2nd GEF-UNDP-IMO GloFouling R&D Forum and Exhibition on Biofouling Prevention and Management for Maritime Industries

11-14 October 2022
London, United Kingdom

PROCEEDINGS

GloFouling PARTNERSHIPS

gef UNDP IMO INTERNATIONAL MARITIME ORGANIZATION

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GloFouling Partnerships project:
The GEF-UNDP-IMO GloFouling Partnerships is a six and a half year global project aimed at protecting biodiversity by tackling the transfer of harmful aquatic species through biofouling in some of the developing regions of the world. The project encourages the sharing and adoption of technologies and innovative solutions that can improve biofouling management across all maritime industries and the energy efficiency of ships.

www.glofouling.imo.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

Implementing Agency:
UNDP – the United Nations Development Programme – partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 170 countries and territories to eradicate poverty and reduce inequality. We help countries to develop policies, leadership skills, partnering abilities, institutional capabilities, and to build resilience to achieve the Sustainable Development Goals. Our work is concentrated in three focus areas; sustainable development, democratic governance and peace building, and climate and disaster resilience.

www.undp.org

Funding Agency:
The Global Environment Facility (GEF) is a multilateral fund dedicated to confronting biodiversity loss, climate change, pollution, and strains on land and ocean health. Its grants, blended financing, and policy support helps developing countries address their biggest environmental priorities and adhere to international environmental conventions. The GEF connects 185 member governments with sustainability leaders across civil society, Indigenous Peoples, and the private sector, and works closely with other environmental financiers for efficiency and impact. Over the past three decades, the GEF has provided more than $22 billion in grants and blended finance and mobilized $120 billion in co-financing for more than 5,000 national and regional projects.

www.thegef.org

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

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LILIA KHODJET EL KHIL
Project Technical Manager - GloFouling Partnerships
Department of Partnerships and Projects
International Maritime Organization

I would like to express my deepest appreciation to everyone who collaborated in the 2nd Research and Development Forum and Exhibition on Biofouling Prevention and Management for Maritime Industries, held at the International Maritime Organization (IMO) headquarters, from 11 to 14 October 2022 in London, United Kingdom and contributed to its success.

In first place, I would like to sincerely thank Katy Ware, Director of UK Maritime Services & Permanent Representative of the United Kingdom to the IMO. We were honoured by her presence and her inspiring opening keynote speech of the Forum. We also wish to extend our gratitude to Mr. Xiaojie Zhang, Director of Technical Cooperation Division at IMO, for delivering the welcome address, as well as to Gyorgyi Gurban, Head of Projects Implementation at IMO's Department of Partnerships and Projects (DPP) for introducing the event.

Our sincere thanks go to all the session chairs, who so diligently facilitated and encouraged the discussions during the event, namely Craig Eason, who was also our moderator throughout the Forum, Paul Holthus, Andrew Want, Henrik Oksfeldt Enevoldsen, Geoffrey Swain, Guillaume Drillet, Gyorgyi Gurban, Agnese Marchini, and Sveinung Oftedal. Of course, great thanks to all the speakers for their papers, presentations, and participation in the discussions. Our appreciation also goes to poster presenters who contributed with their research work to the Forum's poster exhibition.

The Forum success is mainly to be attributed to the active participation of more than one hundred eighty delegates and participants throughout a week full of remarkable presentations on the various aspects of biofouling management and panel discussions, and we would like to extend our sincere appreciation to each one of them.

Finally, warm thanks to our IMO colleagues who supported the organization and delivery of the Forum, in particular Mr. Jose Matheickal, Ms. Gyorgyi Gurban, Mr. John Alonso, Ms. Marija Vranic, Ms. Jurga Šaule, Ms. Carolina Reyes Aldasoro, Ms. Sally McElhayer and Mr. Krishan Sivaneson, everyone from the Department of Partnerships and Projects who supported these efforts, as well as colleagues from other IMO sections who assisted with the logistics and catering.

FOREWORD

JOSE MATHEICKAL

Chief – Department of Partnerships and Projects

International Maritime Organization

These proceedings contain a selection of papers, presentations and posters from the 2nd Research and Development Forum and Exhibition on Biofouling Prevention and Management for Maritime Industries, held at the International Maritime Organization (IMO) headquarters, from 11 to 14 October 2022 in London, United Kingdom.

The Forum was organized by GEF-UNDP-IMO GloFouling Partnerships (glofouling.imo.org), a global technical cooperation project being implemented by IMO to address the transfer of aquatic invasive species via biofouling on ships and minimize greenhouse gas emissions from ships' biofouling.

This event brought together more than one hundred and eighty participants from forty-eight countries representing researchers; academia; leading scientific experts; technology developers; regulatory bodies; government delegates; and representatives from maritime industries such as shipping, ports and harbours, aquaculture & fishing, recreational boating, offshore oil & gas, and ocean renewables.

Over four days, sixty-eight speakers shared their expertise over twelve plenary sessions and seven panel discussions, which allowed an active discussion among participants, covering all aspects of biofouling management. These ranged from emerging technologies; environmental and economic impacts of invasive aquatic species; ocean renewable energy and aquaculture; port perspectives; role of recreational boating; biofouling and fuel efficiency and their potential for GHG emissions savings and policy aspects.

A session dedicated to improving women's participation in biofouling management was presented by a panel of all-women experts representing diverse roles in the biofouling field, in which the importance of increased awareness and commitment to gender equality and inclusion was emphasised.

In addition, an industry panel led by the World Ocean Council (WOC) discussed green investments to support innovation and technology development.

Representatives from the project's Lead Partnering Countries had the opportunity to discuss their experiences, challenges, and progress towards implementing biofouling best management practices.

Besides this comprehensive programme, several studies were presented during the Forum starting with the *Recommendations for biofouling management in the recreational boating sector.* The report was prepared by the GloFouling Partnerships project, in collaboration with the International Council of Marine Industry Associations (ICOMIA), World Sailing, and the International Union for Conservation of Nature (IUCN).

Furthermore, two new studies commissioned by the project's Global Industry Alliance (GIA) for Marine Biosafety were presented. The first study *'Analysing the Impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures'* presents results from seven anti-fouling strategies that demonstrate the magnitude of GHG emissions and cost savings that can be achieved by keeping a ship as clean as possible from biofouling.

The second study, *'Compilation and Comparative Analysis of Existing and Emerging Regulations, Standards and Practices Related to Ships' Biofouling Management'*, is an analysis of the regulatory environment covering biofouling management.

The Forum also hosted an exhibition of the winning entries of a photography competition held by the IMO illustrating the problem of maritime biofouling. Also exhibited were scientific posters and a virtual reality experience that allowed participants to explore submerged surfaces with severe biofouling.

This second forum was very successful thanks to the active participation and lively discussions by all delegates, which also raised awareness to the challenges we have ahead. Biofouling management requires commitment and alliances between many different stakeholders, which will hopefully open many opportunities for some cross-sectoral collaborations and result in innovative biofouling management practices.

We now have a series of challenges and objectives to start working on ahead of the 3rd GloFouling Partnerships Forum which will be hosted by the Korea Research Institute of Ships & Ocean engineering (KRISO) of Republic of Korea, in late 2024.

Finally, I wish to congratulate the GloFouling Partnerships project team, who have a decisive role in raising awareness, training, encouraging best practices and innovation, building partnerships, and engaging with stakeholders to reduce the impact on marine ecosystems of invasive aquatic species introduced via biofouling and minimize greenhouse gas emissions from ships' biofouling.

OPENING SPEECHES

KATY WARE

Director of UK Maritime Services & Permanent Representative of the UK to the IMO

Maritime and Coastguard Agency

Katy studied Marine Technology at the University of Newcastle upon Tyne and joined the Maritime & Coastguard Agency (MCA) in 1999. Katy was appointed as the Director of UK Maritime Services in March 2016. Katy is responsible for the UK flag and port State control regimes, including survey and inspection operations, the UK's safety, security & environmental regulatory regimes, seafarers training, navigational safety, civil hydrography programme and UK Ship Register.

In 2011 Katy was appointed the Permanent Representative of the UK the IMO Organization. Katy leads a diverse work force, including operational surveyors, technical policy officials, legal and economic advisors.

Dear Colleagues, distinguished delegates, Secretariat, guests,

It is a privilege to be speaking on the important issue on biofouling management and the global effort to reduce shipping's effect on the introduction of aquatic invasive species, and above all else protection of marine biodiversity.

Each species in the oceans has a particular role to play, whether that is marine worms converting organic material into carbon dioxide for marine plants to photosynthesize or sharks controlling prey populations.

The rich marine biodiversity which the human race is historically accustomed to, allows nature in our oceans to be productive, resilient and adaptable to environmental changes. With the current challenges, facing global ecosystems, this is this is of particular importance.

The more marine biodiversity becomes depleted, the less nature can provide the food, economic and cultural benefits it currently provides to humanity. The extinction of one species in an ecosystem can easily unravel the entire system and lead to exponential decline in marine life, with consequences not only to the marine area, but our everyday existence.

As we embark on the 2nd GloFouling Partnerships R&D forum, it is important that we all be mindful to the fact that marine biodiversity continues to decline at a global level due to many factors. These include Overfishing, Bycatch, Climate change, Pollution and most relevantly to these discussions, the introduction of invasive non-native species. The rate of this deterioration in biodiversity during the past 50 years is unprecedented in human history. The spread of invasive species is now recognised as one of the greatest threats to the ecological and economic well-being of the planet. These species are causing enormous damage to biodiversity and the valuable natural riches of the earth upon which we depend. Direct and indirect health effects are becoming increasingly serious and the damage to the environment is often irreversible. Moreover, significant economic impact occurs to the industries that depend on the coastal and marine environment such as tourism, aquaculture, and fisheries, as well as costly damage to infrastructure.

With more than half of global GDP being linked to healthy biodiversity, it is crucial to control all factors affecting biodiversity including the introduction of invasive species in new environments where they can settle and outcompete the local fauna and flora. Nowhere is this more true than in some of the most remote communities in the world which are often wholly dependent on a thriving ecosystems for their very survival.

Now more than ever, it is critical to bolster our efforts in research and development into new technologies and management methods to control and ultimately eradicate the spread of invasive species and fouling in general. This push can coincide with the new regulatory requirements on energy efficiency and operational carbon intensity coming into effect next year, and a renewed desire for operators to seek every efficiency possible to improve their GHG emissions.

All of this must take place against a backdrop of bio invasions continuing to increase at alarming rates and new areas being invaded every day.

Here in the UK, as with many countries, the impact of invasive species is of great concern. The UK's Department for the Environment, Food and Rural Affairs has previously reported that there are at least 2,000 non-native species established in the UK, of which 160 are established in marine and freshwater environments. This number is increasing every year and reflects a trend which can be seen in every corner of the world. Unsurprisingly the highest densities of invasive species corelate with major shipping lanes and ports, favouring those with sheltered bays and major port infrastructure.

Whilst we have seen some successful stories about eradication on terrestrial invasive species, in the marine environment, high environmental connectivity fosters the dispersal of species, rendering efforts to control biological invasions more challenging. Eradication of marine invasive species has only been achieved when species were detected early on, and appropriate management implemented rapidly. Accordingly, prevention is key.

Recognising this, the UK acceded to the Convention for the Control and Management of Ships' Ballast Water and Sediments on the 26th May this year, as well as reissuing guidance to industry on technical requirements related to ballast water treatment.

The UK also welcomes confirmation that the COP15 Biodiversity Conference will go ahead later this year in Canada. During preliminary discussions in Nairobi ahead of COP15, the UK led a statement supported by other 46 other high ambition member states to call on the international community to halt and reverse biodiversity loss globally and adopt a target to protect at least 30 per cent of land and ocean by 2030, the so called '30 by 30' and I am pleased to say that nearly 100 countries have pledged support for such a target. We hope that this will help to restore ecosystems, drive species population recovery and halt extinctions by 2050.

Furthermore, the UK has committed to spend at least £3bn on protecting and restoring nature, including £500 million dedicated to the ocean through the Blue Planet Fund. We believe the international community must take urgent action to address this emergency facing our planet and the COP15 Conference is an important step in establishing a solid foundation to support a prosperous future for the human race.

Thinking ahead to the coming days it is clear that we need to do more to address the introduction of invasive species including from ships' biofouling.

This is the reason why this Forum is so important. We all, in our own capacities, have the responsibility to limit the detrimental impact of invasive species as much as possible, and protect our beautiful marine biodiversity.

This week you will receive a variety of presentations and panel discussions regarding innovative anti-fouling systems, biofouling management technologies, how the recreational sector fits into the puzzle, the perspective of ports and how Green House Gas emissions savings and biofouling can come together

I am confident during the days to come each of the expert speakers and panellists will all offer fruitful discussion, and all participants will take away new ideas about biofouling of ships. I therefore encourage you all to actively contribute and use this global opportunity to exchange information and build bridges.

Thank you.

KATY WARE

Director of UK Maritime Services & Permanent Representative of the UK to the IMO

Maritime and Coastguard Agency

XIAOJIE ZHANG

Director Technical Cooperation Division

International Maritime Organization

Mr. Xiaojie ZHANG is the Director of Technical Cooperation Division of International Maritime Organization (IMO), since November 2020.

Before joining IMO Secretariat, Mr. Zhang had worked for the Ministry of Transport, China from 2012 – 2020 as the Counsel/Deputy Director General, Department of International Cooperation and previously as the Director of Bilateral and Regional Cooperation and Director of International Organizations and Multilateral Affairs, Department of International Cooperation, Ministry of Transport from 2002 to 2012. Mr. Zhang had overseen many bilateral and regional transport cooperation activities between the Government of China and the European Union, Central Asia, Latin America, and African countries. He had been in charge of China's participation in many international activities, with a focus on transport-related international organizations and other multilateral/regional cooperation. From 2015 to 2017 he had been the Head of the Chinese delegation to the IMO's Council and Marine Environment Protection Committee. Mr. Zhang was the elected Chair of the IMO Council from 2017 to 2020, before joining IMO Secretariat.

IMO's ITCP and capacity building to tackle marine biodiversity protection

Excellencies, Distinguished guests and participants, Ladies and Gentlemen,

Good morning and welcome to the GloFouling Partnerships' 2nd R&D Forum on biofouling management in maritime industries.

The spread of invasive species is recognized as one of the greatest threats to the ecological and the economic well-being of the planet. But as biodiversity loss is accelerating, the scientific community is raising the alarm about its danger for our environment and economic resources.

An international study by the Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES) has recently (in 2019) highlighted that invasive species are one of the five direct drivers for biodiversity loss.

And this is true for marine biodiversity as well: an even more recent UN Report, the World Ocean Assessment, which was published last year (2021), confirms the role of aquatic invasive species as a major driver of marine biodiversity change.

It describes how aquatic invasive species can not only alter marine biodiversity and the local marine ecosystems where they are introduced, but have also significant economic impacts on shore facilities, fisheries, aquaculture production, and can impact human health as well.

The report highlights the role of ships' biofouling as a major transfer vector and calls for proactive management, because we know that eradication or removal of invasive species, once introduced, is virtually impossible - and very costly.

As most of you know I am sure, the International Maritime Organization and its member States have been at the forefront of the international effort to address the transfer of invasive aquatic species through shipping, via two main vectors: ship's ballast water and ships' biofouling.

With respect to ship's ballast water, a convention was developed and entered into force in 2017.

As for the transfer of invasive aquatic species through ships' biofouling, the issue was first brought formally to IMO's attention in 2006 and in the following year, work started to develop international guidelines to address it.

These efforts culminated in 2011 with the adoption by IMO member States of guidelines on biofouling management, namely the Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species.

These guidelines provide a global approach to the management of ships' biofouling and represent a decisive step towards reducing the transfer of invasive aquatic species by ships.

This work has been supplemented by the development of further guidance applicable to recreational craft (Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft).

The Biofouling Guidelines are currently being revised by IMO member States to improve their uptake and effectiveness, and this exercise is expected to be completed in 2023.

To promote these guidelines and enhance their uptake, the IMO has also been delivering capacity building support to developing countries, through its own Integrated Technical Cooperation Programme. The purpose of this programme is to assist developing countries in building their human and institutional capacities for uniform and effective compliance with IMO's regulatory framework.

IMO has also joined forces with the Global Environment Fund (GEF) and with the United Nations Development Programme (UNDP) to come up with a long-term project to assist developing countries in the implementation of IMO Guidelines namely the GEF-UNDP-IMO GloFouling Partnerships, under which this Forum is being organized.

IMO is the agency that implements, via its Department for Partnerships and Project, this important project. In addition to implementing the project, IMO has also made an important commitment to contribute financially to the project. Most of this financial commitment comes from IMO's Integrated Technical Cooperation Programme, which has so far provided more than half a million USD since the start of the project in 2019, in order to support and expand several capacity building activities undertaken under the GloFouling Partnerships project.

Your excellencies, Distinguished guests and participants, Ladies and Gentlemen,

The clock is ticking, and we hear every day how severely human activities impact oceans' biodiversity, and how biodiversity loss is accelerating. This Forum is about impacts, but also and mainly about solutions to the problem and best management practices. You will have an opportunity, during this event, to exchange the latest about all aspects of biofouling management, with a variety of stakeholders, ranging from marine scientists, experts, the industry, policy makers etc. I therefore encourage you to participate actively in the discussions that will take place under the various sessions and panels of the event, and to make the most of your participation during these four days. Your contribution to the current global efforts to tackle biofouling management is crucial.

I wish you all an excellent Forum,

Thank you.

XIAOJIE ZHANG

Director Technical Cooperation Division

International Maritime Organization

GYORGYI GURBAN

Head, Projects implementation, Department of Partnerships and Projects

International Maritime Organization

Gyorgyi Gurban is the Head of Projects Implementation in the IMO Department of Projects and Partnerships, which she joined last year from the Office of the Secretary General of IMO, where she acted as Senior Maritime Policy Advisor, with a focus on SDGs related issues and key international processes.

Before joining IMO, she was leading Ecosystem Approach related work-stream and projects at UNEP-MAP. Beforehand she worked in the European Commission, overseeing a portfolio of EU funded sustainable development projects and leading EC preparations for Rio+20. She also chaired EU Council Climate Working Groups on behalf of Hungarian EU Presidency and coordinated preparations of the EU to UNFCCC negotiations. Prior to that, Gyorgyi gathered experience at the Legal Service of the United Nations Headquarters in New York, at the Climate Unit of the Hungarian Ministry of Environment and at Allen and Overy Law Firm.

Gyorgyi has a JD (PPKE-JAK), an LLM in International Law (Tulane), and an MSc in Environmental Management (University of San Francisco). She is married, with two children.

Dear participants,

Good morning to all, it is nice to have you here with us for the upcoming week.

