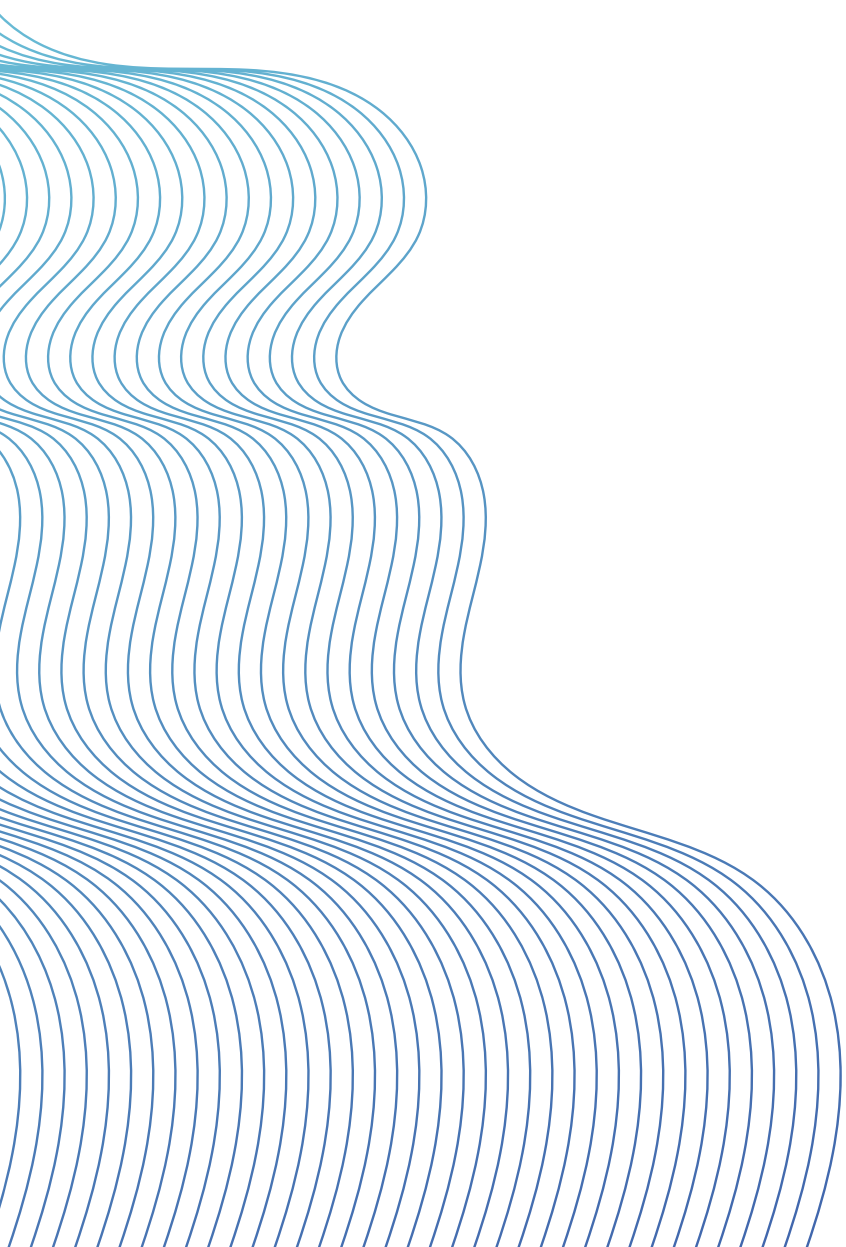
to prevent introduction of Invasive Aquatic Species. Encourage boaters to inspect and wash their boat if biofouling can be observed.

- Train marina staff on good practice for biofouling management, particularly lift-out operators who will see early signs of different marine species, using online awareness training, toolbox talks, or information leaflets.

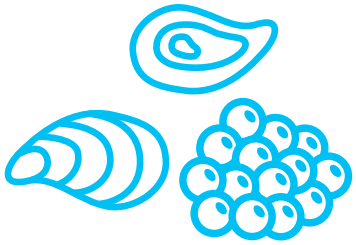
- Encourage boaters to share experiences of effective anti-fouling systems that work in the local area (e.g. at boat club events).

- Encourage users of the marina to identify and report any unusual species on vessels or in the marina and report to the local Environmental Protection Authority.

- Monitor arrivals from significant distance (or areas of known IAS) and, if necessary, encourage visitors to safely clean their boat upon arrival.



SHORE-BASED CLEANING: HOW TO PREVENT THE SPREAD OF INVASIVE AQUATIC SPECIES



Slipways, hoists

- Choose facility with wash water catchment for collection of biofouling waste

Contain and treat

- Prevent biofouling waste and other toxic particles from paint returning to water

Report any unusual marine species
to local authority, regulator

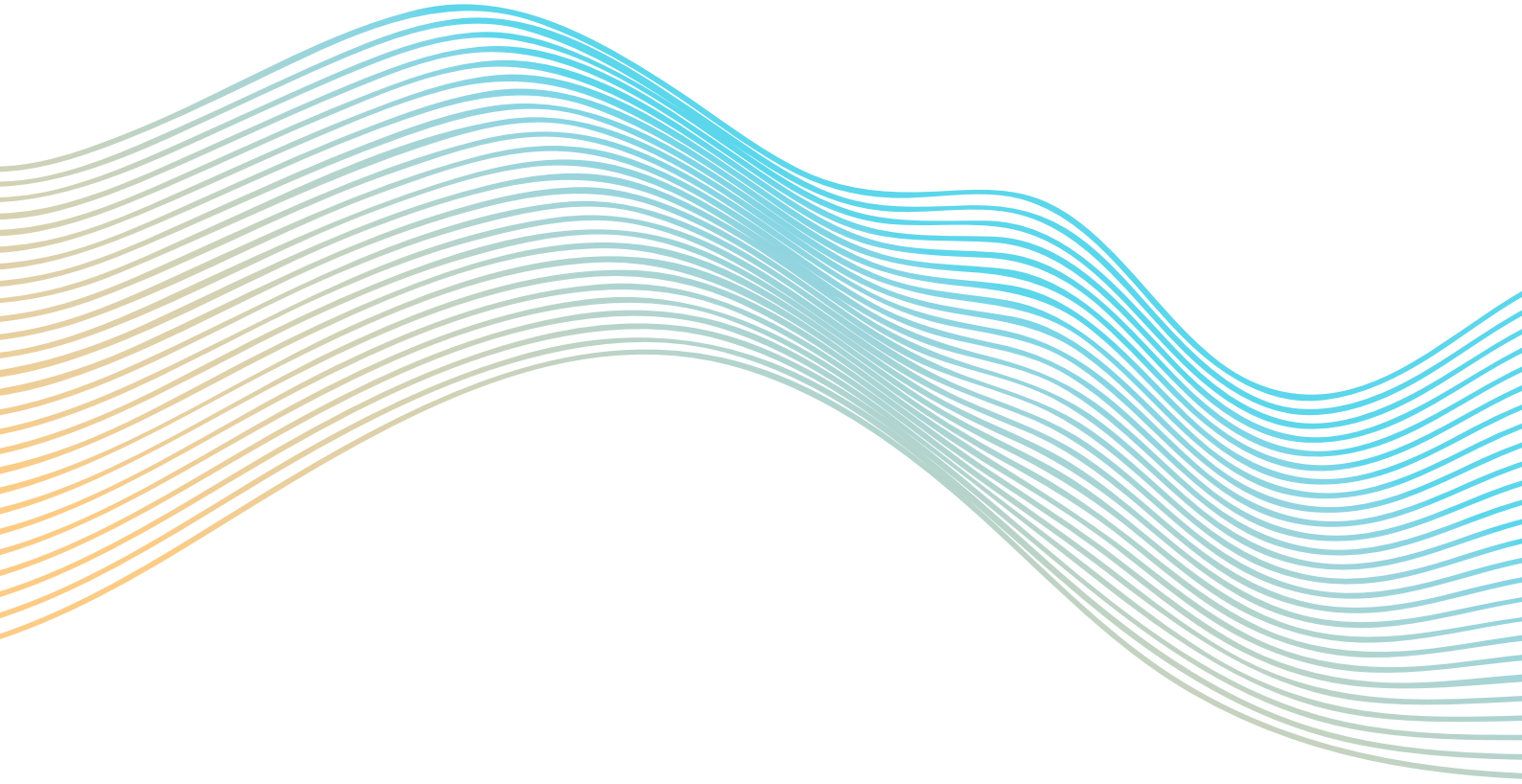
Improve and share knowledge:

- Marina operators
- Public slipway wardens
- Harbour staff
- Management
- Regulators
- Boat owners
- Local clubs/associations

Stop the spread of invasive species **CONTAIN AND TREAT BIOFOULING**

7

LINKS TO FURTHER RESOURCES



7.1 Guidance on biofouling management

The **International Maritime Organization** (IMO) has produced guidance documents for biofouling management, one for commercial ships and a second document for recreational vessels:

Recreational: Guidance For Minimizing The Transfer Of Invasive Aquatic Species As Biofouling (Hull Fouling) For Recreational Craft Mepc.1/Circ.792, 12 November 2012 https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/MEPC.1-Circ.792.pdf

Commercial: 2011 Guidelines For The Control And Management Of Ships' Biofouling To Minimize The Transfer Of Invasive Aquatic Species MEPC 62/24/Add.1, Annex 26. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/RESOLUTION%20MEPC.207[62].pdf

IMO's GloFouling Partnerships project has produced a short video explaining the issue of Invasive Aquatic Species and its link to recreational boating. The role of Recreational boating in the spread of Invasive Species (https://www.youtube.com/watch?v=HwyDmIkwmaY).