Indeed, the GloFouling Partnerships project falls into the portfolio of technical capacity building major projects that are being implemented by the IMO's Department of Partnerships and Projects, the latter being a new Department that was created by the Secretary General of IMO about two years ago, with a view to act with a long-term strategic view.

While these projects complement activities undertaken by the IMO's Technical Cooperation programme, they are different in that more focus is put on long-term challenges, innovation, R&D and investment needs. These are aspects that are included in several of our major projects. Currently, major projects implemented by IMO's DPP are primarily related to marine environment protection, and fall under two main categories: oceans management – under which the GloFouling Partnerships project sits - and GHG emissions.

Even though GloFouling Partnerships looks at preserving oceans ecosystems by minimizing the introduction of invasive aquatic species through ship's hull, it has strong links with climate change mitigation: keeping ship's hulls clean contributes to fuel savings and as a result to GHG emissions reduction - we will hear more about this topic during the week.

As you know, the focus of the World Maritime Day is on new technologies for green shipping which is very much in line with the subjects you will hear about in the coming week. We won't only look at technologies, we will also look at biofouling from a more comprehensive perspective that will includes management practices, science and policy aspects. We will also look from a broader point of view at what is needed in terms of R&D, what are the challenges and the solutions. One of the most important sessions of this Forum will be about lessons learnt from the project's beneficiary countries, and how we can increase cooperation with and amongst the project countries and build on these best practices. You will also hear about investment needs and opportunities.

This is a Forum where discussion and exchange of information is encouraged. We want to hear the views of key players and stakeholders such as ports which play an important role in biofouling management and cease this opportunity to discuss gender and women participation in biofouling related issues. Last but not least, this is a great opportunity to learn about how the project's Global Industry Alliance for Biosafety contributes to global efforts towards biofouling management.

This week will be a very full week addressing a wide range of areas and aspects related to biofouling management and am pleased to see that to support this, we have very different stakeholders in the room from around the world, representing industry, ports, government authorities, industry associations, scientists, universities, and more. This inclusive representation will enable a productive interdisciplinary discussion. I encourage you to air your views and experiences and make the most of this week.

Finally, I would like to convey best wishes from IMO's Secretary General and from our Chief of the Department of Partnerships and Projects, who are both in South Africa to celebrate the World Maritime Day, but with us in spirit.

Thank you all, and have a good Forum!

Gyorgyi GURBAN
Head, Projects implementation, Department of Partnerships and Projects
International Maritime Organization

PROGRAMME

Monday 10 October 2022

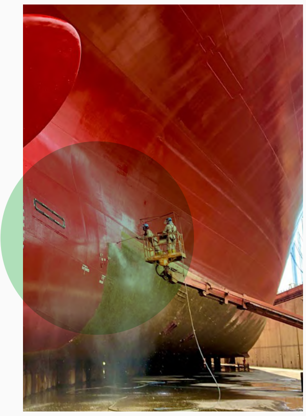
17:00 – 19:00 **OPENING RECEPTION** *One Great George Street*

Tuesday 11 October 2022

Master of Ceremony: **Lilia Khodjet El Khil,** *GloFouling Partnerships, IMO*
Forum moderator: **Craig Eason,** *Fathom World*

8:00 – 9:00 **REGISTRATION** *IMO entrance hall - Registration Desk*
BREAKFAST *Delegates' Lounge area, first floor*

9:00 – 9:30 **OPENING SESSION**
Welcome address from IMO
Xiaojie Zhang, *Director, Technical Cooperation Division, IMO*
Gyorgyi Gurban, *Head, Projects implementation, Department of Partnerships and Projects, IMO*
Opening keynote speaker
Katy Ware, *Director, UK Maritime Services, Permanent Representative of the UK to the IMO*



9:30 – 11:30 **SESSION 1 – Innovative anti-fouling coating systems, biofouling management technologies and methods in shipping, recreational boating, aquaculture, oil & gas, and ocean renewable energy structures.**
Chair of session: **Craig Eason,** *Fathom World*
Presentations
Neil Oxtoby, *AkzoNobel* & **Bart Salters,** *Philips*. UVC Anti-Fouling Solution – Design, Experiments and Results of next generation Samples.
Ralitsa Mihaylova, *Safinah Group*. Data driven approaches to coating selection and the challenges with ship-specific functional specifications.
I Ketut Aria Pria Utama. An Investigation into the Development of Hydrophobic Antifouling Paint to Minimize the Growth of Biofouling on Ship Hull.
Tor Ostervold, *ECOsubsea*. Results of biofouling cleaning in offshore rigs.
Questions and answers

11:30 – 12:00 **SPECIAL PRESENTATION**
Mark Patterson & Gary Rosewell, *Proteus Ocean Group*. Proteus, the International Space Station of the Sea.

12:00 – 13:30 **LUNCH** *Delegates' Lounge area, first floor*

13:30 – 15:00 **SESSION 1 (Cont.) – Innovative anti-fouling coating systems, biofouling management technologies and methods in shipping, recreational boating, aquaculture, oil & gas, and ocean renewable energy structures.**
Chair of session: **Craig Eason,** *Fathom World*
Presentations
Peter Maidment, *CleanSubSea*. Responsible biofouling management through IWHC with complete capture and containment.
Karl Lander, *Armach Robotics*. Autonomous Robots Enable Proactive Cleaning.
Eirik Eide, *Shipshave*. In transit cleaning of hulls for sustainable disposal of effluent.
Melissa Tribou, *Florida Institute of Technology*. Methods to Determine Cleaning Tool Selection for Proactive In-water Hull Cleaning.
Lisa-May Alvarez, *University of Toulon*. Impact of ultrasounds on micro and macro-fouling development.
Questions and answers

15:00 – 15:15 **COFFEE-BREAK AND EXHIBITION VISIT** *Delegates' Lounge area, first floor*

15:15 – 17:00 **INDUSTRY PANEL - World Ocean Council (WOC)**
Theme: Facilitating green investment to support innovation and technology development for biofouling management.
Chair: **Paul Holthus,** *World Ocean Council (WOC)*
Panel discussion: **Tony Foster,** *Marine Capital*; **Birgit Liodden,** *The Ocean Opportunities Lab (TOOL)*; **Diane Gilpin,** *Smart Green Shipping*; **Michael van Niekerk,** *NorthStar Impact*; **Andrew Smith,** *GreenBackers Investment Capital*; **Maarten Biermans,** *Prow Capital*

Wednesday 12 October 2022

8:00 – 8:30 **BREAKFAST** *Delegates' Lounge area, first floor*

8:30 – 10:00 **SESSION 2 – Environmental and economic impacts of invasive aquatic species introduced via biofouling on ships, other marine structures and aquaculture equipment.**

Chair of session: **Craig Eason,** *Fathom World*

Presentations

Mario Tamburri, *GESAMP WG44: Biofouling Management,* Update on the status of development of the GESAMP WG 44.

Sarah Culloty, *University College Cork, Ireland.* Biofouling, pathogens and invasive aquatic species: Understanding the links.

Paula Holland, *NIWA.* Assessing the economic impacts of biofouling and invasive aquatic species. A Guide published by GloFouling Partnerships

Nicola Stokes, *North Queensland Bulk Ports.* Quantifying the economic impact of an invasive species in ports and harbours.

Questions and answers

10:00 – 10:15 **COFFEE-BREAK AND EXHIBITION VISIT** *Delegates' Lounge area, first floor*

10:15 – 12:00 **SESSION 3 – Ocean renewable energy and aquaculture sectors: Challenges and best practices to manage biofouling**

Part 1 - Ocean renewable energy

Chair of session: **Andrew Want,** *Heriot-Watt University/University of Hull*

Presentations

Raeanne Miller, *Aquatera.* Biofouling and ocean renewable energy: what have we learned in the last decade?

Catherine Tait, *European Marine Energy Centre (EMEC).* Biofouling impacts on marine energy technologies: experiences from an open-sea test facility.

Part 2 - Aquaculture

Chair of session: **Henrik Oksfeldt Enevoldsen,** *IOC-UNESCO*

Presentation

Sandra E. Shumway, *Department of Marine Sciences, University of Connecticut.* Recommendations and Best Practices for Biofouling Management in the Aquaculture Sector.

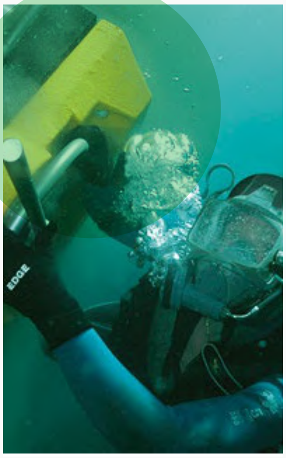
Panel discussion

Simone Durr, *Liverpool John Moores University*

Guillaume Drillet, *World Aquaculture Society (WAS)*

Questions and answers

12:00 – 13:30 **LUNCH** *Delegates' Lounge area, first floor*



13:30 – 15:15 **SESSION 4 - Monitoring biofouling: How can innovation help?**

Chair of session: **Geoffrey Swain,** *Florida Institute of Technology*

Presentations

Alexandre Immas, *Berkeley Marine Robotics.* Automated Ship Hull Inspection with a Swarm of Unmanned Underwater Vehicles.

Marie Dale, *AkzoNobel.* A data driven route to reducing the risk of invasive species translocated through biofouling on ships.

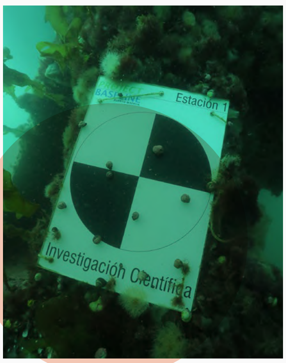
Solène Guéré, *NotiloPlus.* Why rely on cloud-based systems for biofouling management plans?

Lina Ceballos-Osuna, *California State Lands Commission.* Proxy-based model to assess the relative contribution of ballast water and biofouling's potential propagule pressure and prioritize vessel inspections.

Yusik Kim, *TAS Global & Korean Ministry of Oceans and Fisheries.* An update on research conducted in the Republic of Korea.

Questions and answers

15:15 – 15:30 **COFFEE-BREAK AND EXHIBITION VISIT** *Delegates' Lounge area, first floor*



15:30 – 16:30 **SESSION 5 - Testing performance of technologies and methods to manage biofouling – What are the challenges?**

Chair of session: **Guillaume Drillet,** *SGS*

Bev Mackenzie, *BIMCO.* The challenges of assessing biofouling coverage: Can AI play a role in supporting both industry initiatives and capacity development?

Mario Tamburri, *University of Maryland Center for Environmental Science.* Technical Considerations for Development of Policy and Approvals for In-Water Cleaning of Ship Biofouling.

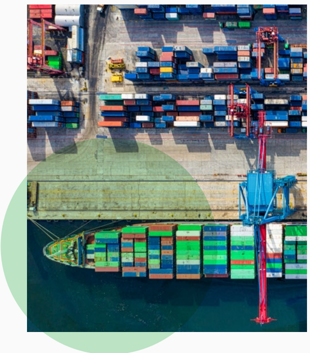
Guillaume Drillet, *SGS.* Global TestNet and laboratory testing capabilities.

Questions and answers

16:45 – 18:15 **TEST Biofouling Project**

Private meeting for beneficiary countries of the TEST Biofouling Project.

Thursday 13 October 2022



8:00 – 8:30 **BREAKFAST** *Delegates' Lounge area, first floor*

8:30 – 10:00 **SESSION 6 – Port perspectives of biofouling management**

Chair of session: **Craig Eason,** *Fathom World*

Presentations
Luc Van Espen, *Port of Antwerp/Brugge*. Underwater cleaning in the Flemish ports.
Reza Ludovic, *Agence Portuaire, Maritime et Fluviale, Madagascar.* International Port of Toamasina, capacity and organization issues to deal with invasion of Invasive Aquatic Species from biofouling.

Panel discussion
Nicola Stokes, *North Queensland Bulk Ports, Australia*
Simon Doran, *HullWiper*
Even Husby, *Port of Bergen, Norway*
Nikhilesh Bhatia, *Hapag Lloyd*

10:00 – 10:15 **COFFEE-BREAK AND EXHIBITION VISIT** *Delegates' Lounge area, first floor*

10:15 – 12:00 **SESSION 7 – Increasing the role of women in biofouling management**

Chair of session: **Gyorgyi Gurban,** *IMO*

Presentation
Sanjam Gupta, *Sitara Shipping*. Charting the route towards inclusive biofouling management.

Panel discussion
Bev Mackenzie, *BIMCO*
Lilia Khodjet El Khil, *GloFouling Partnerships, IMO*
Lina Ceballos-Osuna, *California State Lands Commission*
Solène Guéré, *NotiloPlus*
Shireene M Galal Mounir, *Arab Women In Maritime Association (AWIMA)*
Birgit Liodden, *Founder and CEO, The Ocean Opportunities Lab (TOOL)*

12:00 – 13:30 **LUNCH** *Delegates' Lounge area, first floor*

13:30 – 15:00 **SESSION 8 – ROUNDTABLE – GloFouling beneficiary countries sharing experience on key initiatives and challenges**

Chair of session: **Lilia Khodjet El Khil,** *GloFouling Partnerships, IMO*

Presentations
Gabriel Abad-Neuner, *Dirección Nacional de los Espacios Acuáticos (DIRNEA), Ecuador.* Analysis of the baseline situation in Ecuador for biofouling management in all maritime industries.
Maria Cecilia T. de Castro, *Brazilian Navy.* Brazilian Regulation on the Management of Ships' Biofouling.
Mahmoud Ahmed, *The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA).* Challenges and achievements in the Red Sea and Gulf of Aden.

Roundtable discussion
With representatives from the Lead Partnering Countries of GloFouling Partnerships

15:00 – 15:15 **COFFEE-BREAK AND EXHIBITION VISIT** *Delegates' Lounge area, first floor*

15:15 – 17:00 **SESSION 9 – Recreational boating and its role as a secondary pathway for invasive aquatic species**

Chair of session: **Agnese Marchini,** *University of Pavia*

Presentation
Mar Santos-Simón, *University of Pavia*. Assessment of the effectiveness of different antifouling solutions for recreational boats in the context of bio-invasions.
John Alonso, *GloFouling Partnerships, IMO.* New recommendations on biofouling management for the recreational boating sector.
Evangelina Schwindt, *Centro Nacional Patagonico.* Alternative hull biofouling management in Argentina.

Panel discussion
Udo Kleinitz, *ICOMIA*
Katie Costello, *IUCN*
Alexandra Rickam, *World Sailing*

Friday 14 October 2022

8:00 – 8:30 **BREAKFAST** *Delegates' Lounge area, first floor*

8:30 – 8:45 **SESSION 10 – Global Industry Alliance (GIA) for Marine Biosafety: Private sector-led contributions to the global environment agenda**

Presentation
Yusik Kim, *TAS Global, GIA chair.* GIA objectives and achievements.

Questions and answers

8:45 – 10:00 **SESSION 11 (Part 1) – Biofouling management and fuel efficiency – Understanding the potential for GHG emissions savings**

Chair of session: **Craig Eason,** *Fathom World*

Presentations
Camille Bourgeon, *IMO*. Biofouling management as a tool to achieve IMO Strategy on GHG reduction.
John Alonso, *GloFouling Partnerships, IMO.* Report on the impact of biofouling on GHG emissions.
Stephen Riley, *PPG.* Fouling release coatings: why the use of friction coefficient is the optimal way to measure the hull surface impact on drag reduction.

Questions and answers

10:00 – 10:15 **COFFEE-BREAK** *Delegates' Lounge area, first floor*

10:15 – 12:00 **SESSION 11 (Part 2) – Biofouling management and fuel efficiency – Field analysis**

Chair of session: **Craig Eason,** *Fathom World*

Presentations
Jean Prudhomme, *Embassy of France in the United Kingdom.* Results of an in-water hull cleaning programme of the aircraft carrier Charles de Gaulle.
Markus Hoffmann, *I-Tech AB.* The Impact of 'Fouling Idling' on the Decarbonisation of the Global Shipping Fleet.
Darren R Jones, *Sonihull.* Can we, and should we, fast track new technologies to deal with biofouling?

Questions and answers

12:00 – 13:00 **LUNCH** *Delegates' Lounge area, first floor*

13:00 – 14:30 **SESSION 12 – Policy aspects – How can policy respond to biofouling management challenges?**

Chair of session: **Sveinung Oftedal,** *Norway, Coordinator of the IMO Correspondence Group on Biofouling*

Presentations
Teo Karayannis, *IMO.* Overview of the current status of the revision of the IMO Biofouling Guidelines.
Lilia Khodjet El Khil, *GloFouling Partnerships, IMO.* Efforts made under the GloFouling Partnerships project to streamline the development of biofouling management measures.

Panel discussion
Lina Ceballos-Osuna, *California State Lands Commission, USA*
Timothy Carew, *Department of Agriculture, Fisheries and Forestry, Australia*
Katherine Giroux-Bougard, *Transport Canada, Canada*
Dick Brus, *Ministry of Infrastructure and Water Management, Directorate for Maritime Affairs, The Netherlands*

14:30 – 14:45 **MEETING AGAIN - the 3rd GloFouling Partnerships R&D Forum on Biofouling Prevention and Management**

Seong-yeob Lee, *Korea Research Institute of Ships and Ocean Engineering (KRISO)*
Hoyoon Kim, *Korea Research Institute of Ships and Ocean Engineering (KRISO)*

14:45 – 14:50 **SUMMARY**

Craig Eason, *Forum moderator, Fathom World*

14:50 – 15:00 **CLOSING REMARKS**

Gyorgyi Gurban, *Head, Projects implementation, Department of Partnerships and Projects, IMO*
Lilia Khodjet El Khil, *Technical Project Manager, GloFouling Partnerships, Department of Partnerships and Projects, IMO*

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CONFERENCE PROCEEDINGS

MODERATOR

CRAIG EASON

Moderator

Fathom Maritime Media AB

Craig Eason is the owner of Fathom Maritime Media AB, a Sweden-registered business focusing on delivering content, news, project management and analysis in the maritime, shipping and marine industries. He is a multi-disciplined media and communications entrepreneur with a deep background in the maritime, shipping and ocean space.

He is a former seafarer with a certificate of competency deck and a subsequent post graduate diploma in broadcast journalism. He has an eye for detail, an appreciation of the demands on others and an ability to collaboratively turn situations and projects into opportunities.

As a result of his industry knowledge and independent stance, he is in demand as a semi-professional event moderator and meeting chair. Current workflows also include high level speech writing, knowledge based social media content (based on industry knowledge and broadcast/multimedia background), project management and liaising with conflicting and disparate entities to find forward motion in deliverables.

Fathom Maritime Media AB owns the Fathom World news site and the increasingly popular Aronnax Podcast, both focused on the transformation of the shipping and maritime sector.

Innovative anti-fouling coating systems, biofouling management technologies and methods in shipping, recreational boating, aquaculture, oil & gas, and ocean renewable energy structures.

NEIL OXTOBY

Fouling Control Technical Specialist

AkzoNobel/International Paint

Dr Neil Oxtoby has worked in the area of Fouling Control coatings for 15 years, he is currently a Technical Specialist at AkzoNobel/International Paint helping to support existing fouling control products and develop new products and services globally. He represents his company on the IMO GloFouling Global Industry Alliance (GIA). He is also the chair of the World Coatings Council, Antifouling Coatings Committee (AFCC).

UVC Anti-Fouling Solution – Design, Experiments and Results of next generation Samples

B. Salters*, M.Wijnen[1], K.J.Reynolds[2]

[1] Philips IP&S, High Tech Campus 52, 5656 AE Eindhoven, the Netherlands
[2] Marine, Protective and Yacht Coatings, International Paint Ltd, AkzoNobel, Felling, Gateshead, UK, NE10 0JY
* Bart.Salters_1@philips.com

AkzoNobel and Philips are jointly developing a novel fouling prevention solution based on UV-LEDs. The concept is based on the generation of UVC light by LEDs, which are embedded in a transparent layer. By attaching this layer to any submerged surface, fouling is effectively prevented.

At ICMCF 2014 [1] the basic concept has been presented, and in subsequent presentations [2,3] we have reported on our progress. In the last presentation [3] we have also announced our plans for a next generation device, with improved characteristics.

In this presentation, we will provide details of these latest generation 'products', which are made in tile form. Compared to previous generations, the tiles are now larger, have a reduced power consumption, and the thickness has been reduced to 4mm. Furthermore, the tiles are now 100% watertight, and powered via wireless power transfer, thus substantially reducing any chance of electrical shorts. We will show the electrical, mechanical and optical design considerations; and discuss the scientific challenges involved with making the tiles both thinner and more efficient. Furthermore, we will include detailed measurements of the exact performance of these new design prototypes performed on our newly developed automated measurement system.

Several of these prototypes have subsequently been deployed in trials: on various vessels sailing in the open ocean, as well as on raft-side stationary tests. The anti-fouling performance of these will be shown, and compared to the predictions from the design, and the pre-trial measurements.

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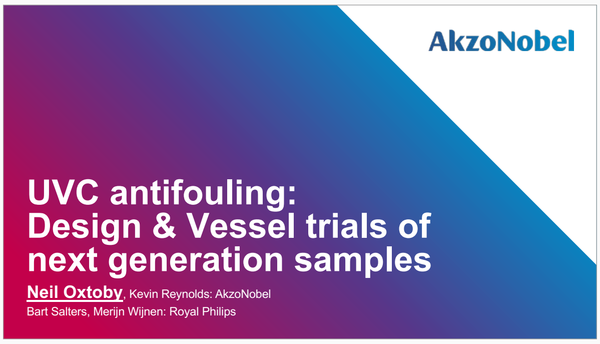
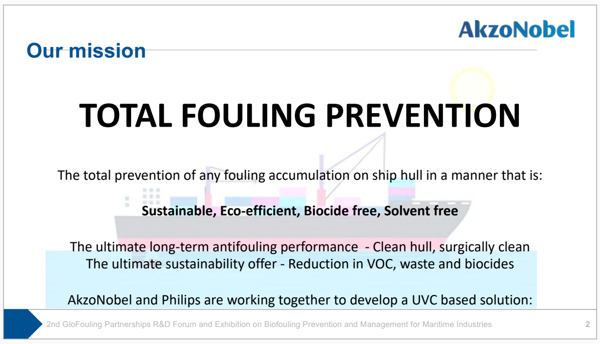
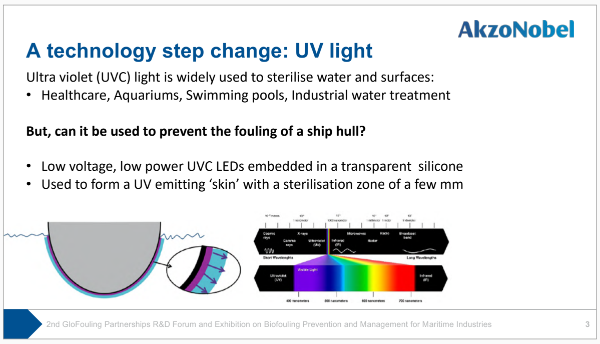
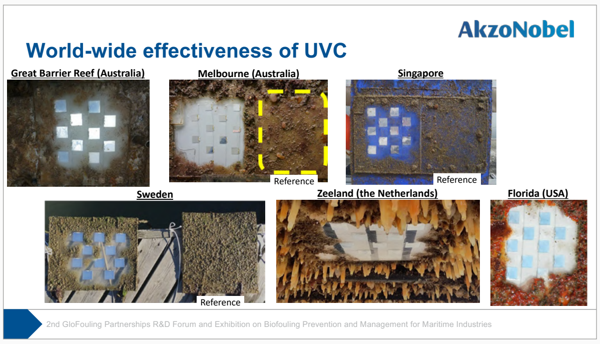
[1] B. Salters et al, ICMCF 2014
[2] B. Salters et al, ICMCF 2016
[3] M. JONGERIUS et al, ICMCF, 2018

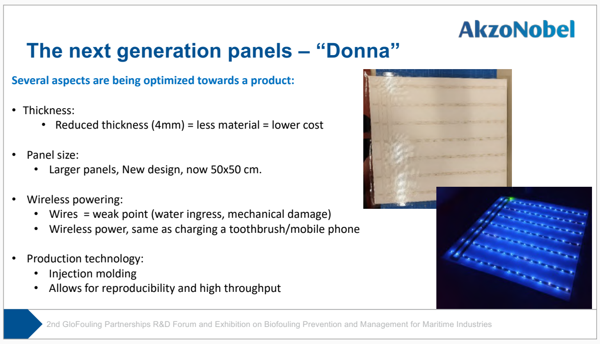
Presentation slides

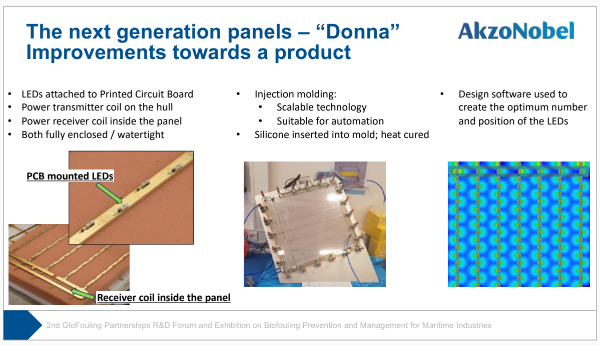


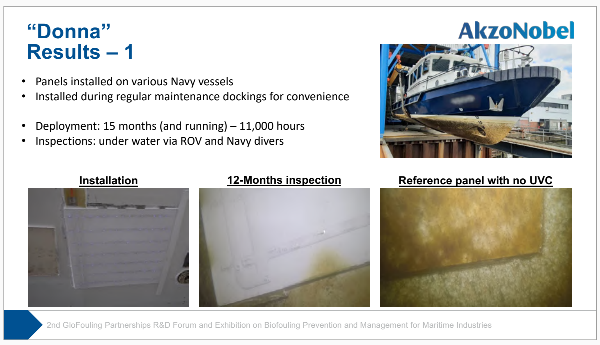












"Donna" Results – 2

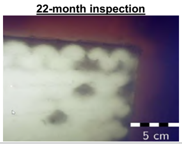
AkzoNobel

- 2 panels installed on a luxury cruise vessel
  - Class society approved through hull penetration
  - Control system in engine room
  - Test duration = 29 months (22,000 hours)
  - Location: Atlantic, Caribbean, Mediterranean
- A few LEDs have failed – end of life
- Fouling on the edge of the panel where intensity is bellow threshold
- For the rest of the panel – spotless where the LEDs are active

Test vessel

Installation

22-month inspection



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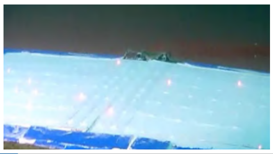
"Donna" Results – 3

AkzoNobel

- Installation on LNG tanker
- Operating globally on commercial schedule
- Certified by class society
- Successful work in large shipyard
- Inspections at 6, 12, 18 and 24 months by ROV
  - Without disturbing vessel operations



- Results so far:
  - No LED failures
  - No adhesion failure
  - Panel spotless
  - (Red visible, diagnostic LEDs to show system is on)

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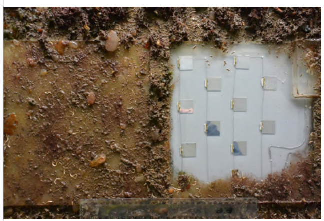
Conclusions

AkzoNobel



- The concept works…
  - Keeps static surface spotless…
  - And ships in normal operation…
  - Globally…
- Limiting factor <u>was</u> lifetime of LEDs.
  - ~10,000 hours = ~ 1 year specification
  - > 2 years demonstrated in field
- New developments by LED manufacturers
  - now at 50,000 hours ~ 6 years, 24/7
  - 25 years if 15 seconds on/45 seconds off

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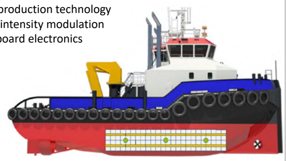
Next steps "Edith"

AkzoNobel

- Next phase:
  - Manufacturing scale up – improved and increased production technology
  - Lifetime up – Newest generation LEDs, pulsing and intensity modulation
  - Vessel integration up – installation technology, on board electronics
- New panel design with next generation LEDs (Edith)
  - Thinner, larger, lower power
  - Better optical efficiency, better coverage of edges
  - Interconnections, joint and seams



- Next installation: ~ 25m², designed for >5 year operation
  - Design underway
  - Installation mid 2023

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AkzoNobel

: Neil.Oxtoby@AkzoNobel.com
: Kevin.Reynolds@AkzoNobel.com

RALITSA MIHAYLOVA

Consultant

Safinah Group, United Kingdom

Dr Ralitsa Mihaylova is the Head of Special Projects for Safinah Group, a leading independent coating consultancy based in the United Kingdom. Her background is in shipping business and operations with experience in data analysis and machine learning techniques. Ralitsa has a keen interest in sustainable solutions and the regulatory framework governing international shipping. She is actively participating in industry-led initiatives and working groups related to biofouling. At Safinah Group, Ralitsa is responsible for coordinating the company's research and development activities and delivering data-driven solutions and insights to inform strategic decisions.

Data driven approaches to coating selection and the challenges with ship-specific functional specifications

Ralitsa Mihaylova[1], Martin Porsbjerg[2], Carl Barnes[1]

Affiliations: [1] Safinah Group, Newcastle upon Tyne, United Kingdom; [2] Safinah Group, Copenhagen, Denmark

The deep-sea marine fleet consists of numerous vessel types with different operational patterns and activity profiles. Therefore, the requirements for fouling control vary significantly across the global fleet. Selecting the optimal system, or a combination of systems, for a specific ship is a complex task as there are multiple options to choose from.

Data on in-service performance of fouling control products independently collected through dry dock project supervision can be used to enhance the coating selection and specification process.

AIMS:

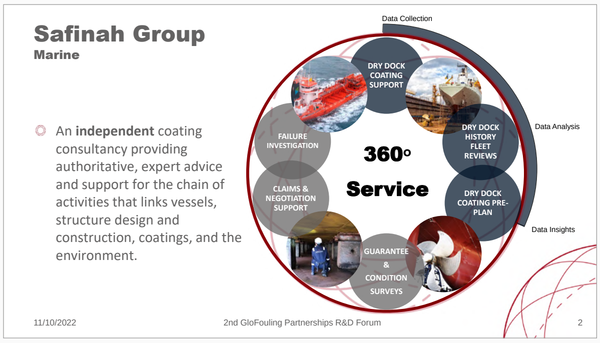
The aim of the presentation is to introduce a data-driven approach to coating selection and specification that allows for continuous learning and serves as the basis for an evidence-based biofouling management strategy.

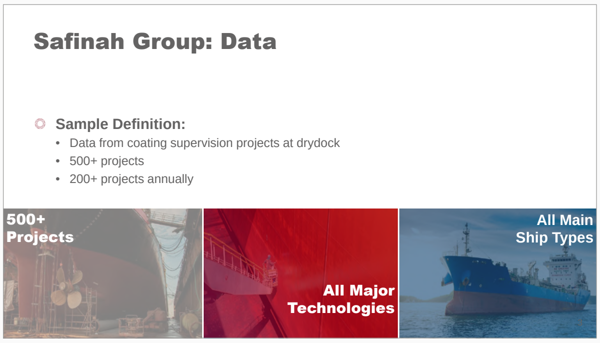
The presentation will highlight some of the most critical findings on product and scheme performance based on more than 500 dry dock projects, selected case studies, and trends in product selection.

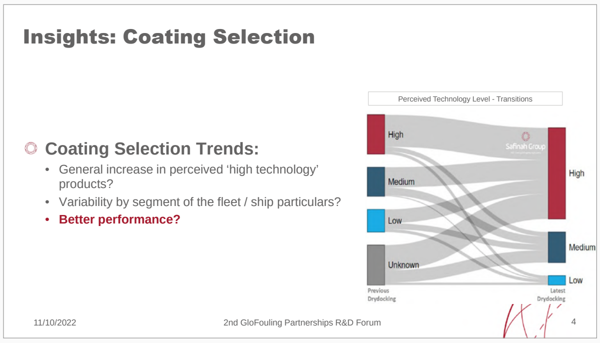
CONCLUSIONS:

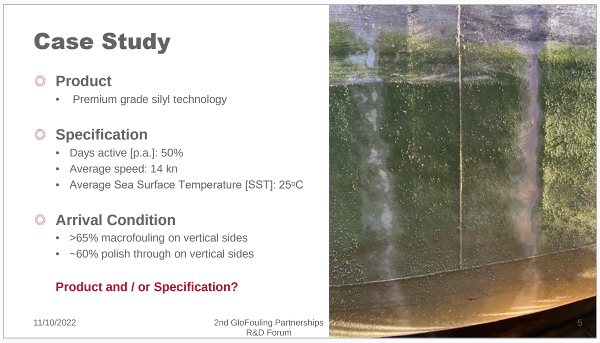
The presentation will conclude with an overview of the main challenges with implementing a ship-specific approach to biofouling management, common misconceptions regarding product selection and expected performance, as well as lessons learnt from a number of coating failure investigations and pre-planning activities.

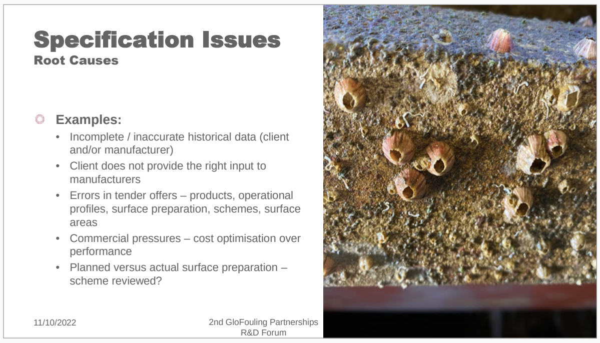
Presentation slides

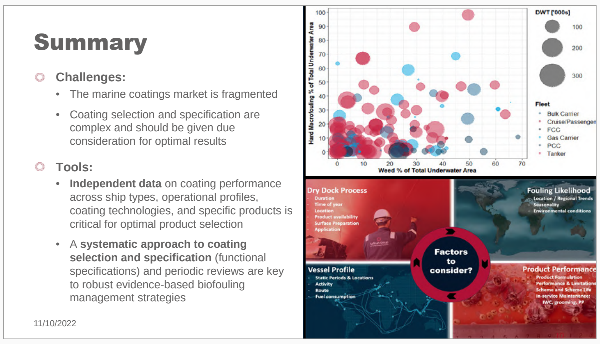












PROF. I KETUT ARIA PRIA UTAMA

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Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

I Ketut Aria Pria Utama is a professor of ship hydrodynamics at the Institut Teknologi Sepuluh Nopember (ITS) at Surabaya, Indonesia. He is a fellow of the Indonesian Academy of Sciences (AIPI) and the Royal Institution of Naval Architects (RINA). He is currently head of Research Centre for Marine-Earth Science and Technology at ITS. His research interests include resistance and powering of multihull vessels; safety of passengers, crews, and fishers onboard ships during COVID-19 era and beyond; the effects of biofouling on ship resistance, powering, and decarbonisation; and the development of ocean renewable energies.

An Investigation into the Development of Hydrophobic Antifouling Paint to Minimize the Growth of Biofouling on Ship Hull

I K A P Utama, Department of Naval Architecture, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
R C Ariesta, Department of Naval Architecture, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
F Martak, Department of Chemistry, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

ABSTRACT

In practice, palm oil bunch materials can be utilized as an essential component in the production of environmentally friendly paints, and it has been processed and investigated to comply with the requirements for paint base materials. This paint is intended to protect the ship's surface against marine biofouling. The goal of the work is to seek how antifouling paint performs in actual ship operations. Twelve samples of specimen plates with dimensions of 150 mm length x 100 mm width x 6 mm thickness were used to learn the growth of biofouling. On two sides of the plate, one side is coated, and the other side is not coated with anti-fouling. The paint with thickness of roughly 300 mm is applied to a ship hull. To capture the rapid increase of biofouling, the specimen plates are performed at a depth of 1-2 meters. The antifouling paint has the same concentration percentage of the substance varying as follows: 5%, 10%, and 20% of polystyrene. The whole tests last in six months, including monthly observations of the growth process for each specimen and the type of fouling that develops on the surfaces of plates. An increase in the region overrun with biofouling will be visible through visual identification. Weight gain is monitored to seek if the pad fouling on the plate surface has increased and followed by a measurement of the paint concentration's effectiveness of biofouling growth on ship hull. Finally, such a recommendation is made out for further research and development.

Keywords: palm oil bunch, hydrophobic, antifouling paint, ship hull, polystyrene.

1 INTRODUCTION

Biofouling is the biological organism that appears on the surface of submerged objects close to the surface. These organisms are classified into two groups, namely microfouling and macrofouling. Microfouling is a thin biofilm consisting of cells, water, and other substances. Macrofouling is a reasonably large organism classified into two: hard and soft fouling. Examples of soft fouling organisms are macroalgae, tunicates, and hydroids. Hard fouling, on the other hand, is made up of things like barnacles, calcareous tubeworms, mussels, and mussels that have hard shells made of calcium carbonate (Hunsucker et al., 2019).