IMO's GloFouling Partnerships webinar on recreational boating. The role of biofouling in recreational sailing, yachting and marinas as a pathway for non-indigenous species (https://www.glofouling.imo.org/webinar-past/2)

World Sailing
World Sailing, in partnership with the World Sailing Trust and 11th Hour Racing, have released a Sustainability Education Programme, developed with The Ocean Race, for sailing clubs and parents as part of its Agenda 2030 – sailing's commitment to global sustainability. Of particular interest are Module 3: Navigating Wildlife & Biodiversity; and Module 6: Boat Cleaning & Maintenance. https://www.sailing.org/inside-world-sailing/organisation/world-sailing/sustainability/

ICOMIA
ICOMIA is the international trade association representing the global recreational marine industry and bringing together national boating federations. ICOMIA has published numerous reports on anti-fouling products, accessible in its library. In addition, their website contains links to reports on other aspects related to the recreational boating industry (regulatory reference guide, etc.). https://www.icomia.org/icomia-library

Argentina
Parques Nacionales. Un video con recomendaciones de buenas prácticas para una pesca y navegación amigable con los ambientes nativos y evitar la dispersión de especies exóticas invasoras. Particularmente enfocado a la pesca deportiva. https://youtu.be/CHHsAj8sewQ

Australia
The Australian Government issued guidance: National biofouling management guidelines for recreational vessels (https://www.marinepests.gov.au/sites/default/files/Documents/recreational-vessel-biofouling-guidelines.pdf) including where to report any findings of marine pests.

Canada
Ontario's Invading Species Awareness Program. To prevent watercraft users from transporting aquatic invasive species, the Ministry of Northern Development, Mines, Natural Resources, and Forestry (MNRF) has regulated watercrafts (i.e., boats, canoes, and kayaks) and watercraft equipment as "carriers" under Ontario's Invasive Species Act, effective January 1, 2022. http://www.invadingspecies.com/pathways/boating/

West Canada Invasive Species Centre. Provides information about the rules and regulations in place to stop the spread of aquatic invasive species, like invasive mussels, in West Canada. https://www.invasivespeciescentre.ca/know-before-you-go/

British Columbia. The website provides information about the Clean Drain Dry program created in British Columbia to help reduce the spread of invasive plants and organisms. https://bcinvasives.ca/play-your-part/clean-drain-dry/

New Zealand
New Zealand has comprehensive regulations on biosecurity for all visiting vessels. The **Craft Risk Management Standard** (CRMS - https://www.mpi.govt.nz/dmsdocument/11668-Biofouling-on-Vessels-Arriving-to-New-Zealand-Craft-Risk-Management-Standard) defines the 'clean hull' threshold that is acceptable, and the procedures to follow at port of entry, including documentation. This is proactively enforced by the Ministry for Primary Industries (MPI).

Cleaning boats: removing pests and water plants: https://www.mpi.govt.nz/outdoor-activities/boating-and-watersports-tips-to-prevent-spread-of-pests/cleaning-boats/

Boating New Zealand: https://boatingnz.co.nz/invasive-species/

United Kingdom
RYA advice on preventing the spread of invasive non-native species, which covers freshwater as well as coastal sailing. https://www.rya.org.uk/knowledge/environment/invasive-non-native-species

There are further links to biosecurity guidance for RIBS, sports boats, and for Biosecurity for boat and kayak (https://www.nonnativespecies.org/biosecurity/) users from the GB NNSS.

The RYA was commissioned by the Council of Europe to develop a European Code of Practice on Recreational Boating and Invasive Alien Species (https://rm.coe.int/CoERMPublicCommonSearchServices/DisplayDCTMContent?documentId=09000016806be12c) to ensure that we are playing our part to stop the spread across Europe. It was adopted by the Bern Convention in November 2016.

The Green Blue is another important initiative launched in the UK to facilitate sustainable boating and help the boating community to safeguard coastal and inland waters https://thegreenblue.org.uk/clubs-centres-associations/facilities-operations/biosecurity/

United States of America
The Aquatic Nuisance Species Task Force (ANSTF) updated their guidelines in 2013: Voluntary Guidelines to Prevent the Introduction and Spread of Aquatic Invasive Species: Recreational Activities (https://www.fws.gov/program/aquatic-nuisance-species-task-force/outreach).

The ABYC (American Boat and Yacht Council) issued technical guidance ABYC T-32 (https://images.saymedia-content.com/.image/cs_srgb/MTU3NDIzNjIzOTM2NjgxMTYy/invasive-manufacturing.pdf) on Design and Construction in Consideration of Aquatic Invasive Species which aims to support the Clean Drain Dry message through design.

Sailors for the Sea has issued some guidance and its website is a valuable source of information both for preventing invasive species and for the application of anti-fouling paints:
https://www.sailorsforthesea.org/programs/green-boating-guide/invasive-species-prevention
https://www.sailorsforthesea.org/programs/green-boating-guide/bottom-paint

California has issued Best Management Practices for In-water cleaning, to be used by commercial divers: http://file.lacounty.gov/SDSInter/dbh/docs/1042893_HullCleaningOrdinance.pdf

The BMP contains useful information for any DIY in-water cleaning: http://file.lacounty.gov/SDSInter/dbh/docs/1025206_LACBH_HullCleaning_Mar8.pdf

The **US Department of Agriculture** has stop aquatic hitch-hikers (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_029120.pdf) following the Clean Check Dry message for the boat, equipment and the dog, including suggesting methods of cleaning with hot water, or vinegar, or 1% salt solution.

Prevent the Spread of Aquatic Invasive Species (New York State Department of Environmental Conservation) https://youtu.be/4Y8zoOrAQ5Y

Maine Lakes Environment Association: Training resources for courtesy boat inspectors
https://youtu.be/YfbaibaiMBU
https://mainelakes.org/invasives/courtesy-boat-inspections/
https://youtu.be/ruXVqJ4wcmM

Stop Aquatic Hitchhikers is a call to action that empowers recreational users of aquatic resources in the United States and other countries to help stop the spread of harmful aquatic invasive species through outreach and partnerships.
https://stopaquatichitchhikers.org/

The **Invasive Mussel Collaborative** in the USA provides an ample range of resources and links to several videos and many resources from several States, including information on watercraft inspections (some States have inspection stations, where boats are checked to ensure that there are no invasive species, visible or not, attached to the watercraft). https://invasivemusselcollaborative.net/monitoring-prevention/recreational-users/

7.2 Identification of Invasive Aquatic Species

IUCN and invasive species

IUCN Species Survival Commissions Invasive Species Specialist Group (ISSG) produces the Global Invasive Species Database (GISD) which is a free online searchable source of information about alien and invasive alien species, including Invasive Aquatic Species. The GISD aims to increase public awareness about introduced species that negatively impact biodiversity and to facilitate further prevention and management

activities by providing easy access to authoritative invasive species information. www.iucngisd.org/gisd/

IUCN has published a global standard on measuring impacts of invasive species upon the environment. The Environmental Impact Classification for Alien Taxa (EICAT) is a simple, objective and transparent method that classifies alien taxa into one of five impact categories, according to the magnitude of the detrimental impacts on native biodiversity. EICAT can be applied at a national, regional and global level, and all assessments undertaken at the global level are published on the GISD. https://www.iucn.org/resources/conservation-tool/environmental-impact-classification-alien-taxa-eicat

IUCN also produces the IUCN Red List of Threatened Species™ which documents the threats and species extinction risk for marine and terrestrial animals, plants and fungi. To date, more than 147,500 species have been assessed. https://www.iucnredlist.org/

Invasive species compendium by CABI

The Invasive Species Compendium (ISC**)** is an encyclopaedic resource that brings together a wide range of different types of science-based information to support decision-making in invasive species management worldwide.

CABI is an international not-for-profit organisation that works to improve people's lives worldwide by solving problems in agriculture and the environment.

https://www.cabi.org/ISC/ The website enables searching by common name or Latin/ scientific name and provides information on introduction and spread, means of movement and dispersal and environmental impact.

7.3 Reporting Invasive Aquatic Species

The first place to report any findings, or suspected findings of IAS will be the local harbour, port or river authority.

There are also various specialist sites for reporting Invasive Aquatic Species, depending on where you are in the world.