Hakim et al., (2019) conducted research on environmental and economic problems in the maritime sector that arise due to biofouling. For the shipping industry, biofouling is known to increase hull roughness, which will lead to increased frictional resistance and fuel consumption. Analysis of the data from the ship's fuel consumption shows that the growth of biofouling can increase fuel use, and then dry-docking efforts can normalize the ship's performance, although not completely back to new condition. In the end, the application of better-quality anti-fouling paint can reduce the increase in fuel consumption. It turns out that the micro-roughness of the antifouling paint also has an impact on increasing the drag, which was investigated by (Schultz et al., 2011), who carried out a drag test using a towing tank on the micro-roughness of the antifouling paint.

Figure 1. Bottom surfaces with biofouling growth

The biofouling exists on the hull of ship represented by Figure 1. A simulation was made by Demirel et al., (2017) on the hull, and it was found that the micro-roughness due to anti-fouling paint can increase the drag by up to 10% compared to the hydraulically smooth hull. While conducted a study on the roughness of the ship's hull, biofouling can increase ship resistance, and inferred from the towing tank experiment, the additional resistance reaches about 42%, and using CFD modeling, it reaches about 40% (Suastika et al., 2021). To maintain the speed of ship service due to fouling, if using MCR (Maximum Continues Rating), the increase in fuel consumption reaches about 62.5%. However, if you continue to use NCR (Normal Continues Rating), it increases about 16.7% of fuel consumption and sailing time. Because the fuel curve is generally curved upwards, if you need extra power at high RPM, it will require a lot of fuel. The measurement of the fuel consumption of the Sunda Strait ferries has added fuel consumption of about 20% enroute at the end of the year, and the ratio of fuel consumption for about a year of sailing for the hull without fouling and in the presence of fouling is about 10%. From the calculation of the addition of fuel consumption above, some of the values are small, namely 10–20% (Ariesta et al., 2021). But if this is seen in large numbers and occurs repeatedly, it will be of great value and be unprofitable for ship operators.

Until now, to prevent organism growth on surfaces, the stage of research that has been carried out is to test the hydrophobic ability of the anti-fouling paint that has been made, namely by dripping water on the surface of objects that have been coated with paint and measuring how water droplets behave on the surface of the paint. Hydrophobic surfaces have the property of repelling water. That is, the surface of objects is not easily wet if exposed to water (Oliveira & Granhag, 2020). The use of anti-fouling for applications is used as fouling prevention. In addition to biocides to prevent biofouling from occurring, it provides a hydrophobic effect on the surface of the stomach. Historically, the use of biocide based for anti-fouling is tributyltin (TBT) self-polishing copolymers; then, unfortunately, the use of TBT was detrimental to environmental issues, therefore in 2001 International Maritime Organization (IMO) on the International Convention on the Control of Harmful Anti-Fouling Systems on the ships restrict for the use of organotin. This regulation entry to force on 17 September 2008 (IMO, 2002).

Based on the conditions, the development of anti-fouling paint from the environmental material is developed. Unbalanced molecular forces cause this phenomenon at the water/solids interface, causing surface tension. In the development of anti-fouling paints, the hydrophobic properties of the material are used where the paint is made with the function of being able to repel water. Droplets hitting the paint layer can bounce off due to the implementation of hydrophobic properties as reported by Richard et al., (2002) and (Liu et al., 2014). In general, hydrophobic coatings are made of composite materials. One component provides roughness, and the other provides low surface energy (Zhang et al., 2021). The hydrophobic ability of paint has an important role, especially in the development of paint for ships, because it can reduce the friction force experienced by the hull's surface with water due to a decrease in contact between the particles on the water surface and the hull wall. It could lower the ship's total resistance since 85%–90% of the ship's total resistance comes from friction force in the slow-moving ship.

Therefore, this research will investigate the development of hydrophobics paint. The effect of concentration from polyester has become a control variable in numerous case studies. The color will apply following the standard procedure for coating applications on ship surfaces. These results will obtain facts on biofouling prevention on paint covers with experimental tests.

2. MATERIAL AND METHODS

2.1 Surface Treatments

The material is thoroughly prepared prior to the application of the antifouling cat, and several treatment processes are carried out on it, as follows:

a) Surface treatment is carried out on the paint surface according to ISO standards. The primary material for the experiment is a type of carbon steel called A36, a standard material used for basic shipbuilding materials that is shown in Figure 2. The treatment of the surface material plate is to remove dirt on the top plate before applying the paint. Surface preparation is the earliest stage of the material before the coating process is carried out. This stage significantly affects the material's ability to bind the coating layer (ISO, 2000).

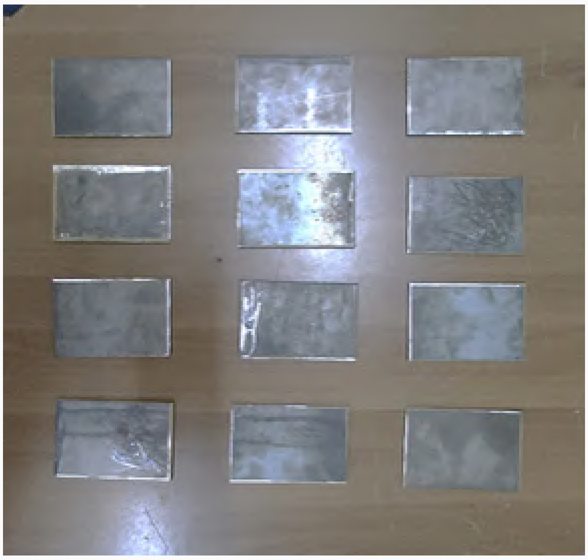

Figure 2. Raw material objects

b) The treatment process begins with blasting preparation. The initial process is spraying on the surface of the material. The sandblasting process is carried out in a closed workshop to keep the material at a stable temperature and humidity.

c) The existing material falls under the new steel category and is thought to have a mill scale layer or a residual layer from manufacturing, hence it must be blasted. Surface preparation monitoring is prepared using an abrasive blast with steel grit media at a nozzle pressure of 95 psi. A blotter test is used to conduct the examination. To determine the grade level of the steel surface, refer to ISO. There are five levels of surface preparation results, according to ISO. The better the surface preparation, the better the corrosion protection performance. The process identifies surface preparation are represented at Figure 3.

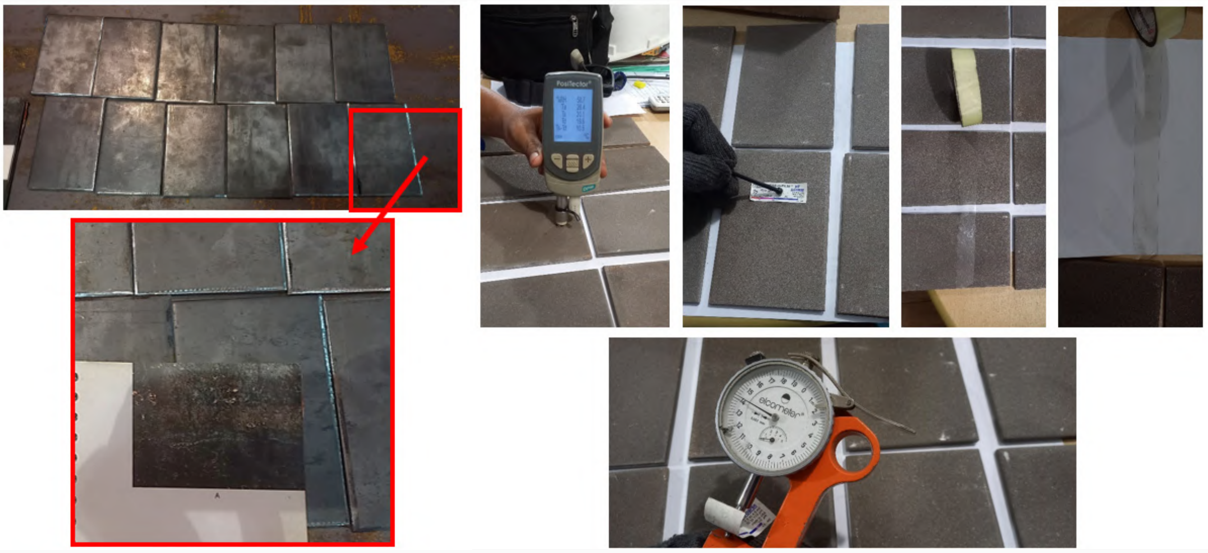

Figure 3. Grade identification process

2.2. Coatings Procedures

After the blasting process, the surface that has been blasted must be immediately painted with a base layer so that oxidation does not occur, which can result in corrosion of the material. The basic painting was done with Hempel Hempadur Quatro paint in the 17634 series. Painting is carried out with the help of a compressor equipped with a nozzle to obtain an even paint surface. The painting stages are carried out in the following way:

a) We are preparing the paint to be used by mixing the components of the paint component with a thinner. The paint is stirred until it is perfectly mixed.

b) Put the paint into the water spray gun tube.

c) Spray several times on the paper to obtain the consistency of the spray shape. If necessary, adjust the air pressure or thickness of the paint. Place the panel sample on the panel holder and hold the spray gun at a distance of 25-30 cm from the surface of the panel sample. Perform spray movements at a speed of 25–40 cm/s.

d) Wet with the method according to the standard. This test is carried out to determine the thickness of the wet paint on the specimen. This measurement helps to obtain the accuracy of the thickness of the paint that will be produced after the paint has dried. The test procedure is carried out in the following way (ASTM, 2020):

   i. Wet film comb pressed perpendicular to 90o on the specimen's surface

   ii. Placing the wet film comb onto the paper and then matching it with the wet film comb that represents in Figure 4.

   iii. Avoid wet film comb by continuously measuring the thickness of the wet film during the spray process.

(a)

(b)

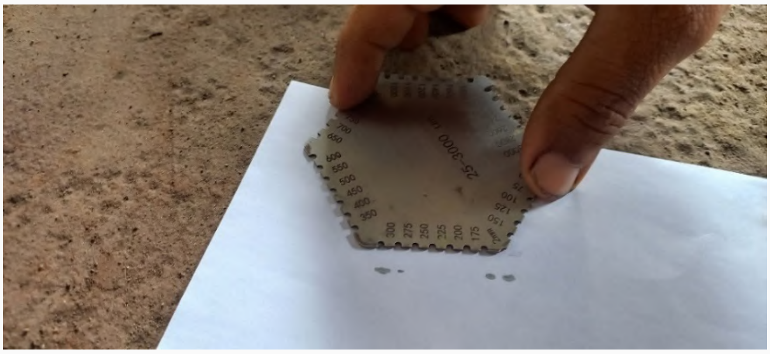

Figure 4. wet film measurements

Painting on the specimen is carried out until it reaches the thickness to be achieved. A dry film thickness test can be carried out. This test is carried out with the standard, which requires the paint to be measured in dry conditions. The stages of the testing process are carried out with the following steps (ASTM, 2021):

i. After the paint film layer is dried according to the duration listed in the data sheet with air media, a measurement of the thickness of the dry film (DFT) is measured.

ii. Measurements are carried out by placing a thickness gauge coating in five areas on the specimen. Each area is measured at 3 points.

iii. Then an average calculation is carried out to obtain a dry film thickness figure (DFT).

iv. Reapply the spray at each overcoat interval if the dry film thickness is less than desired.

DFT measurements were carried out with the PosiTector 6000 tool to obtain the thickness on the surface of the primer paint, and the measurement process is shown in Figure 5.

Figure 5. DFT measurements

The paint layer is applied in the stages of primary paint, secondary paint, and anti-fouling paint. The application of paint dwelling time should be noticed. If the paint stage exceeds the time limit, the cat's adhesive ability can be reduced, and the cat can work optimally.

Table 1. Concentrate of Polystyrene

Specimen code for immersion test	Components
A 0	20 % Polyesterine (PS)
A 1	20% PS + 3% ZNO_3
A 2	20% PS + 2% ZNO_3
A 3	20% PS + 1% ZNO_3
B 0	10 % Polyesterine (PS)
B 1	10% PS + 3% ZNO_3
B 2	10% PS + 2% ZNO_3
B 3	10% PS + 1% ZNO_3
C 0	5 % Polyesterine (PS)
C 1	5 % PS + 3% ZNO_3
C 2	5 % PS + 3% ZNO_3
C 3	5 % PS + 3% ZNO_3

Table 1 is parameter in each specimen will be tested by submerging it in seawater based on these contents. The immersion test on the specimen was carried out in the waters of Gresik, on the north coast of Java. The previous immersion test was carried out by setting up experiments with schemes that were carried out to test several parameters. For reference, the specimen set parameters using the same method performed by (D'hont et al., 2018).

3. DISCUSSION AND ANALYSIS

3.1. Surface cleaning analysis

Surface preparation is essential in determining the success of tank lining applications. There are two categories in surface preparation work, including the level of cleanliness and the level of roughness. Cleanliness aims to provide visual information about the number of contaminants left on the surface of the substrate. In comparison, roughness aims to provide a profile on the surface of the substrate so that the paint can adhere properly. In addition, roughness also has a role as a parameter of the adhesion strength of the color applied to the surface of the substrate. Cleanliness has several levels, namely Sa 2 (commercial blast cleaning), Sa 2.5 (near white metal cleaning), and Sa 3 (white metal cleaning). The three cleanliness levels provide different roughness values so that the adhesion strength values that arise are also different. Choosing the right level of cleanliness is very necessary because applying the right level of cleanliness can reduce long-term losses related to the value of adhesion strength that arises due to different roughness values. With the following grid capacity assessment, the surface treatment has been successfully carried out with good results judging from the surface preparation index in Table 2, the stages can be continued with the paint application process.

Table 2. Index surfaces preparation grade

Description	International ISO-8501-1
White Metal	Sa 3
Near White Metal	**Sa 2 1/2**
Commercial Blast	Sa 2
Power Tool Cleaning	St 3
Hand Tool Cleaning	St 2

Based on the results of the identification process are shown in Figure 5. The surface, then continuing with measuring roughness on the surface. The roughness standard on the surface ranges from 75 to 90 microns; in this condition, the RH value must be above 50% before the material can be painted. From the results of the measurement of peels on the surface of this material, it is included in the near-white metal grid category because it has a clean surface.

3.2. Hydrophobics paint characteristics

The characteristics of hydrophobics can be seen in Figure 5 that the smooth surface without the implementation of paint (coating) causes the scattering of water droplets and shows that an extensive wet surface area occurs on the surface of the object. However, when the paint is applied to the surface of the object and is dropped by water, the droplets from the water will clump and not spread over the entire surface. This proves the hydrophobic nature of the paint that has been produced. This phenomenon causes a reduction in the wet area experienced by the surface of the object due to the implementation of paint, so that it has the potential to reduce frictional resistance. Tests related to frictional resistance due to the implementation of paint have not been carried out, but this phenomenon can provide confidence that drag reduction due to the resulting hydrophobic nature can be achieved. It can also be seen in Figure 1 that over time, the hydrophobic nature of the paint did not disappear and instead increased its hydrophobic ability, as evidenced by the increasing contact angle formed between the surface of the object and water droplets. Figure 5 contact angle between water and a hydrophobic surface as a function of the length of interaction time.

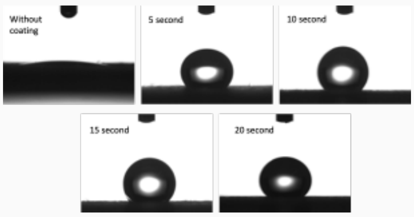

Figure 5. Characteristics of hydrophobics paint on the surfaces.

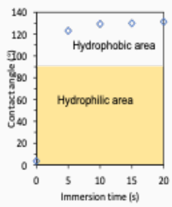

Figure 6. The contact angles surfaces

The hydrophobic nature of the contact angles of the two surfaces, namely the surface of the object coated with paint and water droplets, is shown in Figure 6. With increasing time, the contact angle formed gets higher, and on observation, at 20 seconds, a droplet shows a contact angle of approximated 130°. As a comparison regarding the hydrophobic ability, the higher the contact angle formed, the higher the hydrophobic ability. For example, the Lotus leaf has a contact angle with water of 150°, which is considered to have a very high hydrophobic ability. Then, it can be said that the hydrophobic ability of the paint produced is relatively high because the contact angle is in the range of 120°-130°. Furthermore, in successfully determining the right composition, characterization is performed by classifying the content of paint compounds according to Table 1. The average thickness of the primary paint is 150 microns in dry conditions, the secondary paint has an average thickness of 125 microns, and the anti-fouling paint has an average thickness of 42 microns, for an average thickness of 314 microns for the entire thickness of the layers in 12 specimens. Experimental tests compare the surface with numerous specimen parameters concentration, with an average anti-fouling thickness of 275 microns. The overall paint application data is summarized graphically in Figure 7.

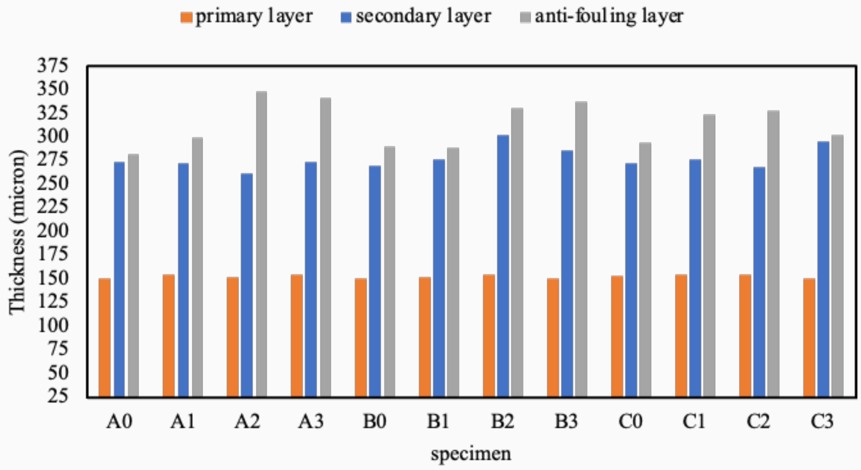

Figure 7. The thickness of specimens

3.3. Sea water exposure in a biofouling growth

Figure 8 provides the biofouling growth after 180 days of seawater immersion. Twelve specimens with different concentrations of anti-fouling paint application show the influence of paint on the surface. The plate was immersed in a depth of about 2 meters beneath the surface. It is because the territory of fouling grows near the surface of the water. The boundary conditions for the experiment were set up in the same condition in all samples.