Australia – Use the Report a Pest website: https://www.marinepests.gov.au/report

Mediterranean - The IUCN owned MedMIS is an online information system for monitoring invasive non-native species in Marine Protected Areas (MPAs) in the Mediterranean Sea. There is a guide to all the IAS, the number of reports and a guide on how to report any sightings - Get involved (https://www.iucn.org/about-iucn).

United Kingdom – The GB non-native species secretariat (NNSS) covers all invasive species, not just marine. It has an 'Alert' list, ID sheets, and other information. Sightings should be reported to https://www.nonnativespecies.org/what-can-i-do/recording/

USA Fish & Wildlife Service Invasive Species website (https://www.fws.gov/program/invasive-species) has information about IAS. Their guidance on reporting is:

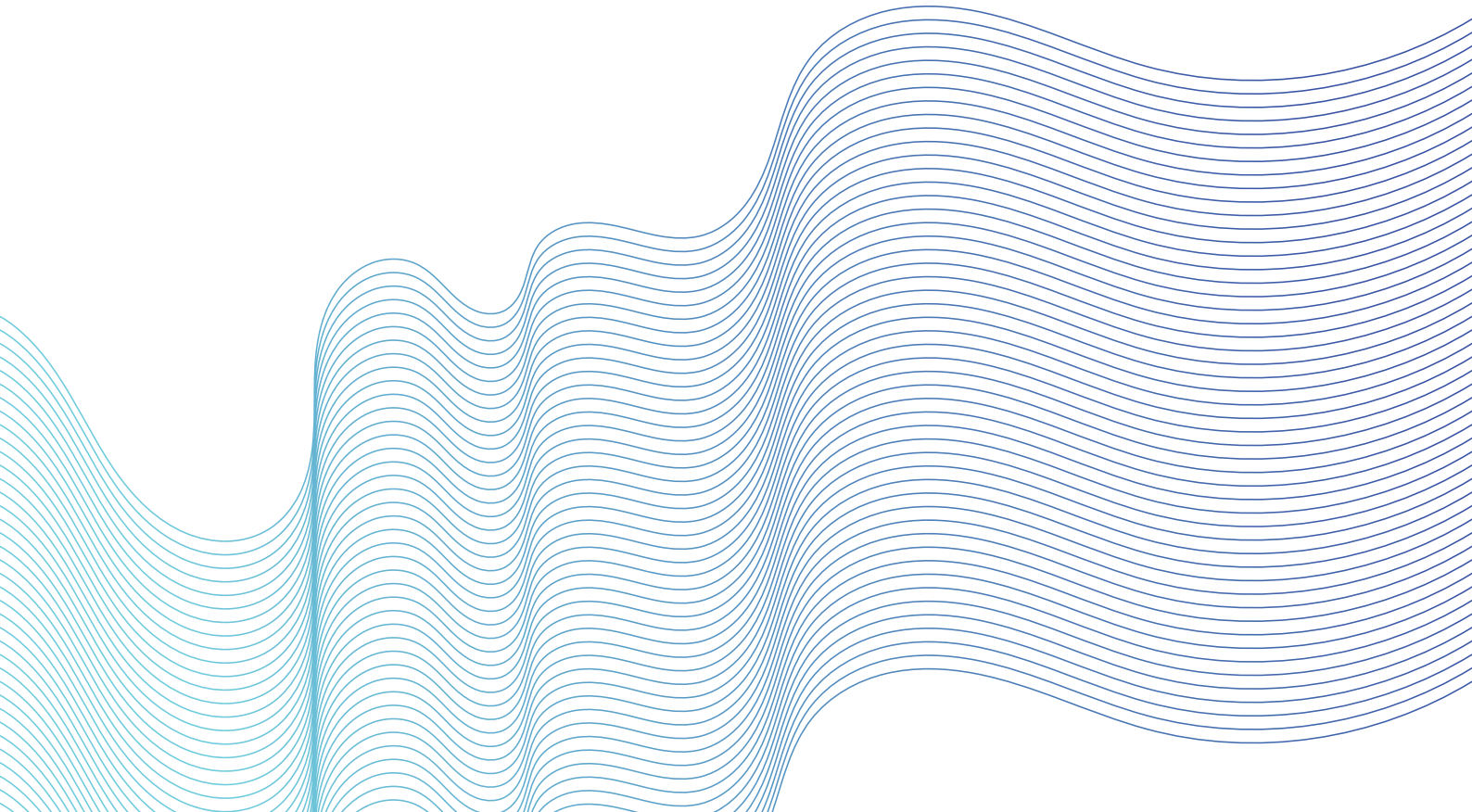
If you are in a National or State Park, National Wildlife Refuge, or other piece of public land and you think you may have discovered a new invasive species, you should contact the closest park or refuge office and see if they are aware of the invasive species.

If you think you have found an aquatic invasive species, you should try and alert the local office as mentioned above, but there are two other ways you can report the discovery.

- To report an aquatic invasive species by phone, the U.S. Fish and Wildlife Service and the U.S. Geological Survey maintain an ANS Hotline at 800-STOP-ANS (877-786-7267).
- To report an aquatic invasive species online, please follow this link to the USGS Nonindigenous Aquatic Species Sighting Report Form (https://nas.er.usgs.gov/SightingReport.aspx).

8

SUPPLEMENTARY REPORTS



8.1 Gaps

PATCHWORK OF REGULATIONS

New Zealand has implemented strict biosecurity controls at their borders, with clear information for all visiting boats. The location of New Zealand, and its distance from other countries means that visiting boats need to plan their journeys in advance, rather than a weekend visit as in many other parts of the world.

This level of biosecurity control between nations will not be easy to replicate in other parts of the world without significant commitment and investment by governments and regulators.

While increased focus on the biofouling issue is expected to catalyse the development of more policies or requirements at the national level, at the time of writing this report there are few other countries that have a national regulation focusing specifically on biofouling. However, in many countries there are different entities (regional or local authorities, environmental agencies, etc.) that, spurred by the identification of Invasive Aquatic Species in their geographical area, have issued requirements applicable to recreational boating in their jurisdiction. In some instances, and due to differences in requirements or procedures, this patchwork of regulations or requirements can confuse the recreational boating community and, unless there are clear sources of information, it may affect compliance. It is important that information about any requirements related to biofouling management and the prevention of Invasive Aquatic Species is publicly available, shared and promoted within the recreational boating community.

IMPROVING AWARENESS

Providing clear information and guidance to users around the role of ships' biofouling as a vector for introducing and spreading IAS will be a strong first step in raising awareness.

In a survey conducted by GloFouling Partnerships in 2021, 85% of respondents were aware of IAS, reducing to 70% who said they were aware of biofouling as a vector for IAS. A careful analysis by region highlighted that awareness of biofouling as a vector was low in the Northeast Pacific, East Asian seas and the Indian Ocean.

With regard to sources of information, responses to the same survey confirmed that 26% received information from the internet and blogs, and 24% from industry service providers and manufacturers; with only 5% from government and 4% from NGOs, including ICOMIA, World Sailing and national sailing federations.

Another survey in the Netherlands from 2018[39] of a group of harbours masters, state representatives and recreational boat users found that all questionees were aware of the risks of biocides in anti-fouling systems, but not of the risks of alien species being spread by hull fouling. IMO guidance focussed on recreation craft (MEPC.1/Circ. 792) was unknown to most questionees before the survey.

Many of the controls in place were in line with current IMO guidance, but this was to maintain Blue Flag status[40] rather than control if IAS. In general, the guidelines in the IMO guidance were found to be adequate for their purpose to minimize the transfer of Invasive Aquatic Species as biofouling on recreational crafts.

One recommendation from the survey was to further engage with Blue Flag to raise awareness of IAS as well as pollutants potentially released from coatings. This could be achieved through the existing criteria for marinas to annually organize educational events aiming at raising the environmental awareness of harbour masters and recreational craft owners.

There are many examples of guidance aimed at inland water users, all based around the Check, Clean, Dry message.

Where there is guidance available for coastal vessels, this appears to be less accessible, both in presentation and availability. Possible reasons for this include:

- Lack of single solution (Clean, Check, Dry) for managing biofouling on permanently afloat vessels.
- Uncertainty on the biocidal anti-fouling paint vs protection of marine species dilemma
- Low demand for information due to low perceived risk/ lack of knowledge of IAS transfer on biofouling
- Lack of facilities or cost of services to follow recommendations for enhanced management of biofouling.

This information and guidance need to be tailored for the target audience. For example, 'Check, Clean, Dry'

works well for trailer boats on inland waters but is not as relevant to a permanently afloat boat in a coastal harbour. As seen in an Australian survey[41], not all recreational boat users are the same. To start to close these gaps, the aim must be to raise awareness of IAS with all interested parties, as listed in the table below:

Reaching this wide range of interested parties will require a targeted approach and for maximum engagement, in terms of information, and how the message is communicated.

The best practices presented in chapter 6 aim to address this gap. These recommendations, or similar, will need to be regularly communicated to the different groups of interested parties.

LACK OF CLARITY ON SOLUTIONS TO MANAGE BIOFOULING

This applies mainly to coastal vessels, as trailer or portable craft have the Clean, Check, Dry message.

All vessels that remain in the water need some form of anti-fouling system. From this point onwards, there is a myriad of options for the recreational boat owner that faces taking decisions such as:

- Biocidal vs non-biocidal systems
- Annual maintenance or longer-term coating
- Is in-water cleaning a good option or harmful to the environment?
- Hull material and performance

It is not possible to provide a simple answer for boat owners as there are so many variables. Product information including performance comes from the manufacturer, making it difficult to assess and compare information. There are various new biocide-free systems available, but there are no comprehensive evaluations, or owner experiences to inform boat owners, other than manufacturer trials.

As discussed in Chapter 5, a successful anti-fouling coating needs to tick many boxes: it should be durable, reliable, easily applicable, stable, cost-effective, minimal harm to the environment, and substrate independent. This is a considerable challenge. So far, no single chemistry has been identified as the universal anti-fouling strategy to meet all requirements and trying

Table 2: Interested Parties who should be aware of IAS

Stakeholder categories	Type
Boat owners	Inland
	Coastal
	Power
	Sail
	Racing / performance
	Cruising
Commercial operators – providing services to boat owners	Marinas
	Ports
	Public authorities
	Contractors
	Divers
NGOs	National Sailing organisations / federations
	Media, magazines, commentators, bloggers
Regulators	International
	National
	Local authorities
	Border control / customs
	Environmental health (pollution control, water quality)
	Politicians to set Policy and regulations

to develop one universal coating strategy is likely to be an unreachable goal[42]. Instead, industry and boat owners should make use of synergetic strengths by combining several anti-fouling strategies into one multifunctional coating.

It would be helpful for all interested parties (see Table 2) to have more informed studies / reports on the solutions to enable recreational boat owners to select the best option for their vessel and location. Developing a standard process or metrics for measuring the safety and performance of the different anti-fouling systems and solutions would enable consumers and regulators to compare products on a like for like basis and select products most suitable to their vessel and its intended use.

8.2 Limited Engagement with users

8.2.1 How to present, communicate and enhance the use and circulation of these Recommendations among potential users

An Australian survey in 2018[43] found there was a 95% awareness of marine pest risk amongst the recreational boaters who took part in the survey, with a slightly lower number 86% aware that all boats can transfer marine pests if biofouling is present. This is a higher level of awareness than found by the IMO survey in 2021 for which 70% of respondents were from the UK.

Australia is a country with a strong biosecurity system, and as anyone who has visited Australia will have experienced, under Australian law, all air and cruise lines coming into Australia must provide an approved passenger message prior to arriving. In the Netherlands survey of 2018 (see 10.1.2 Awareness), the IMO guidance focussed on recreation craft (MEPC.1/Circ. 792) was unknown to most questionees before the survey.

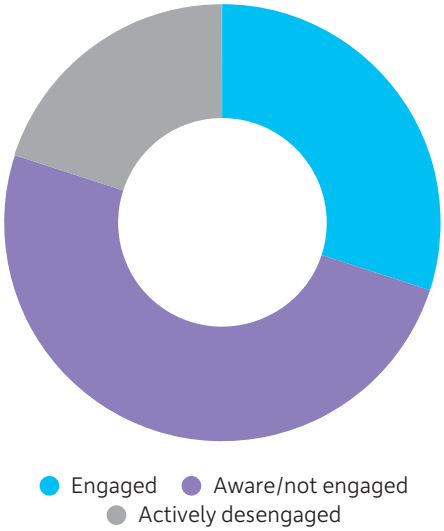
Among this highly 'aware' group of respondents in Australia only 20% were aware of key national biofouling guidelines. Despite this, 60% of respondents were adopting many of the best practices, including: regularly cleaning the boat hull, cleaning the niche areas of the boat, renewing the anti-fouling coating each year and capturing the biofouling waste after cleaning. However, only about a third were cleaning the boat before moving it to another location.

This demonstrates the challenge on educating recreational boaters around the world, as even in a country with high biosecurity awareness, there is only 20% awareness of the national guidelines.

Part of the communication challenge is that, as the survey found, recreational boat users are not all the same. The survey identified the following groups of boat users:

- 43% of respondents categorised as Minimalists – DIY group. Infrequent cleaning and anti-fouling suggest high risk for biofouling growth and marine pest translocation.
- 19% Comprehensive regime – active club members, typically motivated by boat efficiency and performance. Due to lack of biofouling, considered low risk of marine pest translocation.
- 38% as OK but could improve. Some confusion around in water cleaning, so recommend improved guidance.

Engagement level (example)



Within each of these groups of boat users, there will be a range of engagement regarding biofouling management and biosecurity risks.

Some users will be actively engaged and want to do all they can to manage biofouling and the associated risks from IAS.

Others will be managing biofouling to some level, but not particularly concerned or aware of the biosecurity elements of biofouling control.

And there is a third group who have no interest, or do not care about biofouling and the risks from IAS.

One way to improve engagement is to consider the social and financial impacts as well as the risk to biodiversity. A study of 182 environmental projects in Columbia, Canada[44], found that communication and education is rarely considered an important part of legislation or management strategies in Columbia.

The report made five recommendations to improve engagement:

- Promote more clearly the benefits humans get from nature / ecosystems in policies, plans and programmes.
- Ramp up education and training programmes.
- Make communication, education and participation actions the core of all projects, from design to implementation.
- Consider and engage with a more diverse set of stakeholders, above all indigenous communities and women.
- Develop and implement social indicators to evaluate environmental management practices (e.g., quality of participation of stakeholders involved) to complement the more commonly used environmental measures of success.

To add to the engagement challenge, people of different age groups respond best to different styles of communication.

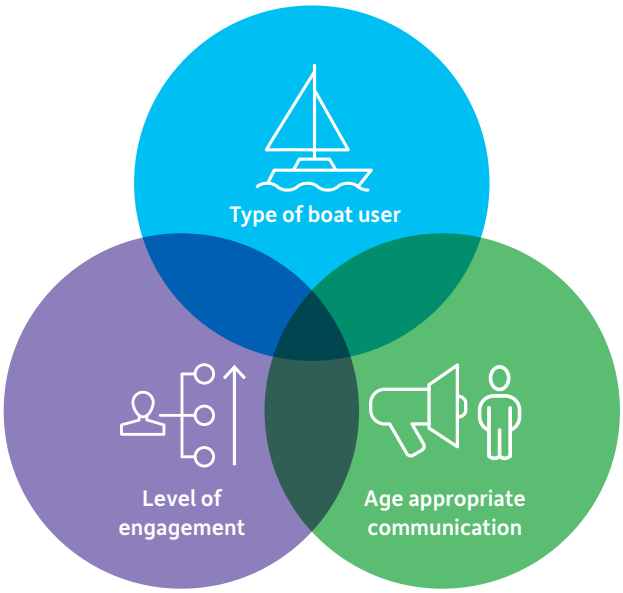
Research around workplace engagement has highlighted the differences between generations[45].

- **Baby Boomers** (ages 55-73) are embracing digital technology, including smartphones and social media, but they still want to maintain opportunities for face-to-face communication when possible.
- **Generation X** (ages 39-54) are not digital natives, but they are just as likely to be comfortable using technology in the workplace. More than half say they are tech-savvy.
- **Millennials** (ages 23-38) or Generation Y want to work for a company that embraces technology more so than the generations before them. In general, Millennials want mobile technology that facilitates collaboration and teamwork.
- **Generation Z** (ages 22 and younger) has never known a world without technology and expects the tech they use in the workplace to be just as frictionless as the apps they use at home. Web based communication is the norm.

8.2.2 Adapting communication

Therefore, to be successful, any communications will need to be tailored to engage with these different groups to improve their willingness to engage with IAS. The same information can be used; however, it will need to be presented in different formats to meets the needs / expectations of these different groups.

3 Dimensional engagement



Depending on the location and expected audience of the best practice guidelines, the format will need to be adapted. At the risk of generalising all people:

- For Generation Z, public notices probably need to be eye catching, therefore diagrammatic.
- For Baby boomers and Generation X, supporting information needs to be backed up by science / research but readable.
- Younger readers generally want shorter, snappier style, older readers are more used to longer sentences.

ENGAGEMENT MATRIX

Example of an engagement matrix that may guide the development of communication materials and their adaptation to educate recreational boat users, based on their existing level of engagement.