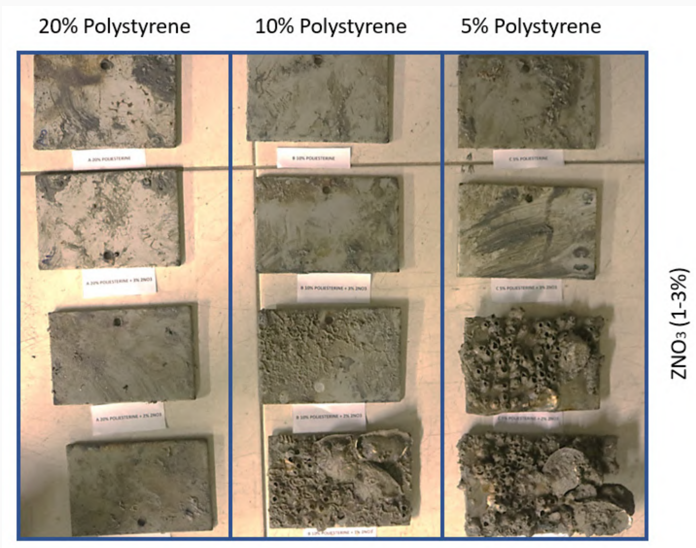

Figure 8. Immersion results after 180 days

The biofouling does not appear on the plates with high concentrations of Polystyrene. Sequentially to the right, the concentration value of Polystyrene decreases from 20% to 5%. As well as from top to bottom, there are variations in the addition of ZNO3 as an inhibitor to prevent biofouling from approaching, as evidenced by the content of ZNO3, a ferrous substance or material that can prevent biofouling from approaching. Low ferrous content makes fouling more susceptible to penetration on the paint surface. From the test results, it can be seen that the growth of the barnacle and Perna Viridis caught on the surface of the specimen test plate, indicating the existence of those types of fouling in the area.

4. CONCLUSION

Using environmentally friendly paints for anti-fouling aims to support IMO regulations regarding the prohibition of toxic anti-fouling. However, this study applies a mixture of environmental and waste material, polystyrene, which is processed into an anti-fouling coating. The use of anti-fouling varies with the concentration of the content and the addition of ferrous substances to prevent the growth of biofouling on the paint surface. In this initial study, from the experimental results, it is known that polystyrene is proven to be able to prevent the growth of biofouling. The effect of variations in adding ferrous substances to prevent fouling growth as a paint characteristic can also show good performance. Furthermore, the next stage experiment was applied to the actual surfaces of the boat to measure the paint performance to withstand ship in all operational conditions.

ACKNOWLEDGEMENT

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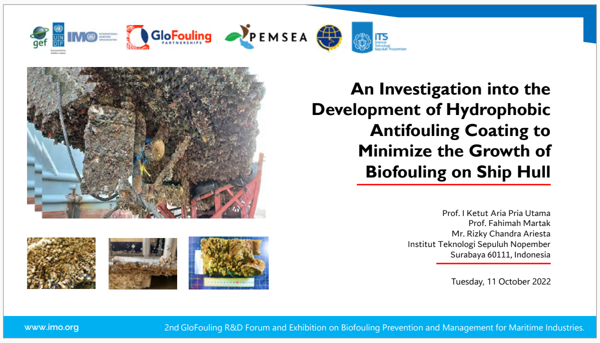
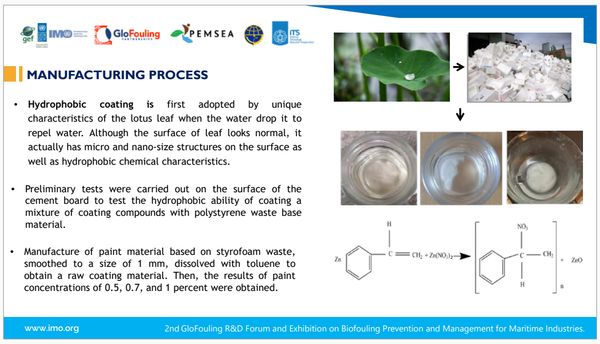
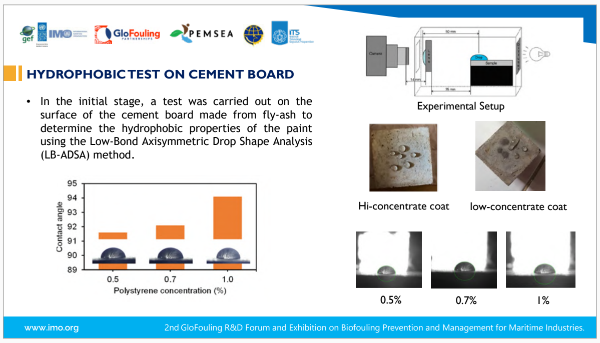
Presentation slides






HYDROPHOBIC TEST ON CEMENT BOARD
• In the initial stage, a test was carried out on the surface of the cement board made from fly-ash to determine the hydrophobic properties of the paint using the Low-Bond Axisymmetric Drop Shape Analysis (LB-ADSA) method.
Contact angle
Polystyrene concentration (%)
Experimental Setup
Hi-concentrate coat
low-concentrate coat
0.5%
0.7%
1%
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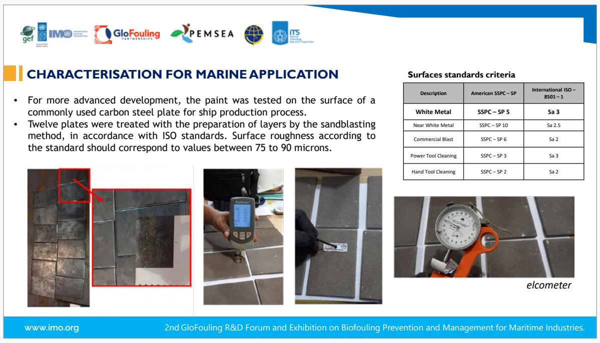
CHARACTERISATION FOR MARINE APPLICATION
• For more advanced development, the paint was tested on the surface of a commonly used carbon steel plate for ship production process.
• Twelve plates were treated with the preparation of layers by the sandblasting method, in accordance with ISO standards. Surface roughness according to the standard should correspond to values between 75 to 90 microns.
Surfaces standards criteria
Description | American SSPC – SP | International ISO – 8501 – 1
White Metal | SSPC – SP 5 | Sa 3
Near White Metal | SSPC – SP 10 | Sa 2.5
Commercial Blast | SSPC – SP 6 | Sa 2
Power Tool Cleaning | SSPC – SP 3 | Sa 3
Hand Tool Cleaning | SSPC – SP 2 | Sa 2
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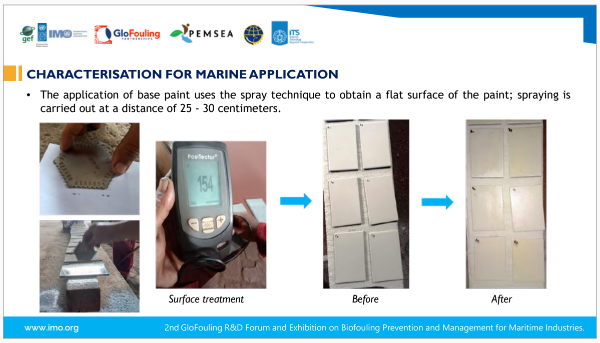
CHARACTERISATION FOR MARINE APPLICATION
• The application of base paint uses the spray technique to obtain a flat surface of the paint; spraying is carried out at a distance of 25 - 30 centimeters.
Surface treatment
Before
After
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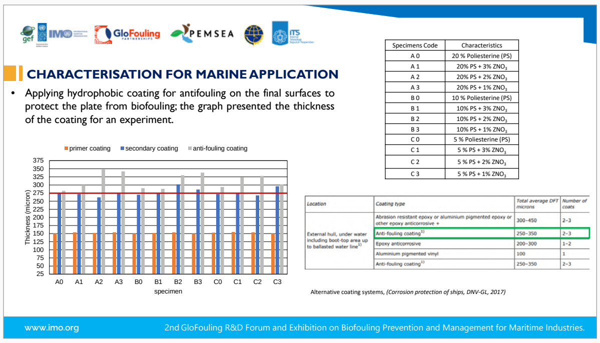
CHARACTERISATION FOR MARINE APPLICATION
• Applying hydrophobic coating for antifouling on the final surfaces to protect the plate from biofouling; the graph presented the thickness of the coating for an experiment.
primer coating
secondary coating
anti-fouling coating
Thickness (micron)
specimen
A0 A1 A2 A3 B0 B1 B2 B3 C0 C1 C2 C3
Specimens Code | Characteristics
A 0 | 20 % Poliesterine (PS)
A 1 | 20% PS + 3% ZNO3
A 2 | 20% PS + 2% ZNO3
A 3 | 20% PS + 1% ZNO3
B 0 | 10 % Poliesterine (PS)
B 1 | 10% PS + 3% ZNO3
B 2 | 10% PS + 2% ZNO3
B 3 | 10% PS + 1% ZNO3
C 0 | 5 % Poliesterine (PS)
C 1 | 5 % PS + 3% ZNO3
C 2 | 5 % PS + 2% ZNO3
C 3 | 5 % PS + 1% ZNO3
Location | Coating type | Total average DFT microns | Number of coats
External hull, under water including boot-top area up to ballasted water line1) | Abrasion resistant epoxy or aluminium pigmented epoxy or other epoxy anticorrosive + | 300–450 | 2–3
Anti-fouling coating1) | 250–350 | 2–3
Epoxy anticorrosive | 200–300 | 1–2
Aluminium pigmented vinyl | 100 | 1
Anti-fouling coating1) | 250–350 | 2–3
Alternative coating systems, (Corrosion protection of ships, DNV-GL, 2017)
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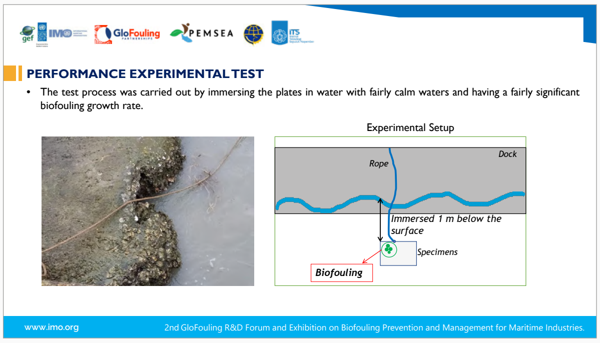
PERFORMANCE EXPERIMENTAL TEST
• The test process was carried out by immersing the plates in water with fairly calm waters and having a fairly significant biofouling growth rate.
Experimental Setup
Dock
Rope
Immersed 1 m below the surface
Specimens
Biofouling
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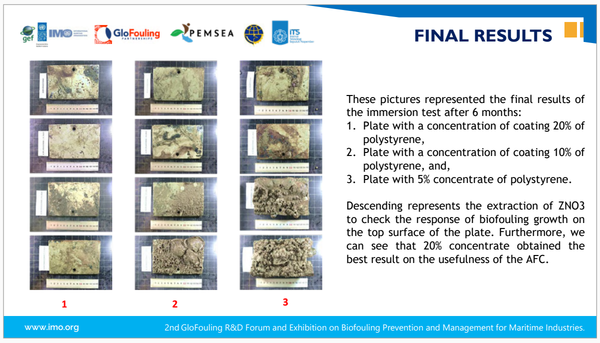
FINAL RESULTS
These pictures represented the final results of the immersion test after 6 months:
1. Plate with a concentration of coating 20% of polystyrene,
2. Plate with a concentration of coating 10% of polystyrene, and,
3. Plate with 5% concentrate of polystyrene.
Descending represents the extraction of ZNO3 to check the response of biofouling growth on the top surface of the plate. Furthermore, we can see that 20% concentrate obtained the best result on the usefulness of the AFC.
1
2
3
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Future Work
• More tests to be carried out on the use of more concentrated polystyrene and submerge the specimens up to 12 months,
• Extended tests on fishing vessels, which is the majority made from wood thus can help the local fishers to maintain their fishing fleets,
• Joint work with painting companies (such as Avian and Propan) to produce more affordable anti-fouling coatings.
Anti Fouling
Avian
propan
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TOR ØSTERVOLD

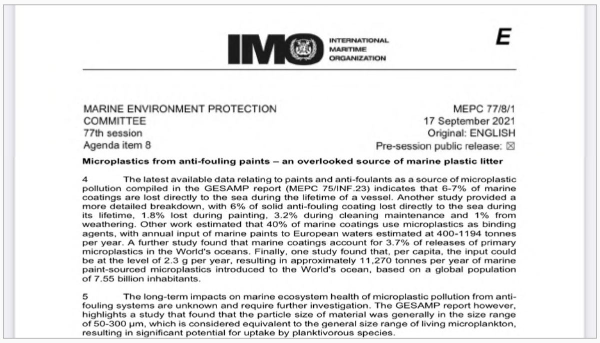
CEO

ECOsubsea

Tor Østervold is the CEO and Founder of ECOsubsea, a world-leading provider of revolutionary hull cleaning technology that drastically reduces biofouling. ECOsubsea was established in 2008 and since then has been awarded the "Young Entrepreneur Award", "Orcelle Award", "Green Shipping Technology Award" and "Global Freight Award" for the development of sustainable technology for the shipping industry.

Results of biofouling cleaning in offshore rigs

Presentation slides



IMO INTERNATIONAL MARITIME ORGANIZATION E

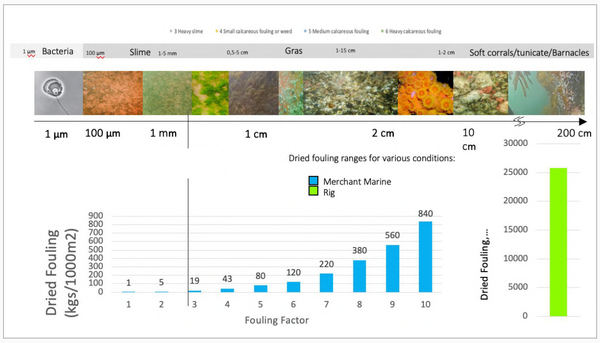
MARINE ENVIRONMENT PROTECTION COMMITTEE
77th session
Agenda item 8

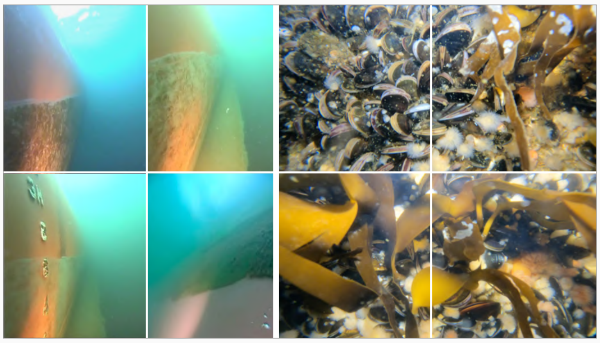
MEPC 77/8/1
17 September 2021
Original: ENGLISH
Pre-session public release: ☒

Microplastics from anti-fouling paints – an overlooked source of marine plastic litter

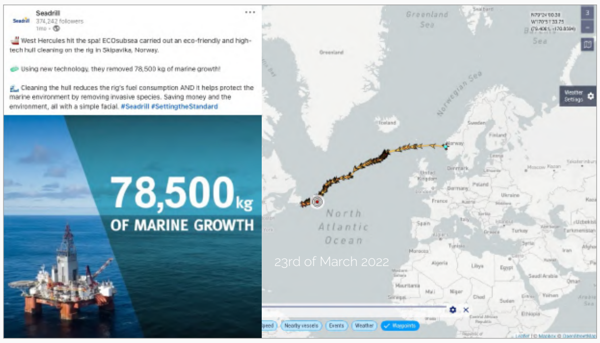
4 The latest available data relating to paints and anti-foulants as a source of microplastic pollution compiled in the GESAMP report (MEPC 75/INF.23) indicates that 6-7% of marine coatings are lost directly to the sea during the lifetime of a vessel. Another study provided a more detailed breakdown, with 6% of solid anti-fouling coating lost directly to the sea during its lifetime, 1.8% lost during painting, 3.2% during cleaning maintenance and 1% from weathering. Other work estimated that 40% of marine coatings use microplastics as binding agents, with annual input of marine paints to European waters estimated at 400-1194 tonnes per year. A further study found that marine coatings account for 3.7% of releases of primary microplastics in the World's oceans. Finally, one study found that, per capita, the input could be at the level of 2.3 g per year, resulting in approximately 11,270 tonnes per year of marine paint-sourced microplastics introduced to the World's ocean, based on a global population of 7.55 billion inhabitants.

5 The long-term impacts on marine ecosystem health of microplastic pollution from anti-fouling systems are unknown and require further investigation. The GESAMP report however, highlights a study that found that the particle size of material was generally in the size range of 50-300 µm, which is considered equivalent to the general size range of living microplankton, resulting in significant potential for uptake by planktivorous species.






ESG
WEST HERCULES' HIGH-TECH HULL CLEANING IS A FIRST FOR SEADRILL
The Stages of a Hull Cleaning
PRE-PLANNING, BUSINESS CASE, SUPPLIER SELECTION (6–18 MONTHS)
HULL ASSESSMENT
CLEANING ON SITE (2 WEEKS)
DISPOSAL OF MARINE WASTE
Why did you run a hull cleaning on the West Hercules?
How was the hull cleaned?
What's new about this?
Why did you decide to work with EcoSubsea?
What have you learned from running this initiative?
What's next for the project team?
Any final thoughts?
Fast fact


Seadrill
374,242 followers
West Hercules hit the spa! ECOsubsea carried out an eco-friendly and high-tech hull cleaning on the rig in Skipavika, Norway.
Using new technology, they removed 78,500 kg of marine growth!
Cleaning the hull reduces the rig's fuel consumption AND it helps protect the marine environment by removing invasive species. Saving money and the environment, all with a simple facial. #Seadrill #SettingtheStandard
78,500kg
OF MARINE GROWTH
North Atlantic Ocean
23rd of March 2022


THANK YOU
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Innovative anti-fouling coating systems, biofouling management technologies and methods in shipping, recreational boating, aquaculture, oil & gas, and ocean renewable energy structures.

PETER MAIDMENT

Engineering and Technical Manager

CleanSubSea

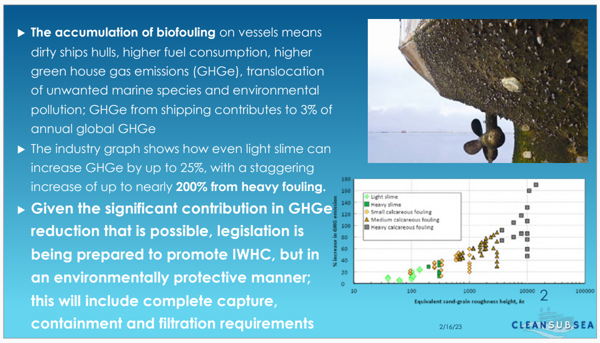
Peter Maidment is CleanSubSea's Engineering and Technical Manager and has overseen the development and production of its first remote-operated (diverless) Envirocart in-water hull cleaning system.

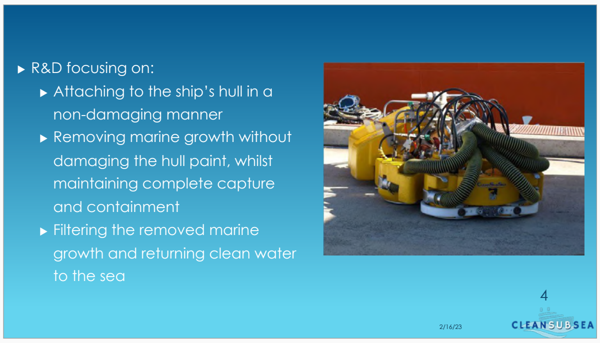
Prior to this, Peter has 20 years' experience in Oil & Gas projects in Europe, the Middle East, SE Asia and Australia. Roles and projects have ranged from pipeline installation and subsea construction, ROV, IMR and DSV vessel management to FPSO hook-up and decommissioning, working onsite, offshore and onshore.

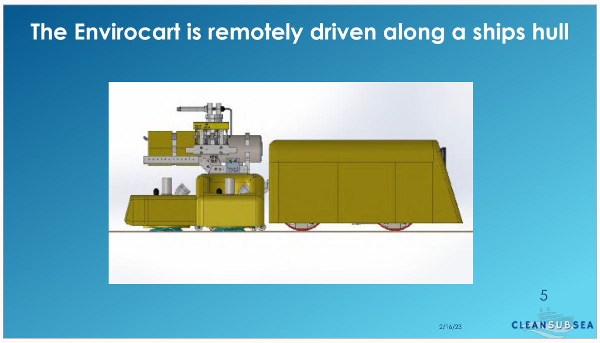
Responsible biofouling management through IWHC with complete capture and containment

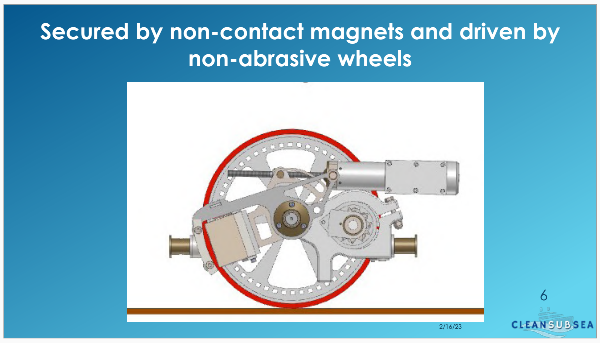
CleanSubSea is an Australian company that has developed the innovative, diver driven or remotely operated (diverless) Envirocart System, a world-first completely closed in-water hull cleaning system with biofouling removal, capture, containment and filtration (meaning no collected marine growth enters the ocean). It includes a subsea cleaning system with interchangeable blades for cleaning bio-fouling from submerged steel surfaces with biocidal and non-biocidal Anti Fouling Coating (AFC). Using nonabrasive technology, the system does not damage the AFC and eliminates polluting the surrounding marine environment during the cleaning operation. The captured effluent is pumped to the surface, filtered through a multi stage treatment system that removes marine growth, particulates and metal toxins from the AFC, which is then rendered nonviable via Ultraviolet reaction before being returned to the marine environment. The purpose of this is to remove marine growth from the hulls of ships, in the water, without costly and time-consuming dry docking but doing so in a very environmentally protective manner; removing marine growth reduces the fuel consumption of a vessel, and eliminates the potential for spreading unwanted/alien "invasive marine species" into Australia's waters or into other marine ecosystems internationally. This process will also save money through reduced fuel costs but more importantly have a very positive environmental impact, in less fuel consumed and a contribution towards net zero targets by significantly reducing greenhouse gas emissions worldwide. The technology has been developed to meet the pending international in-water hull cleaning legislation (through BIMCO/IMO) and is approved for use in Australian waters.

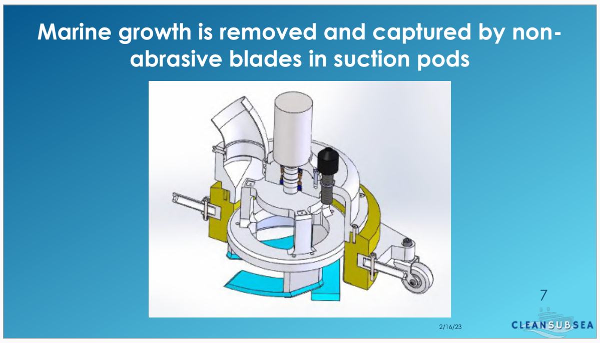
Presentation slides

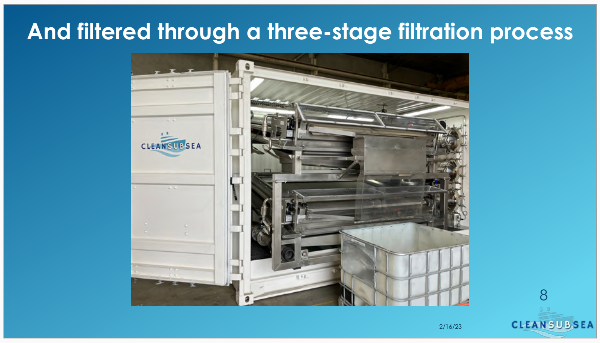












Demonstration of first stage marine growth removal

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FUTURE R&D

- CleanSubSea are conducting ongoing R&D into other innovative technologies that could complement IWHC services. These include:
  - Use of the recovered marine growth as biomass, fuel etc. – the marine growth is incredibly nutrient-rich and has potential as fertiliser or biofuel
  - Additional surveys or mapping of hulls/subsea structures with the Envirocart's cameras, including 3D underwater surveys for detecting damage/anomalies, as well as potentially contributing to or replacing in-water surveys (Class, UWILD etc.)
  - Developing blockchain-based, digital global vessel cleanliness "passports" – i.e., an online system where any port can verify an incoming vessel's most recent marine growth cleans and surveys

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CONCLUDING SUMMARY

- Marine growth increases the friction, and hence drag on a ships hull, leading to higher fuel consumption and increased GHG emissions
- Ships burn approximately 325 million tons of fuel oil to generate around 1 billion tons of GHG emissions annually.
- Removing the marine growth and responsible biofouling management can greatly reduce annual GHG emissions in the order of >150 million tons.
- IWHC is currently managed in different ways all over the world – from prohibition to completely unregulated, abrasive cleaning that pollutes the environment
- Legislation is being prepared to standardise IWHC; and this will include requirements for complete capture, containment and filtration
- Technologies such as the Envirocart System are now available – new IWHC closed systems that clean, capture, contain and filter marine growth

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KARL LANDER

Director, Regulatory Compliance & Outreach

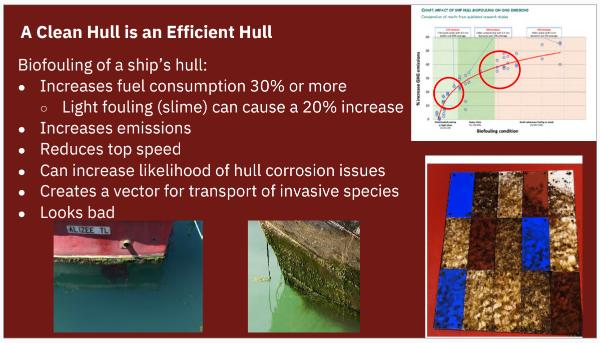
Armach Robotics

Commander Karl Lander, USCG, retired, graduated from the US Coast Guard Academy with a Bachelor of Science degree in Naval Architecture and Marine Engineering. During his 20-plus year career, he served on 6 cutters in a range of roles, including diver, Engineer Officer and Executive Officer, as well as in positions overseeing cutter maintenance and acquisition. Following his retirement, he entered the field of marine robotics, working first for Greensea Systems as Director, Hull Robotics. When Armach Robotics was spun out of Greensea Systems in 2021, he followed, and currently serves as Director, Regulatory Compliance and Outreach.

Autonomous Robots Enable Proactive Cleaning

This presentation will discuss how an autonomous cleaning robot, used habitually and frequently, to keep ship's hulls free of biofouling can improve fuel efficiency, saving money and reducing emissions. Early stage biofouling, or microfouling, has been demonstrated to impact fuel efficiency as much as 15-20%, yet current approaches to biofouling management are directed towards prevention of late stage biofouling or macrofouling. Both current coating systems and current cleaning methods are targeted towards macrofouling, and are of limited effectiveness against microfouling. A new approach is necessary. Small autonomous robots, purpose built for microfouling removal will allow for routine cleaning of vessels without interfering with schedules and operations, and without negatively impacting the coating system. These autonomous robots have been made possible through advancements in positioning technology that allow the robot to track its precise position on the vessel's hull, independent of the vessel's location on the planet. This presentation will provide an overview of the technology behind the robot, including the positioning and autonomy capabilities, as well as the cleaning methodology. Video of the system in operation will be included, as well as long term test results on representative coating systems. Finally, the benefits of a proactive in-water cleaning regimen, including discussion of fuel savings and emissions reduction, compliance with new regulations regarding control of invasive species, and aiding in an effective long term maintenance program will be presented.

Presentation slides



So why aren't we removing biofouling more often?

Current hull cleaning methods are manpower and infrastructure dependent – meaning they are expensive and disruptive to ship schedules

"Until the robot can do the job as expected with minimal operator input and until the human-robot relationship is optimal, a robot is not applicable for the job"

Ben Kinnaman, Founder and CEO
Greensea & Armach Robotics

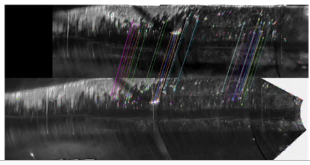
Vehicle

- Includes the following:
  - 6 thrusters for full range of motion in flight
  - Low pressure generator for adhesion
  - Fiber Optic Gyroscope
  - Accelerometers for automatic alignment
  - Track encoders
  - Pressure Sensor
  - Doppler Velocity Logger
- Tracks optimized for coatings
  - Proper traction
  - No damage to coating

Navigation Solution

Sensor Fusion provides a robust solution:

- Fiber-optic gyro based Inertial Navigation System
- Uses gravity and hull-orthogonal vector to establish on-hull orientation
- Precision track velocimetry
- Low-altitude DVL provides off-hull tracking and redundant odometry
- Sonar feature localization bounds navigation error
- Grooming-line detection

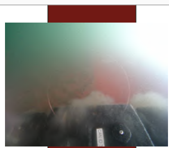


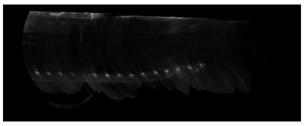
Proactive In-water Cleaning

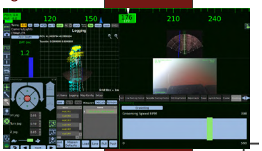
- Cleaning tool tool integrated with crawler skid
- Independent brush control provides coverage feedback
- Independent mounting allows brush heads to follow concave or convex hull surfaces

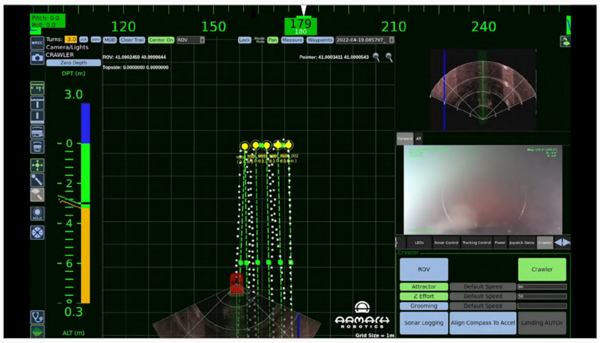
Proactive In-water Cleaning Application

- Clear 4,500 sq ft (±10%) of hull per hour
- Routine (every 1-3 weeks) cleaning proven effective in long-term fouling control[a,b]
- Sonar and Video Inspection while cleaning



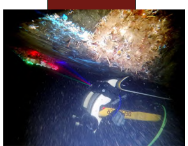


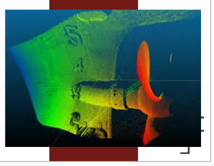




Additional Applications

- Hull Health Monitoring - routine inspection of fouling and coating coverage as part of grooming
- Hull Inspection
  - Class and Flag Inspections
  - UT Inspection
  - 3D mapping
- Security (IED) Inspection





ARMACH ROBOTICS

Questions?

Karl Lander
Director, Regulatory Compliance and Outreach
klander@armachrobotics.com
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EIRIK EIDE

Chief Commercial Officer of Shipshave A/S

Shipshave

Starting as a mariner with Unlimited Deck Officer Class 1, Eirik Eide has held positions with major stakeholders in Shipping. In 2000 he went ashore for commercial positions as Shipbroker, in 2005 as Chief Commercial Officer with a Shipowner and in 2012 as a Marine Logistics Supervisor with an Oil Major&Charterer. Since 2015 he has been a supplier to Shipowner as Area Manager with a large group of shipyards and Eirik is with us in the capacity as Chief Commercial Officer with Shipshave, a young company delivering the innovative and never seen before grooming solution - ITCH.

In-Transit Cleaning of Hulls for sustainable disposal of effluent.

Current methods of in-water removal of fouling are performed on a stationary hull near the shore. No methods yet manage 100% of effluent capture. Ergo the risk of spreading invasive species is still present.

The risk of NIS along a coastline from a ship being cleaned is a function of maturity of the fouling, distance from shore and the efficiency of effluent capture and pacification. The balance is between emitting excessive CO_2 through a fouled hull and remedial hull cleaning causing risk of NIS.

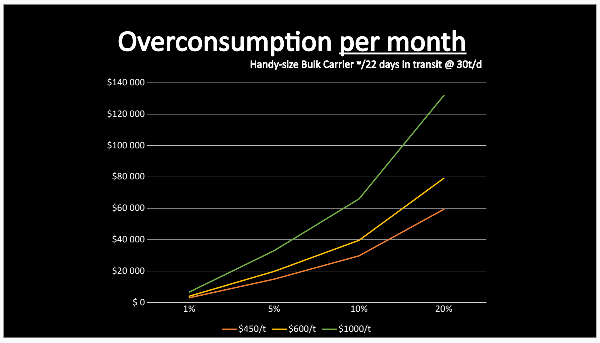
A new grooming method, operated by the seafarers while the vessels generate freight revenues, is available – Shipshave's In Transit Cleaning of Hulls. The method has been demonstrated on ships from 11m to 368m from 9 to 18knots and has been commercially used on 25 ships.

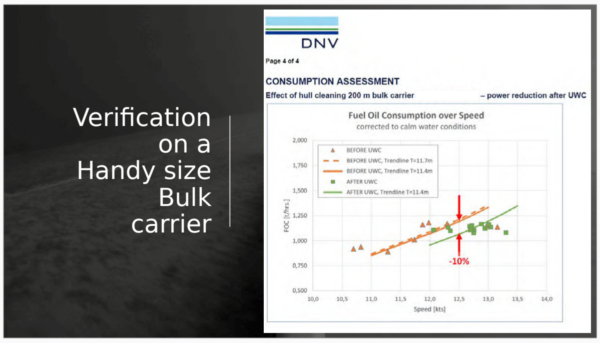
It allows for:

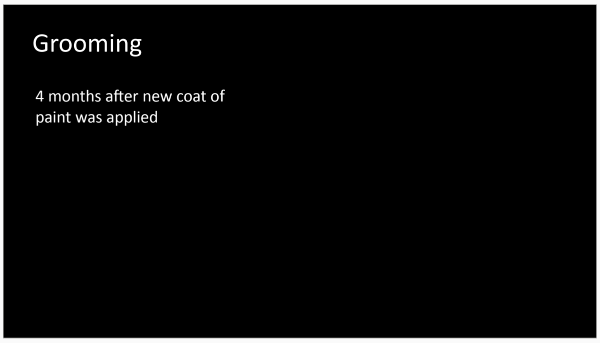
- Disposal of fouling in deep oceans outside territorial waters. Most macrofouling sinks and will not reach the coastline. Unless very shallow waters the NIS will not breed in deep waters
- A 95-99% OPEX reduction without logistical constraints. Cleaning frequency can increase and therefore avoid macrofouling.
- Operation by the crew and transfer of responsibility from a hull performance department to the captain

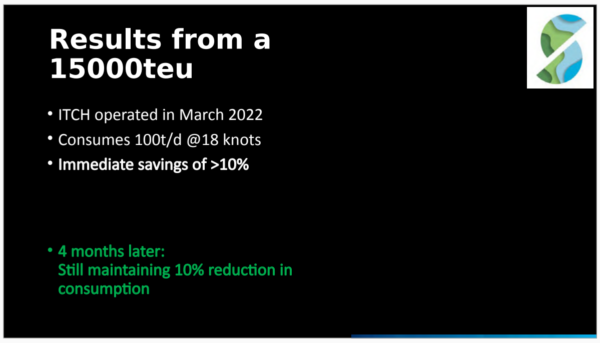
The presentation will cover method, real life case studies, video evidence and operational experience.