Engagement level	Boat users	Marinas
I want to manage biofouling and transport of invasive aquatic species because...	I care about the environment and biodiversity of the areas where I use my boat	I care about the environment and biodiversity of the marina and the surrounding area
	I care about the local businesses and livelihoods of the people where I use my boat and the potential harm I can cause through IAS	I care about the businesses and livelihoods of the people in and around my marina and the potential harm that can be caused through IAS
I want to manage biofouling because...	I care about the higher emissions caused by biofouling	
	It affects the performance of my boat, either racing, faster passage times when cruising and fuel efficiency	I want to proactively maintain and avoid damage to machinery and equipment in the marina (locks, workboats, pumps)
	It looks bad and I want to keep up appearances	It looks bad and I want to keep up appearances
I manage biofouling because...	That is what I have always done	
	It causes damage to my boat / propeller, engine inlets	It clogs up and damages machinery and equipment in the marina (locks, workboats, pumps)
I have to manage biofouling because...	It is a requirement of the area where I use / want to use my boat	It is a legal requirement for the region / country where I operate
I don't manage biofouling...	It's my boat, don't go far from home	It's just an additional cost with no benefit
	I don't believe it's a problem for me	
	It's a conspiracy dreamt up by the paint companies to charge more	

Encourage or educate people to move up a level

8.3 Communication of best practices

As described in the previous section, for effective communication of these recommendations and best practices, there will need to be a multi-faceted approach.

To add another dimension, there could be 2 broad types of guidance for recreational boaters.

- General background information – Government guidance, local authority, National associations, clubs
- Event specific guidance – races, competitions, spring launch and end of season lift out.

General guidance: There is already general guidance available; this includes these Recommendations published by the GloFouling Partnerships project, the IMO Guidance for minimising transfer of IAS as Biofouling for Recreational Craft, the New Zealand CRMS, ABYC and the RYA guidance (see references in chapter 7) and some specific information from yacht and sailing clubs.

This could be enhanced by encouraging all national associations, clubs, owner associations, sports bodies, marina associations, industry bodies, port authorities, international rally organisers, governing bodies, etc. to have a policy, guidance or information on the risks of IAS. This should be relevant to the local area and to the audience of that association. For example, freshwater fishing clubs will have areas of concern that will be different from a sea-going cruising association. This guidance can have more supporting information, such

as links and references, as the audience will typically have more time to read and investigate.

A central source of information, such as IMO's GloFouling Partnerships project could have free images / videos /downloads which different regions can pick and mix as appropriate for their audience and region.

Event specific guidance will need to be shorter and provide clear dos and don'ts for that event. This could be for a sailing dinghy open event, an open water swimming event, fishing competition, international sailing event or a long-distance rally.

By the nature of these events, people will be travelling and may not be familiar with local guidelines, therefore there is an increased risk of transporting IAS.

This information can be included in an event pack, as well as in extra notices. National organisations or local regulators could provide this information for local event organisers to provide consistency. An example of this is the Biosecurity Pack provided by South Cumbria Rivers Trust made available for local event organisers https://scrt.co.uk.

Other 'events' include the typical spring launching, when anti-fouling systems are applied, and the end of season haul out. As with a competition, these are planned events where marina operators and boat owners will be focusing on biofouling management. This could be a win-win situation for commercial marinas, as they can use the awareness raising message as part of advertising their mid-season and end of season scrubs.

Marinas with the appropriate wash down & containment facilities should promote themselves and be rewarded for the investment in containment facilities, which will further raise awareness of the risks from IAS and biofouling.

9

EXAMPLES OF EXISTING REGULATIONS AND CONTROLS FOR IAS AND BIOFOULING MANAGEMENT

Country	Biosecurity regulations on prevention of IAS	Implications
Global	Guidance for minimizing the transfer of Invasive Aquatic Species as biofouling (hull fouling) for recreational craft. MEPC.1 Circ.792 2012	The International Maritime Organization (IMO) recommends that a recreational craft is hauled out of the water for cleaning the hull and niche areas at least every 12 months (International Maritime Organization 2012).
New Zealand	The Craft Risk Management Standard (CRMS) for Biofouling Craft Risk Management Standard (CRMS) for Biofouling All recreational vessels entering New Zealand waters are required to meet this standard, strictly enforced by Customs / Ministry for Primary Industries (MPI).	Vessels must meet the biofouling requirements by doing one of the following (and having documentation to prove it): Undertaking continual hull maintenance using best practices (recommended for short-stay vessels). Cleaning the hull and niche areas within 30 days before arrival in New Zealand (recommended for long-stay vessels). Booking an appointment for the vessel to be hauled out and cleaned by an MPI-approved treatment supplier within 24 hours of arrival (recommended for vessels coming to New Zealand for refit or repair). For long-stay vessels, the recommended option is to clean the vessel's entire hull, including all niche areas, fewer than 30 days before arrival to New Zealand. Acceptable evidence for cleaning of all hull and niche areas: may include hull cleaning or dry-docking reports. photographs or video of all hull and niche areas after cleaning. If your vessel is fouled and you want to have it hauled out or re-fitted in New Zealand, before you arrive you must: book an appointment for haul-out with an MPI-approved treatment supplier (the booking time must be within 24 hours of arrival) give MPI evidence of your booking with the provider. Currently, in-water cleaning of international vessels is not allowed in New Zealand. This means that there are no approved providers of in-water cleaning services for international vessels at this time. https://www.mpi.govt.nz/import/border-clearance/ships-and-boats-border-clearance/biofouling/yachts-and-recreational-vessels/
Australia	Australia Marine Pest Plan 2018-23. Anti-fouling and in-water cleaning guidelines - Department of Agriculture, Water and the Environment, 2019 National biofouling management guidelines for recreational vessels Version 1.0, 2009	The Pest plan has 5 Objectives including supporting biosecurity research and engaging with stakeholders to better manage marine biosecurity. The Anti-Fouling and In-water Cleaning Guidelines recommend regular, 6-12 monthly, cleaning of submerged surfaces, particularly niche areas of recreational vessels (Australian Government 2015). The 2009 Guidelines for Recreational Vessels recommends: your hull has an effective anti-fouling coating that is less than 12 months old. you clean your vessel's hull and any equipment that has been in contact with seawater at your last port of call or within one week prior to arriving in Australia. all biofouling waste should be contained, collected and disposed of appropriately after cleaning the hull into identified bins at a licenced vessel maintenance facility

Country	Biosecurity regulations on prevention of IAS	Implications
Europe	Regulation (EU) no 1143/2014 on the prevention and management of the introduction and spread of invasive alien species. (not particularly marine) The EU Biodiversity Strategy (May 2020) and the Maritime Strategy Framework Directive addresses invasive alien species and calls for improved implementation of the EU Invasive Alien Species Regulation. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0056 Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) – European Code of Conduct on Recreational Boating and Invasive Alien Species	The prevention approach acting on pathways and vectors of introduction is globally acknowledged as the best possible management strategy to mitigate marine bio-invasions. However, the prevention actions appear to be very poorly actuated and harmonised. A major issue is the multiplicity of vectors involved in the marine invasion phenomenon. While current provisions mainly focus on prevention of ballast water other vectors are weakly addressed, if not completely ignored. These include biofouling on recreational vessels, *IUCN Tech report* IUCN recommended actions should focus on a multi-vector approach: development of a regional biofouling assessments, including the recreational boating vector, following virtuous examples from other marine regions, establishment of reception facilities for biofouling in ports, surveying and certifying ships and boats, inspections of hulls and applying penalties for infringements, more stringent regulation applied on vessels moving out from acknowledged 'hot-spots' of bio-invasions, e.g., lagoons, heavily fouled ports, etc. The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) has been involved since 1993 in providing guidance to governments on avoiding new introductions and controlling the spread of invasive alien species. In 2010 the Standing Committee to the Convention endorsed a European Charter on Recreational Fishing and Biodiversity and in 2013 a European Code of Conduct on Recreational Fishing and Invasive Alien Species. In 2016, another code of conduct was published focussed on recreational boating. https://rm.coe.int/1680746815
California USA	Article 4.8 Biofouling Management Regulations to Minimize the Transport of Nonindigenous Species from Vessels Arriving at California Ports. Effective as of October 1, 2017.	Applicable for ships over 300GT, so excludes recreational vessels.
California, USA	*50333-1 Underwater cleaning* Underwater Hull Cleaner's Best Management Practices (BMPs) 2010 (McCoy & Johnson, 2010)	Best Management practices issued for in water cleaning by University of California where allowed. Key points: Wait 90 days after applying new paint. Use only a piece of sponge & other soft materials to clean the hull. Clean gently to avoid creating a plume or cloud of paint in the water. This recognises the issue with in-water cleaning from extra release of metals but does not address the potential release of IAS to local environment.

Area	Regulation on prevention of pollution	Implication
Global	IMO - International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001 (AFS Convention)	Anti-fouling systems containing organotin compounds acting as biocides must not be applied or be present on the hulls or external parts or surfaces of all ships and boats. Boats of 24 metres in length or more but less than 400 gross tonnage engaged in international voyages must carry a declaration of compliance. Aside from organotin tributyltin (TBT) an amendment to the AFS Convention will enter into force at the end of 2022 to limit the use of cybutryne.
Washington State, USA	In 2011, the Washington State Legislature passed *RCW 70.300.020 – Restrictions on Sale and Application of Anti-fouling Paint Containing Copper,* to phase out the use of copper-based anti-fouling paints on recreational boats from 2018. (A recreational vessel is defined in the law as being no more than 65 feet in length and used primarily for pleasure.)	However, a review by the Department of Ecology found that some non-copper alternatives might be more harmful to the environment than the copper-based paints they would have replaced. This uncertainty caused the legislature to delay the ban until 2026 and directed the Department of Ecology to review risk assessments, scientific studies, and other relevant analyses regarding the toxicity and environmental impacts of anti-fouling paints. The Department of Ecology continues to be concerned that non-copper anti-fouling alternatives may pose a significant threat to Washington's environment. In water cleaning prohibited for hulls with soft, toxic coatings. State Waste Discharge General Permit for Boatyards (boatyard general permit) required for managing wastewater from pressure washing
UK	Trade effluent – UK Water Resources Act, Environmental Permitting Regulations	Most countries have similar regulations on trade effluent controls, with strict limits on zinc and copper levels, whereby trade effluent cannot be discharged to 'controlled' waters, such as rivers and estuaries without a permit or licence, which will have strict controls and limits.
EU	EU Biocidal Products Regulation (BPR) refers to Regulation (EU) 528/2012) concerning the placing on the market and use of biocidal products.	Approval process for active substances and products includes a Risk Analysis, including risk to humans as well as the natural environment. Purpose is to prevent harm to people and the environment;

Area	Voluntary Guidelines	
USA	Voluntary guidelines to prevent the introduction and spread of aquatic invasive species: recreational activities	*Stop Aquatic Hitchhikers! TM* is a national education campaign that helps recreational users to become part of the solution to stop the spread of AIS.

ENDNOTES

1 Ferrario, Sarah Caronni, Anna Occhipinti-Ambrogi & Agnese Marchini (2017) Role of commercial harbours and recreational marinas in the spread of non-indigenous fouling species, Biofouling, 33:8, 651-660, DOI:10.1080/08927014.2017.1351958

2 International Maritime Organization. (2012). Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling (Hull Fouling) for Recreational Craft. London: IMO.

3 GEF-UNDP-IMO GloFouling Partnerships (2021). Impact of Ships' Biofouling on Greenhouse Gas Emissions. Preliminary results. 2021.

4 CABI 2021. (1993). Dreissena polymorpha (zebra mussel) - Social Impact - in Invasive Species Compendium, Wallingford, UK: CAB International. www.cabi.org/isc [Accessed June 4, 2021]

5 Rothlisberger, J., Finnoff, D., & Cooke, R. (2012, February 29). Ship-borne Nonindigenous Species Diminish Great Lakes Ecosystem Services. Retrieved June 9, 2021, from //doi.org/10.1007/s10021-012-9522-6

6 Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M., Ozturk, B., Cardosa, A. (2014). Impacts of invasive alien marine species on ecosystem services and biodiversity:. Aquatic Invasions, 9(4), 391-423.

7 Summerson, R., Skirtun, M., Mazur, K., Arthur, T., Curtotti, R., & Smart, R. (2013). Economic evaluation of the costs of biosecurity response options to address an incursion of Mytilopsis sallei (black-striped mussel) into Australia. Canberra: ABARES Report to client prepared for Plant Health Australia.

8 Natural_Devon. (n.d.). Devon Invasive Species Initiative (DISI) FACT SHEET - Carpet Seasquirt. https://www.naturaldevon.org.uk/wp-content/uploads/2018/12/Carpet-Sea-Squirt-DISI-Species-Factsheet.pdf [Accessed June 4, 2021]

9 https://www.invasivespeciescentre.ca/invasive-species/meet-the-species/fish-and-invertebrates/spiny-waterflea/ [Accessed August 12, 2021]

10 CABI 2021. (n.d.). Austrominius modestus in Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc [Accessed June 4, 2021].

11 Klassen, G., & Locke, A., 2007. A biological synopsis of the European green crab, Carcinus maenas. Canadian Manuscript Report of Fisheries and Aquatic Sciences, Issue 2818.

12 Burchnall, W. (2012, Dec 24). Wetland Biosecurity Officer, Braods Authority, UK. (B. News, Interviewer)

13 Gergs, R., & Rothhaupt, K. (2008). Effects of Zebra mussels on a native amphipad and the invasive Dikerogammarus villous; the influence of biodeposition and structural complexity. Journal of the North American Benthological Society, 27(3), 54-548.

14 Anderson, L. (2004). Eradication of Caulerpa taxifolia in the US 5 years after discovery; are we there yet? Ennis, Co Clare, Ireland: 13th International Conference on Aquatic Invasive Species.

15 West, E., PB, B., JT, W., & AR, D. (2007). Anchors aweigh; fragment generation of invasive Caulerpa taxifolia by boat anchors and its resistance to desiccation. Aquatic Botany(87(3)), 196-202.

16 Relini, G; Relini, M; Torchia, G; 2000. The Role of fishing gear in the spreading of allochthonous species; the case of Caulerpa taxifolia in the Ligurian sea. *ICES Journal of Marine Science, Volume* 57(5), pp. 1421-1427.

17 Karatayev, A., Burlakova, L., & Paddila, D. (2002). Impacts of Zebra mussel on aquatic communities and their role as ecosystem engineers. Invasive Aquatic Species of Europe, Kluwer Academic Publishers, 433-446.

18 CABI 2021, 1993. *Dreissena polymorpha (zebra mussel) - Social Impact - in Invasive Species Compendium, Wallingford, UK: CAB International*. [Online] Available at: www.cabi.org/isc [Accessed June 4, 2021].

19 CABI_2021, 2014. *Dreissena rostriformis burgensis - Roy et al 2014*. [Online] Available at: www.cabi.org/isc [Accessed June 4, 2021].

20 Karatayev, A., Burlakova, L. & Paddila, D., 2002. Impacts of Zebra mussel on aquatic communities and their role as ecosystem engineers. *Invasive aquatic species of Europe, Kluwer Academic Publishers*, pp. 433-446.

21 CABI & Pimentel, 2005. *Dreissena rostriformis bugensis in Invasive Species Compendium, Wallingford, UK; CAB International*. [Online] Available at: www.cabi.org/isc [Accessed June 2021].

22 Orlova, M., Therriault, T., Antonov, P. & Scherbina, G., 2005. Invasion ecology of quagga mussels (Dreissena rostriformis bugensis); a review of evolutionary and phylogentic impacts. *Aquatic Ecology*, Volume 39(4), pp. 401-418.

23 New York Invasive Species Information. (2021, December 29). Rock Snot, Didymo. Retrieved from New York Invasive Species Information: http://nyis.info/invasive_species/rock-snot-didymo/

24 International Maritime Organization. (2012). MEPC.1/Circ.792. Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling (Hull Fouling) for Recreational Craft. London: IMO.

25 International Maritime Organization (2011). Resolution MEPC.207/62. 2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species. London: IMO.

26 Maan, M., Hofman, A., DeVos, W. & Kamperman, M., 2020. *Recent Developments and Practical Feasibility of Polymer-Based Antifouling Coatings*. [Online] Available at: https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202000936 [Accessed June 7, 2021].

27 Davidson, I et al, 2014, Vessel biofouling in Hawaii: current patterns of a potent marine bioinvasion vector and potential management solutions. Smithsonian Environmental Research Center.

28 Dalton, B. & Cottrell, S., 2013. Quagga and zebra mussel risk via veliger transfer by overland hauled boats. *Management of Biological Invasions*, 4(2), pp. 129-133.

29 Invasive Species Centre, n.d. *Killer Shrimp*. [Online] Available at: https://www.invasivespeciescentre.ca/invasive-species/meet-the-species/fish-and-invertebrates/killer-shrimp/ [Accessed 11 June 2021].

30 BBC_News;, 2012. *The superhero battling the killer shrimp in our waters*. [Online] Available at: https://www.bbc.co.uk/news/uk-england-20724883 [Accessed June 11, 2021].

31 CEPE. Sustainable use of biocidal antifouling products. https://www.vci-nord.de/fileadmin/vci-nord/Bilder/publikationen/1911CEPE_Sustainable_use_Final.pdf

32 Scianni, C. & Georgiades, E., 2019. *Vessel in-water cleaning or treatment: identification of environmental risks and science needs for evidence-based decision making.* [Online] Available at: https://www.frontiersin.org/articles/10.3389/fmars.2019.00467/full [Accessed June 8, 2021].

33 Tamburri, M. et al., 2020. *In-water cleaning and capture to remove ships biofouling: an initial evaluation of Efficacy and environmental safety.* [Online] Available at: https://www.frontiersin.org/articles/10.3389/fmars.2020.00437/full [Accessed June 7, 2021].

34 Department of Agriculture, 2015. *Anti-fouling and in-water cleaning guidelines*, Canberra: Department of the Environment and New Zealand Ministry for Primary Industries.

35 Department of Agriculture, 2015. *Anti-fouling and in-water cleaning guidelines*, Canberra: Department of the Environment and New Zealand Ministry for Primary Industries.

36 Woods, C., Floerl, O. & Jones, L., 2012. Biosecurity risks associated with in-water and shore-based marine vessel hull cleaning operations. *Marine Pollution Bulletin*, 64(7), pp. 1392-1401.