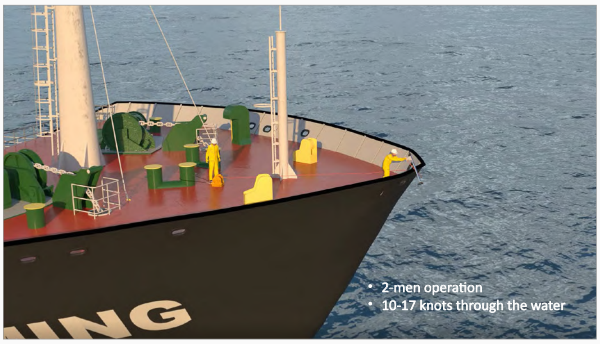
Presentation slides

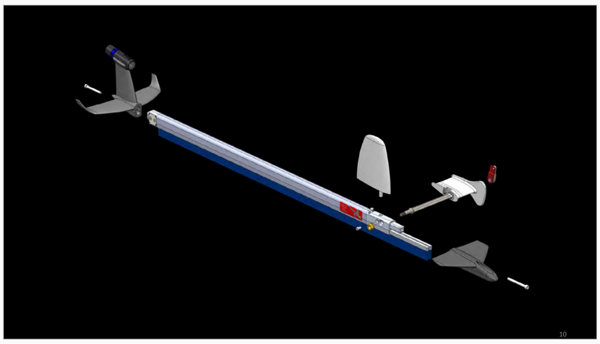


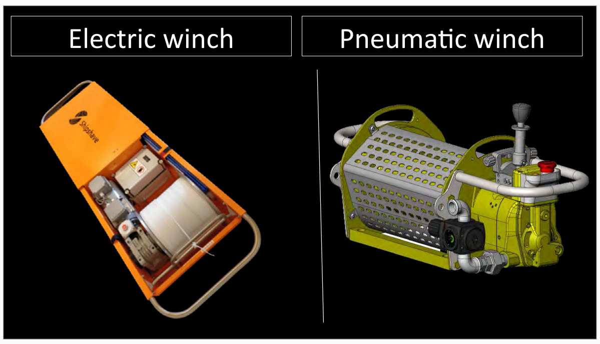


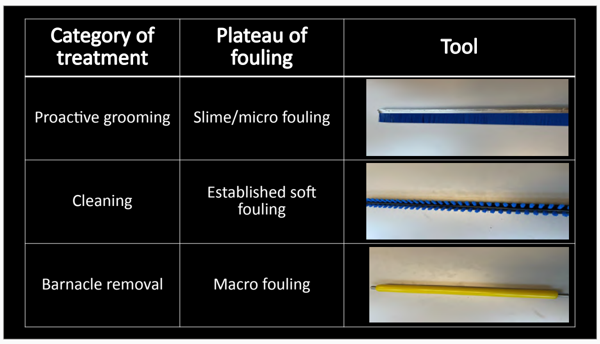


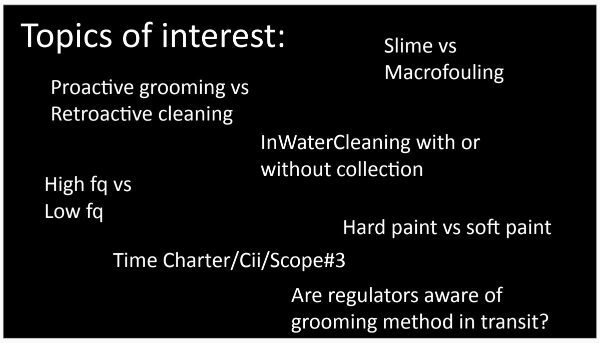











Topics of interest:
Slime vs
Macrofouling
Proactive grooming vs
Retroactive cleaning
InWaterCleaning with or
without collection
High fq vs
Low fq
Hard paint vs soft paint
Time Charter/Cii/Scope#3
Are regulators aware of
grooming method in transit?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THANK YOU FOR YOUR ATTENTION

MELISSA E. TRIBOU

Ocean Engineering and Marine Sciences Research Professional

Florida Institute of Technology

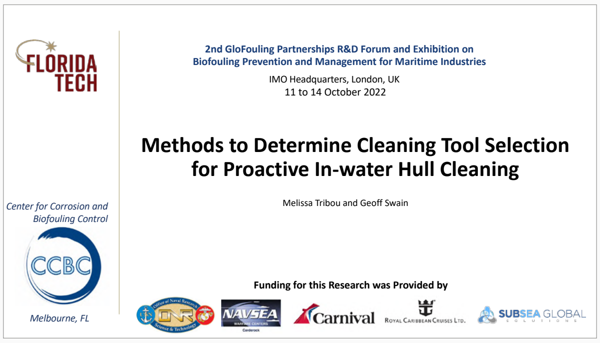
Dr Melissa Tribou is a Post-Doctoral Researcher in the Center for Corrosion and Biofouling Control at Florida Institute of Technology. She holds degrees in Oceanography and Ocean Engineering, and has been funded since 2005 by ONR, cruise lines, and underwater hull maintenance companies to perform research investigating the effects of proactive (grooming) and reactive cleaning on ship hull coatings. She has performed and developed quantifiable methods to measure cleaning effects and has published several articles on the subject. In her leisure time, she can be found in or near the water, primarily racing sailboats.

Methods to Determine Cleaning Tool Selection for Proactive In-water Hull Cleaning

Melissa Tribou and Geoffrey Swain. Ocean Engineering, Florida Institute of Technology. Melbourne, Florida, USA.

Proactive cleaning, or grooming, of a ship's hull is now being considered as a method to maintain fouling control surfaces in a smooth and fouling free condition without damage to the coating. This method is attractive as it reduces environmental risks, hydrodynamic penalties, and ultimately reduces costs. To achieve this; however, the method to clean must be matched to the coating type and applied at a frequency where fouling levels remain low. The factors needing consideration in the design and selection of cleaning tools will be presented, as well as methods to measure fouling adhesion, coating properties, and cleaning tool effectiveness. The goal is to create metrics that allow for the input of coating properties and fouling forecasting from which to output recommended cleaning tools and cleaning frequency. This is an ongoing process and developments and challenges toward reaching this goal will be presented. It is anticipated that the different categories of new and existing coatings will require the development of complimentary grooming methods to maintain them in a smooth and fouling free condition.

Presentation slides




Proactive (Grooming) vs. Reactive Cleaning
Groomed for 1 year
Cleaned after 22 months
Proactive
Higher Cleaning Frequency
Gentle Grooming Tools
No Hard Fouling
Coating Longevity
No Capture Required
No Divers
Lower Vehicle Power Requirements
Reduced GHG Emissions
Prevents Invasive Species
Reactive
Lower Cleaning Frequency
Heavy duty Cleaning Tools
Fouling Penalty
Coating Damage
Capture and Treatment for Discharge may be Required
Divers Required
Powerful Vehicles
Increased GHG Emissions
Risk of Invasive Species
Center for Corrosion and Biofouling Control
Florida Institute of Technology, Melbourne FL
2nd GloFouling Partnerships R&D Forum and Exhibition on Biofouling Prevention and Management for Maritime Industries
IMO Headquarters, London, UK
11 to 14 October 2022
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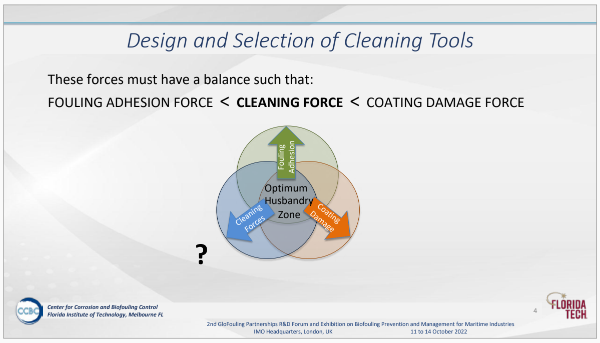
Design and Selection of Cleaning Tools
These forces must have a balance such that:
FOULING ADHESION FORCE < CLEANING FORCE < COATING DAMAGE FORCE
Fouling Adhesion
Optimum Husbandry Zone
Cleaning Forces
Coating Damage
?
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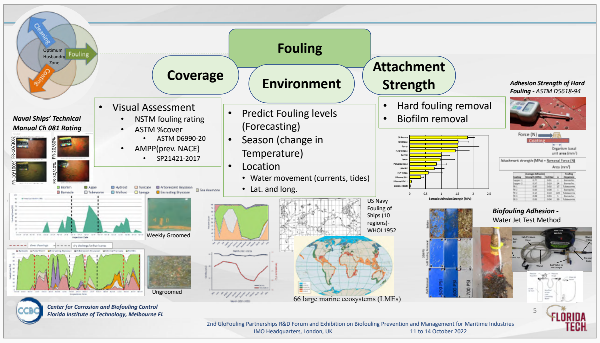
Fouling
Coverage
Environment
Attachment Strength
Visual Assessment
NSTM fouling rating
ASTM %cover
ASTM D6990-20
AMPP(prev. NACE)
SP21421-2017
Predict Fouling levels (Forecasting)
Season (change in Temperature)
Location
Water movement (currents, tides)
Lat. and long.
Hard fouling removal
Biofilm removal
Naval Ships' Technical Manual Ch 081 Rating
Adhesion Strength of Hard Fouling - ASTM D5618-94
Weekly Groomed
Ungroomed
US Navy Fouling of Ships (10 regions)- WHOI 1952
66 large marine ecosystems (LMEs)
Biofouling Adhesion - Water Jet Test Method
Center for Corrosion and Biofouling Control
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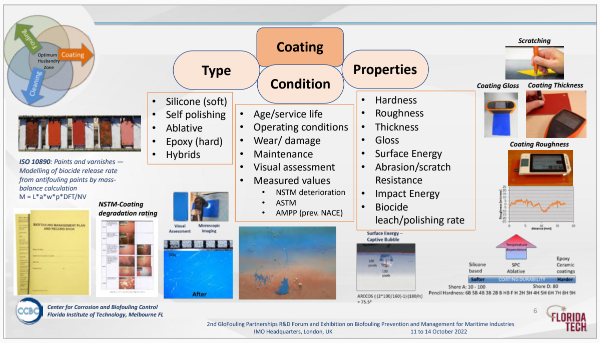
Coating
Type
Condition
Properties
Silicone (soft)
Self polishing
Ablative
Epoxy (hard)
Hybrids
Age/service life
Operating conditions
Wear/ damage
Maintenance
Visual assessment
Measured values
NSTM deterioration
ASTM
AMPP (prev. NACE)
Hardness
Roughness
Thickness
Gloss
Surface Energy
Abrasion/scratch Resistance
Impact Energy
Biocide leach/polishing rate
Scratching
Coating Gloss
Coating Thickness
Coating Roughness
ISO 10890: Points and varnishes — Modelling of biocide release rate from antifouling paints by mass-balance calculation
NSTM-Coating degradation rating
Surface Energy - Captive Bubble
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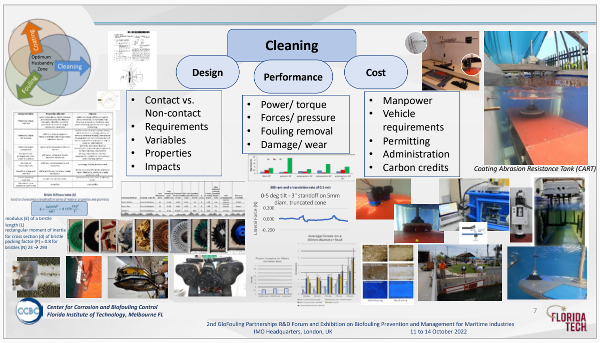
Cleaning
Design
Performance
Cost
Contact vs. Non-contact
Requirements
Variables
Properties
Impacts
Power/ torque
Forces/ pressure
Fouling removal
Damage/ wear
Manpower
Vehicle requirements
Permitting
Administration
Carbon credits
Coating Abrasion Resistance Tank (CART)
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Non-contact and contact testing on fouling release coatings
output rate of 2.4 gal/min at 2700PSI
1 month Census
Before Cleaning
After Cleaning
Before Cleaning
After Cleaning
6 months
Static
Dynamic
Groomed
Ungroomed
Center for Corrosion and Biofouling Control
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Coating Abrasion Resistance Tank (CART) testing
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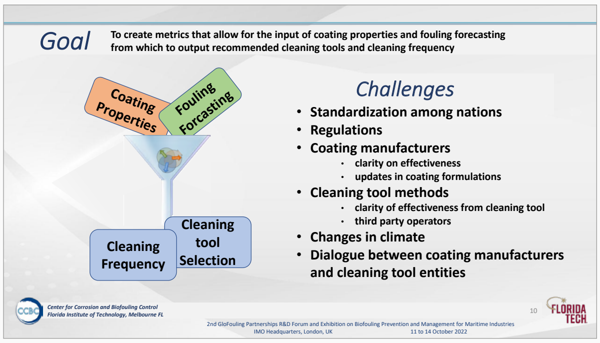
Goal
To create metrics that allow for the input of coating properties and fouling forecasting from which to output recommended cleaning tools and cleaning frequency
Coating Properties
Fouling Forecasting
Cleaning Frequency
Cleaning tool Selection
Challenges
Standardization among nations
Regulations
Coating manufacturers
clarity on effectiveness
updates in coating formulations
Cleaning tool methods
clarity of effectiveness from cleaning tool
third party operators
Changes in climate
Dialogue between coating manufacturers and cleaning tool entities
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LISA-MAY ALVAREZ

Engineer

University of Toulon

I was born and raised in Lyon, France. Here I completed my studies at Claude Bernard University, with my undergraduate degree focusing on genetics and molecular biology. This was followed by a Master of Molecular and Cellular Biology specialised in Infectiology. Now, I am a study engineer in MAPIEM laboratory at the University of Toulon. I study the impact of ultrasounds on biofilm formation and on macro-fouling.

Impact of ultrasounds on micro and macro-fouling development.

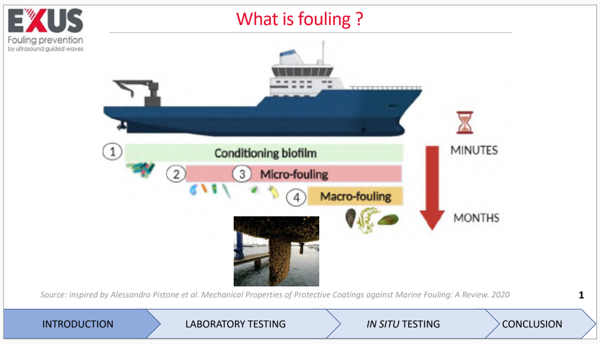
Lisa-May Alvarez[1] (lisa-may.alvarez@univ-tln.fr), Raphaëlle Martinet[1], Maëlle Molmeret[1], André Margaillan[1] and Claudine Baraquet[1]

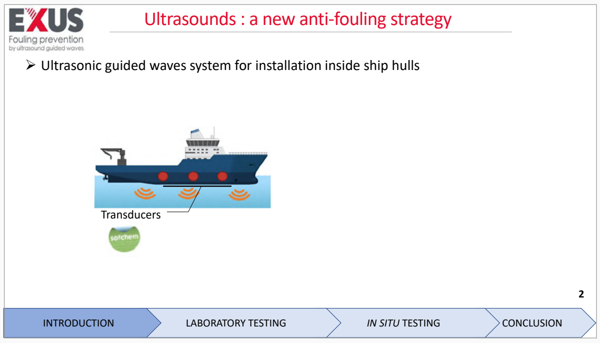
[1] Laboratoire MAPIEM, EA4323, Université de Toulon, La Garde, France

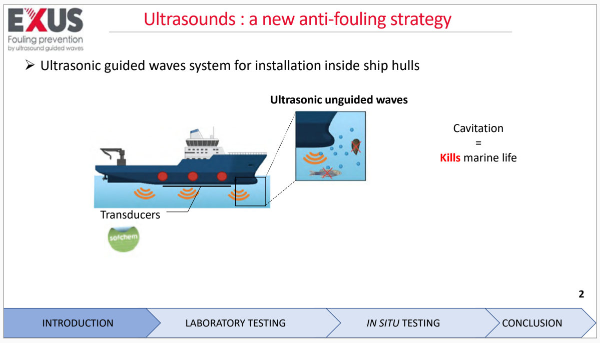
ABSTRACT

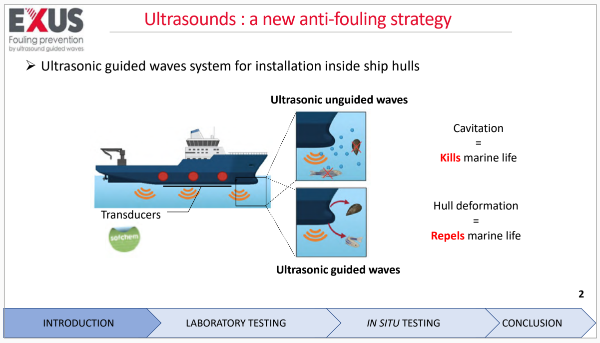
All artificial structures or surfaces immersed in an aqueous medium can be subjected to the accumulation of micro- and macro-organisms called biofouling. Marine biofouling causes significant economic costs for the marine industries. The formation of microbial biofilm is considered as a preliminary step to biofouling. Targeting the marine biofilm is an approach that could limit adhesion and colonization by other organisms. Various anti-biofilm strategies have been developed. However, these strategies pose environmental issues and there is a need for more environmentally friendly antifouling technologies. Some emerging strategies using ultrasounds could offer alternative options to successfully reduce/inhibit biofilms. The purpose of this work was to analyze the impact of ultrasounds on micro- and macro-fouling development. To do that, a laboratory test was performed. In this assay, a transducer generating ultrasounds guided waves was attached to a stainless-steel plate where bacteria can adhere. Quantification of bacteria adhered to the surface was performed by CFU counting and fluorescence microscopy. The presence of ultrasounds significantly reduced (or delayed) biofilm formation. The application of ultrasounds on pre-formed biofilms also had a curative effect. In parallel, a sea trial measuring the impact of ultrasounds on macro-fouling is currently being conducted for a period of 18 months. Transducers generating ultrasonic guided waves were attached on plates (1m by 1m), representatives of a hull in a port environment. The effectiveness of ultrasounds is studied on different industrial coatings such as Biocide-Based Coatings, Fouling Release Coatings and coatings without anti-fouling activity. A visual inspection of the macrofouling is performed monthly. Analysis of the data is ongoing.