37 Tamburri, M. et al., 2020. *In-water cleaning and capture to remove ships biofouling: an initial evaluation of Efficacy and environmental safety*. [Online] Available at: https://www.frontiersin.org/articles/10.3389/fmars.2020.00437/full [Accessed June 7, 2021].

38 ABYC; 2018. T32 design and construction in consideration of aquatic invasive species. [Online] Available at: https://abycinc.org/general/custom.asp?page=AIS. [Accessed June 11, 2021].

39 GiMaRIS report 2018_72, Evaluation of biofouling guidelines in the Netherlands for the control and management of recreational ships' biofouling to minimize the transfer of Invasive Aquatic Species. Issued by the Dutch Ministry of Infrastructure and Water Management.

40 Blue Flag is one of the world's most recognised voluntary awards for beaches, marinas, and sustainable boating tourism operators. In order to qualify for the Blue Flag, a series of stringent environmental, educational, safety, and accessibility criteria must be met and maintained.

41 Stenekes, N., Kancans, R. & Binks, B., 2018. *Recreational boat operators' self management of biofouling in Australia, ABARES technical report*, Canberra: Aquatics and Marine Pests Unit, DAWR.

42 Maan, M., Hofman, A., DeVos, W. & Kamperman, M., 2020. *Recent Developments and Practical Feasibility of Polymer-Based Antifouling Coatings*. [Online] Available at: https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202000936 [Accessed June 7, 2021].

43 Stenekes, N., Kancans, R. & Binks, B., 2018. *Recreational boat operators' self management of biofouling in Australia, ABARES technical report*, Canberra: Aquatics and Marine Pests Unit, DAWR.

44 Burgos-Ayala, A. J.-A. A. R.-V. D., 2020. *Five ways to boost social engagement in environmental projects*. [Online] Available at: https://www.stockholmresilience.org/research/research-news/2020-05-29-five-ways-to-boost-social-engagement-in-environmental-projects.html [Accessed June 25, 2021].

45 Bloodworth-Rivers, T., 2019. 8 *Tips to Improve Communication Between Generations in the Workplace*. [Online] Available at: https://www.iofficecorp.com/blog/improve-communication-workplace [Accessed June 25, 2021].

More information:
GloFouling Partnerships Project Coordination Unit
Department of Partnerships and Projects
International Maritime Organization
4 Albert Embankment
London SE1 7SR
United Kingdom
www.glofouling.imo.org

IMO INTERNATIONAL MARITIME ORGANIZATION

Rushton Gregory Communications

My company works with Hempel and Propspeed - producers of biocide-free foul release coatings (FRC) for boat hulls (Hempel) and running gear, underwater lights and transducers (Propspeed). Hempel's Silic One has been proven effective for over 10 years in Europe and Propspeed for over 10-years in Oceana and Europe. Both company's products have been extensively tested, used on recreational (and commercial) vessels of all sizes including those under 24 meters. For both products, any fouling that does weakly attach is removed as the boat gets under-way. In the case of slower boats, any loosely adhered fouling can be easily removed by gentle wiping with a soft sponge. FRC-based coatings do not contain fluoropolymer-based binders or oils (PFAS) and organotin catalysts, and are less hazardous than biocidal antifouling paints and better for the environment. In addition, by protecting surfaces with Hempel and Propspeed, electrolysis and the degradation of zinc anodes is greatly reduced.

I urge you to look deeper into the benefits and performance of biocide-free foul release coatings that have been proven on thousands of recreational vessels in markets around the world.

December 20, 2023

CeRam-Kote AF Marine (CK-AF) Boat Bottom Paint

(A Safe & Effective Alternative to Copper Bottom Paint)

Information Requested by Washington State Ecology Department & Additional Comments

Information as requested:

1. CK-AF is an upgrade to CeRam-Kote Coatings standard CeRam-Kote 54 (CK-54) ceramic epoxy coating which has been applied throughout the military, industrial and marine markets since 1985. It meets the "food grade" requirements of FFDCA. CK-54 has been applied to boat bottoms for over 24 years as a "hard surface treated composite coating." It is still on boat bottoms after all that time, and environmentally oriented boaters love it. However, it does have to be cleaned one week sooner than copper bottom paint, and if allowed to fall behind a steady cleaning schedule, may require a greater scrubbing effort.
2. CK-AF is CK-54 with Zinc Oxide (ZnO) added as an *inert* ingredient to ward off marine fouling. It is rated as a "minimum risk pesticide" by EPA and does not require registration. CK-AF contains no cuprous oxide (Cu2O) and is not a leaching paint as is the case with most bottom paints, which are designed to allow water to penetrate the coating and leach out the toxins contained therein. The high concentration of ceramics prevents water from penetrating. Rather, the ceramic epoxy shell formed upon curing holds the ZnO indefinitely.
3. ZnO is an unbalanced molecule with extra electrons, called an *ion.* These ions form a self-contained ion field within the ceramic epoxy matrix. It serves as a very strong low voltage shield, which wards off marine microbes that normally attach to boat bottoms to form a biofilm. Algae feed on this biofilm, but without it they search for another surface to feed. Without algae to feed on, barnacles and other hard marine growth also search elsewhere for food, leaving the boat bottom free of marine fouling. The

marine “food chain” has been interrupted. And this process has been repeated throughout nature for thousands of years. CK-AF simply follows nature’s own way.

4. To my knowledge, CK-AF is the only bottom paint in the world which uses this proprietary technology. The ZnO is carefully selected to meet specific requirements, and the percentage of concentration is confidential.
5. I believe the frequency of cleaning in the Washington market can stretch beyond the 3-4 weeks cycle as practiced in California. The only substance to clean is occasional seaweed, and this is washed off when a boat is underway. If a boat remains in its slip for long periods, then the seaweed cleaning frequency will be determined by how often a diver cleans the running gear (props and shafts).
6. ZnO in other bottom paint is designed to leach, so that is why performance seemed inhibited in the reported sample. After the 56 days mentioned, it was simply expended.

Additional comments:

a. CeRam-Kote Coatings does plan to introduce CK-AF to the Washington market, and this communication serves to kick it off now. Since copper bottom paint has to be replaced every 2-3 years, over a relatively short period of time, CK-AF could replace all the copper leaching bottom paint and serve to eliminate the high concentration of copper in the water column in Washington State.
b. CK-AF has an expected life span of 10+ years at a minimum, so the cost of frequent copper bottom paint jobs can be greatly reduced for boat owners.
c. Also, CK-AF can be rolled on over old hard (modified epoxy) copper bottom paint without requiring expensive blast removal. The usual cleaning and sanding practice should be followed. The savings to the boat owner is especially beneficial here.
d. I would like to submit a formal public comment with you to the Legislature but am not familiar with the procedure. Perhaps this report can serve that purpose.
e. I trust testing of CK-AF by you can commence soonest, and we look forward to supplying the amount of coating required for the test panels. Please

note that I have been testing CK-AF in San Diego Bay for the past 4 years. IT WORKS.

f. The Port of San Diego and the Los Angeles Department of Beaches & Harbors are both in the process of coating boats with CK-AF. Some are from private boat owners, and some are port operation vessels. Such an effort by you would greatly speed up the qualification process.

Bill Kraus, CeRam-Kote Manager for Marine Coatings

USNA: BSEE, BSME (24 years perfecting marine coatings)

HQ San Diego

Office: 858-924-9611

Mobile: 858-775-8382

AMERICAN chemet CORPORATION

P.O. Box 1160
East Helena, MT 59635 USA

Telephone +1 406-227-5302
Fax +1 406-227-8522
nblossom@chemet.com

January 14, 2024

Iris Deng
Natural Resources Scientist
Department of Ecology
State of Washington
Iris.Deng@ecy.wa.gov
Phone: 360-480-6555

Submitted Electronically

RE: Antifouling Paints in Washington State: Third Report to the Legislature

American Chemet Corporation appreciates the opportunity to comment on the Washington State Department of Ecology's (DOE) *Antifouling Paint in Washington State: Third Report to the Legislature.* Thank you also for the well thought out and thorough report. The report exemplifies how well DOE understands the need for efficacious, safe coatings and has involved all relevant parties. American Chemet agrees with the report's general conclusion that Ecology cannot determine "that safer and effective alternatives to copper-based antifouling paints are feasible, reasonable, and readily available."

Copper-based antifouling coatings are the recognized most universally effective antifouling coatings globally available. It is estimated that 90% of global vessels, including recreational vessels, have copper-based marine antifouling coatings. Globally dozens of risk assessments have been conducted on copper based antifouling coatings and, in all cases, the continued use of these coatings has been approved. Many current regulatory activities and goals are focused on reducing greenhouse gas emissions from commercial and recreational vessels as well as preventing the further introduction of invasive species from hull fouling. This includes the International Maritime Organization's Glofouling Initiative and 2023 Strategy on Reduction of GHG Emissions from Ships, New Zealand's Craft Risk Management Standard for Biofouling, Australia's Biofouling Management Requirements, and California's Biofouling Management

Requirement. With the continued regulatory approval of copper based antifouling coatings and the emphasis on the extremely important goal of preventing global warming and reducing the introduction of invasive species in mind, we provide the following comments that we believe will help DOE improve the report and assist in a reasonable and productive path forward:

On page 4 of the report is mentioned the US EPA leach rate for antifouling paints that contain copper. We believe it should include mention that this only applies to recreational vessels.

Also, on page 4 the second paragraph discusses the toxicity of copper. We believe it could more fully express the complexity of this issue by beginning with "*Copper is a micronutrient and is ubiquitous in all aquatic environments. However elevated levels……".* Bioavailability is a key scientific fact that the audience of this report must understand, or an incorrect conclusion could be drawn that if copper exists in the environment there is a problem, and it is toxic. This also applies to the bioavailability and bioaccumulation discussion on page 14 of the draft. The bioaccumulation of copper has been well reviewed in the EU copper evaluation at the Technical Committee for New and Existing Substances (TCNES) and the Scientific Committee for Health and Environmental Risk (SCHER) and the conclusion was because of the essentiality of copper, an increase in body concentration of copper cannot be considered as "bioaccumulation" as commonly understood for typical organic molecules. To achieve optimum biological efficiency and growth, organisms actively and deliberately accumulate essential metals in nutrient depleted environments using bio-regulatory (homeostatic) mechanisms to ensure body concentration does not become harmful. For this reason, it is not relevant to define an essential metal as bioaccumulative as this has no meaning for homeostatically regulated essential metals.

TCNES and SCHER agreed with the conclusions of the review, which is that from the considerable amount of copper accumulation data available:

- There is an inverse relation between the copper bioaccumulation and copper concentrations in the environment.
- Waterborne exposure is most the critical exposure route in aquatic ecosystems.
- Copper is well regulated in all living organisms and that the concept of bioaccumulation has no meaning for hazard assessment of essential metals such as copper.

On page 14 in the second paragraph, we believe it would be more accurate and thorough if the statement, *"Copper is moderately bioaccumulative and is very toxic to aquatic organisms"* be removed. Instead, we recommend this statement, "*For the naturally occurring substances such as essential metals as copper, bioaccumulation is complex, and many processes are available to modulate both accumulation and potential toxic impact."*

On page 5 of the report, it is stated that cupric oxide is a dominant form of copper in antifouling coatings. We believe this is incorrect. Cupric oxide is used in wood treating and agricultural products, but it is not used in antifouling coatings. It is cuprous oxide that is used in antifouling coatings.

The draft states "*Concerns about salmon In Washington State, one of the motivations to phase out copper in antifouling paints is to protect culturally and ecologically important species, such as salmon. The sublethal effects of copper on Coho salmon, and particularly on the salmon's sensory function, have been well documented (Baldwin et al, 2003; McIntyre et al., 2008, 2012; Sandahl et al., 2007; Hecht et al., 2007)*." (page 12). All five studies cited are freshwater studies. The olfactory effect of copper is significantly reduced in marine water and the emphasis on this project by DOE is focused on marine water environments. It would be appropriate for DOE to mention in this draft that the studies cited are freshwater studies. The salmonid olfactory studies conducted in marine water, i. e. Labenia et al. (2007), Sommers et al. (2016), indicate that the threshold for negative olfactory effects in salt water may be significantly higher than concentrations found in marinas in Washington. This is a significant fact that greatly calls into question the primary justification for the legislation calling for this potential ban. In addition to mentioning the freshwater issue and the studies citing the lack of effect in salt water, it should be included that of the Hecht 2007 study cited in your draft it states, "*Dissolved copper's effect on salmonid olfaction in saltwater environments remains a recognized data gap and it is presently uncertain whether the BMC thresholds derived in this document apply to saltwater environments*," (page 16). We believe this should be noted in your report to assist in the direction of the future evaluation of salmonid olfactory effects due to copper.

The draft states "*DCOIT is a safer antifouling chemical comparing to copper.*" (page 19). We believe that DCOIT is a valuable biocide for use in marine antifouling coatings; however, coatings that only contain DCOIT are not effective coatings. DCOIT is almost exclusively used as a co-biocide with other biocides, most commonly cuprous oxide. In addition, DCOIT is not safer to humans. The US EPA's mandatory label for this active ingredient includes the following:

DANGER
CORROSIVE
CAUSES IRREVERSIBLE EYE DAMAGE AND SKIN BURNS
MAY CAUSE ALLERGIC SKIN REACTION
MAY BE FATAL IF INHALED
HARMFUL OR FATAL IF SWALLOWED OR ABSORBED THROUGH THE SKIN (US EPA pesticide registration #707-175 approved label, 2016)

Also, at this time DCOIT cannot be used in the USA on recreational vessels. The US EPA requires the following statement for this active: "*Paints formulated with this product are intended solely for commercial and military applications adhering to recommended safe handling procedures*." (US EPA pesticide registration #707-175 approved label, 2016) This should be mentioned in the final report to fully state the limits of this alternative.

Regarding the efficacy testing, FRC coatings, such as the 1100SR® and Propspeed®, are applied with the expectation of a 7-to-10-year life while biocide coatings generally have a 1-to-3-year life expectation. Therefore a 12-month evaluation of all coatings doesn't give an accurate comparison of efficacy. We recommend you mention this in your report and if possible, continue the panel test beyond 2024.

This report completes the third review by DOE of this subject with the analyses of alternatives to the use of copper in recreational vessel antifouling coatings. All three have reached the same conclusion. Biocide antifouling actives and coatings are continuously going through regulatory review in jurisdictions around the world. Biocide and biocide-free coatings are continuously going through introduction, evaluation, and use on thousands of vessels. If safer and more effective coatings are found, they will quickly get adopted and manufacturers will be introducing those coatings to markets around the world including Washington state. The use of Washington Department of Ecology resources to repeat this exercise for the fourth time is not necessary or productive. We encourage the Department of Ecology to request the Washington Legislature repeal the Antifouling Paints Law and allow Ecology to pursue more critical environmental and human health issues.

Once again, we thank you for the very well conducted review. The draft has very sound logic with an accurate overall conclusion. We offer these comments as an effort to assist DOE in concluding this review with additional clarity and pursuing a productive path forward in all its important work.

Best Regards,

Neal W. Blossom

Neal Blossom
Director of Global Regulatory Affairs
American Chemet Corporation
nblossom@chemet.com
(406) 459-3526

REEFERENCES

Labenia JS, Baldwin DH, French BL, Davis JW, Scholz NL. 2007. Behavioral impairment and increased predation mortality in cutthroat trout exposed to carbaryl. Marine Ecological Progress Series 329:1-11.

Sommers F, Mudrock E, Labenia J, Baldwin D. 2016. Effects of salinity on olfactory toxicity and behavioral responses of juvenile salmonids from copper. Aquatic Toxicology 175:260-268.

Hecht, S. A., Baldwin, D. H., Mebane, C. A., Hawkes, T., Gross, S. J., & Scholz, N. L. (2007). An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. Retrieved from https://repository.library.noaa.gov/view/noaa/3524

Seawide Distribution

Biocide-free paints for recreational vessels less than 24 metres in length (LOA) Effective, proven, safer and feasible Biocide-free foul release coatings will be available in Washington State for all types of recreational boats < 24m LOA from 2024. Seawide distribution welcome the opportunity to comment on the draft document “Antifouling Paints in Washington State : Third Report to the Legislature”. There are several inaccurate statements made in the draft report regarding biocide-free foul release coatings (FRCs). We therefore provide the information below and request that the section on FRCs is amended : Biocide free FRCs are commercially available for use on recreational craft As a market leader in fouling control coatings, Hempel developed and introduced a full range of biocide-free Fouling Release Coating (FRC) products based on silicone coating technology which are suitable for use on all types of leisure boats less than 24 meters LOA. First introduced in 2012, over 10 000 successful applications of biocide-free Hempel FRC products have since been made to the hulls of recreational boats across Europe. In September 2023, Hempel announced that it’s innovative, proven high-performance, copper-free, and biocide-free antifouling coating - Silic One will be available in the United States and Canada, distributed by SeaWide distribution [1] . Application and mode of action Silic One can be applied by consumers and works by providing an amphiphilic surface that microscopic settling stages of fouling organisms cannot strongly adhere to. The amphiphilic surface consists of a low surface energy and elastomeric silicone matrix combined with a superhydrophilic hydrogel microlayer which sets up on immersion, producing a non-stick surface which prevents organisms from attaching firmly to the hull. This technology is described in the presentation attached to this comment “Fouling control coatings for use on vessels less than 24 meters overall (LOA)”. Any fouling that does weakly attach is removed as the boat gets underway. In the case of slower boats, any loosely adhered fouling can be easily removed by gentle wiping with a soft sponge. The first biocide-free FRC product, Silic One was introduced by Hempel in 2012, and is proven to provide effective fouling control on leisure boats less than 24 meters LOA. Silic One is proven and effective In independent tests, Silic One has consistently showed performance on pleasure craft