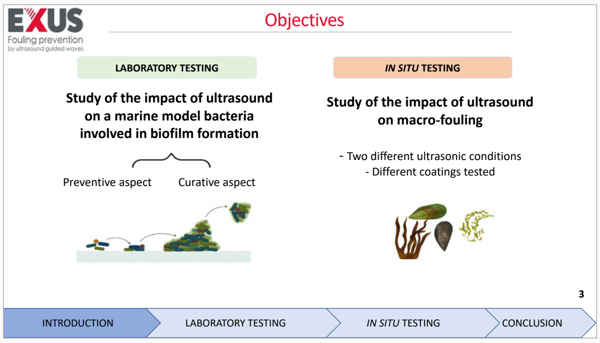
Presentation slides

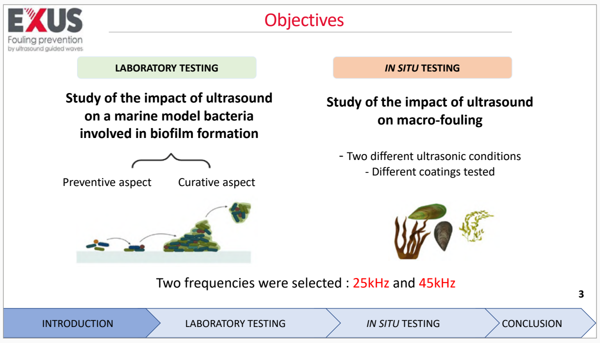


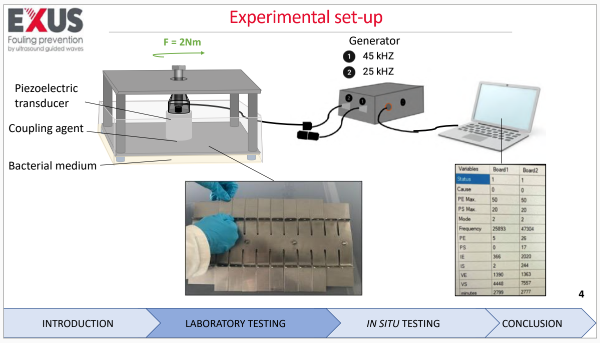


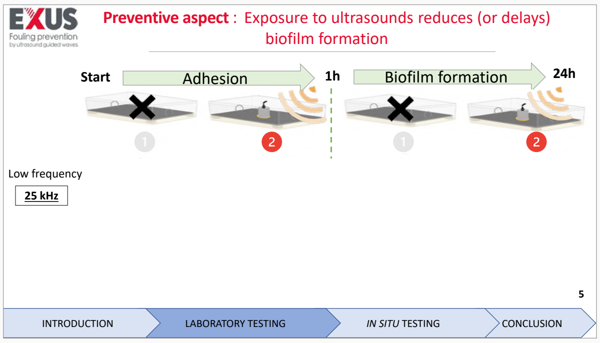


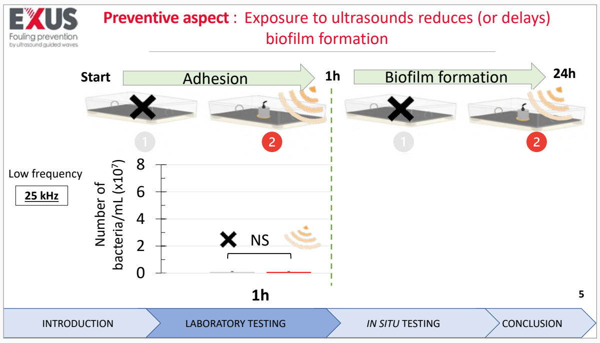


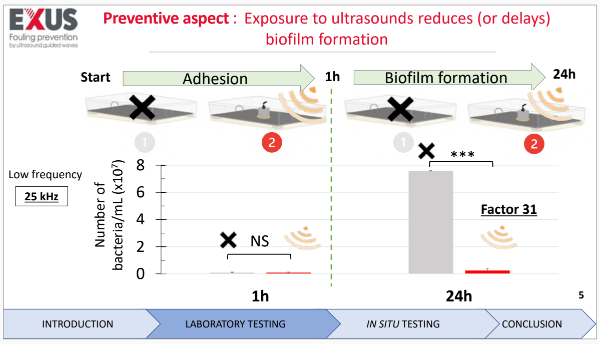


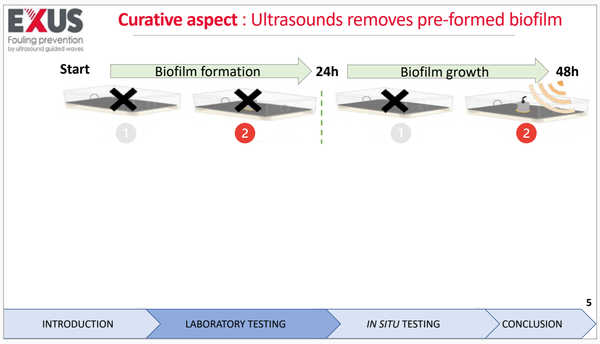









EXUS
Fouling prevention
Preventive aspect : Exposure to ultrasounds reduces (or delays) biofilm formation
Start
Adhesion
1h
Biofilm formation
24h
Low frequency
25 kHz
Number of bacteria/mL (x10⁷)
NS
***
Factor 31
1h
24h
5
INTRODUCTION
LABORATORY TESTING
IN SITU TESTING
CONCLUSION


EXUS
Fouling prevention
Curative aspect : Ultrasounds removes pre-formed biofilm
Start
Biofilm formation
24h
Biofilm growth
48h
5
INTRODUCTION
LABORATORY TESTING
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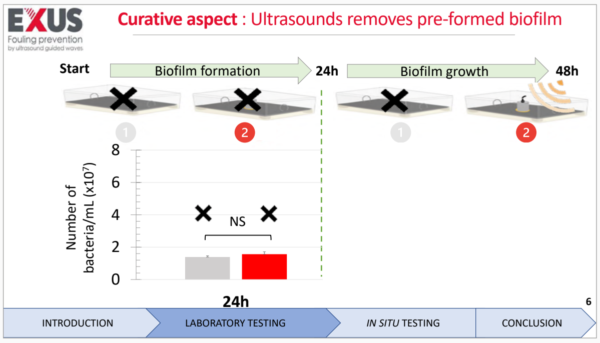
CONCLUSION


EXUS
Fouling prevention
Curative aspect : Ultrasounds removes pre-formed biofilm
Start
Biofilm formation
24h
Biofilm growth
48h
Number of bacteria/mL (x10⁷)
NS
24h
6
INTRODUCTION
LABORATORY TESTING
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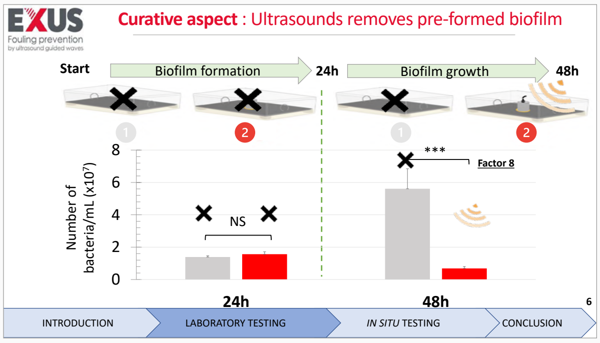
CONCLUSION


EXUS
Fouling prevention
Curative aspect : Ultrasounds removes pre-formed biofilm
Start
Biofilm formation
24h
Biofilm growth
48h
Number of bacteria/mL (x10⁷)
NS
***
Factor 8
24h
48h
6
INTRODUCTION
LABORATORY TESTING
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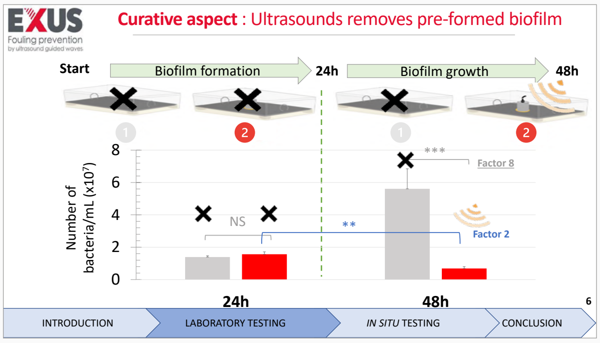
CONCLUSION


EXUS
Fouling prevention
Curative aspect : Ultrasounds removes pre-formed biofilm
Start
Biofilm formation
24h
Biofilm growth
48h
Number of bacteria/mL (x10⁷)
NS
**
***
Factor 8
Factor 2
24h
48h
6
INTRODUCTION
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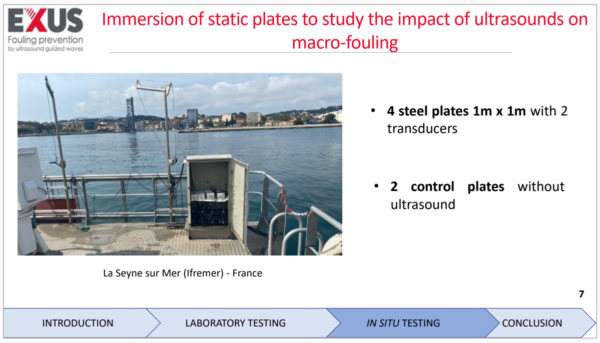
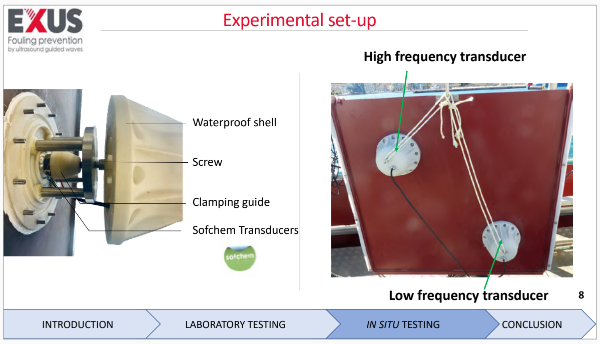
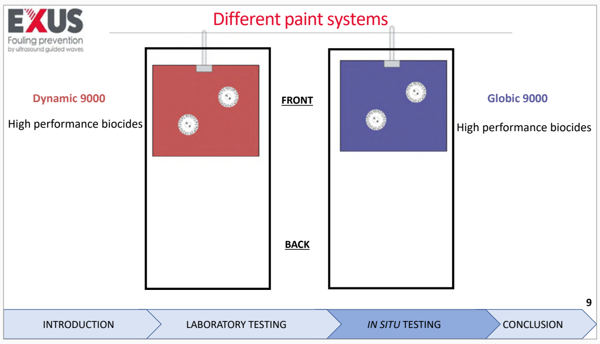
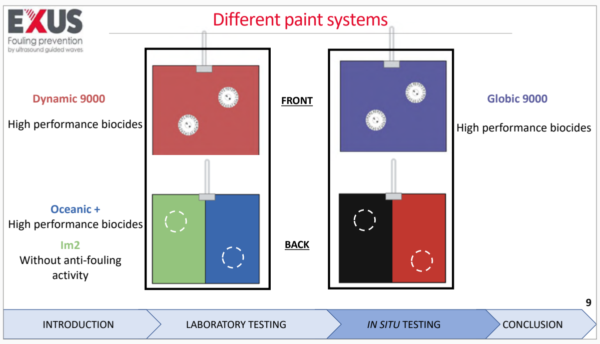
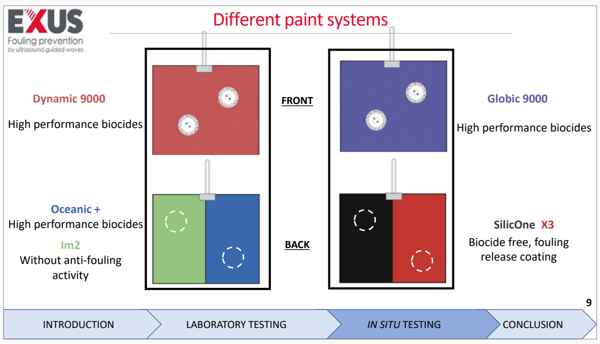
CONCLUSION


EXUS
Fouling prevention
Immersion of static plates to study the impact of ultrasounds on macro-fouling
4 steel plates 1m x 1m with 2 transducers
2 control plates without ultrasound
La Seyne sur Mer (Ifremer) - France
7
INTRODUCTION
LABORATORY TESTING
IN SITU TESTING
CONCLUSION


EXUS
Fouling prevention
Experimental set-up
Waterproof shell
Screw
Clamping guide
Sofchem Transducers
High frequency transducer
Low frequency transducer
8
INTRODUCTION
LABORATORY TESTING
IN SITU TESTING
CONCLUSION


EXUS
Fouling prevention
Different paint systems
Dynamic 9000
High performance biocides
FRONT
BACK
Globic 9000
High performance biocides
9
INTRODUCTION
LABORATORY TESTING
IN SITU TESTING
CONCLUSION


EXUS
Fouling prevention
Different paint systems
Dynamic 9000
High performance biocides
Oceanic +
High performance biocides
Im2
Without anti-fouling activity
FRONT
BACK
Globic 9000
High performance biocides
9
INTRODUCTION
LABORATORY TESTING
IN SITU TESTING
CONCLUSION


EXUS
Fouling prevention
Different paint systems
Dynamic 9000
High performance biocides
Oceanic +
High performance biocides
Im2
Without anti-fouling activity
FRONT
BACK
Globic 9000
High performance biocides
SilicOne X3
Biocide free, fouling release coating
9
INTRODUCTION
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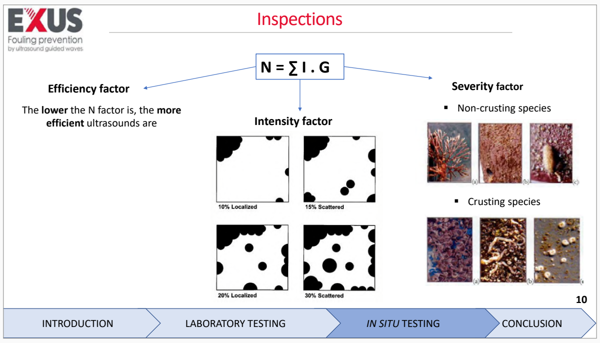
IN SITU TESTING
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
Inspections
N = ∑ I . G
Efficiency factor
The lower the N factor is, the more efficient ultrasounds are
Intensity factor
10% Localized
15% Scattered
20% Localized
30% Scattered
Severity factor
Non-crusting species
Crusting species
10
INTRODUCTION
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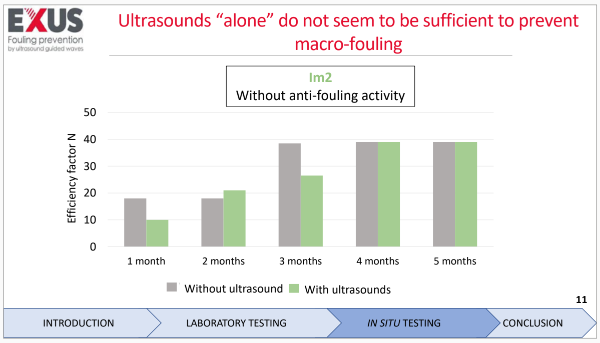
IN SITU TESTING
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
Ultrasounds "alone" do not seem to be sufficient to prevent macro-fouling
Im2
Without anti-fouling activity
Efficiency factor N
50
40
30
20
10
0
1 month
2 months
3 months
4 months
5 months
Without ultrasound
With ultrasounds
11
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LABORATORY TESTING
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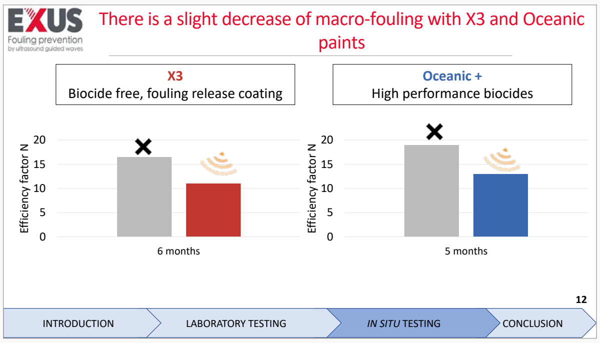
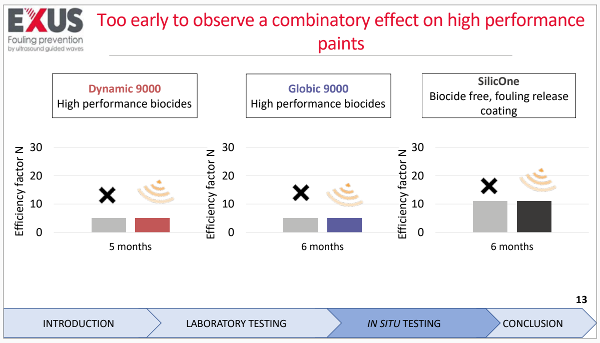
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
There is a slight decrease of macro-fouling with X3 and Oceanic paints
X3
Biocide free, fouling release coating
Oceanic +
High performance biocides
Efficiency factor N
20
15
10
5
0
6 months
5 months
12
INTRODUCTION
LABORATORY TESTING
IN SITU TESTING
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
Too early to observe a combinatory effect on high performance paints
Dynamic 9000
High performance biocides
Globic 9000
High performance biocides
SilicOne
Biocide free, fouling release coating
Efficiency factor N
30
20
10
0
5 months
6 months
6 months
13
INTRODUCTION
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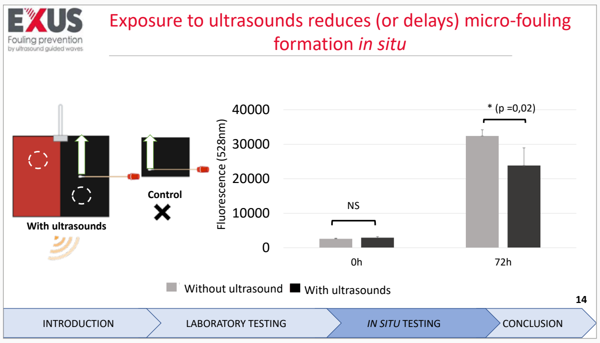
IN SITU TESTING
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
Exposure to ultrasounds reduces (or delays) micro-fouling formation in situ
With ultrasounds
Control
Fluorescence (528nm)
40000
30000
20000
10000
0
NS
* (p =0,02)
0h
72h
Without ultrasound
With ultrasounds
14
INTRODUCTION
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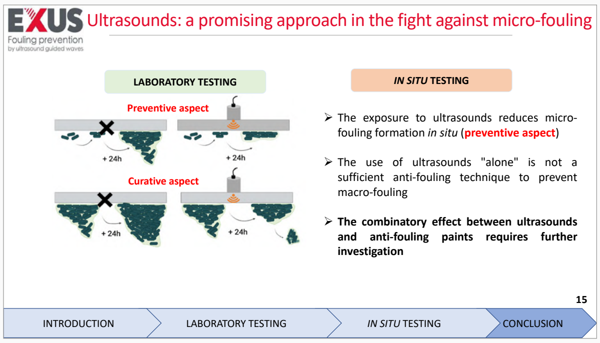
IN SITU TESTING
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
Ultrasounds: a promising approach in the fight against micro-fouling
LABORATORY TESTING
Preventive aspect
+ 24h
Curative aspect
+ 24h
IN SITU TESTING
The exposure to ultrasounds reduces micro-fouling formation in situ (preventive aspect)
The use of ultrasounds "alone" is not a sufficient anti-fouling technique to prevent macro-fouling
The combinatory effect between ultrasounds and anti-fouling paints requires further investigation
15
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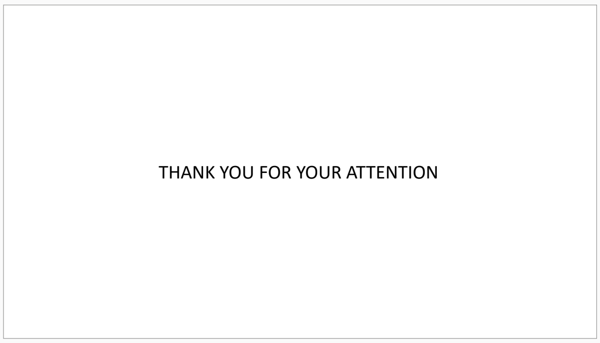
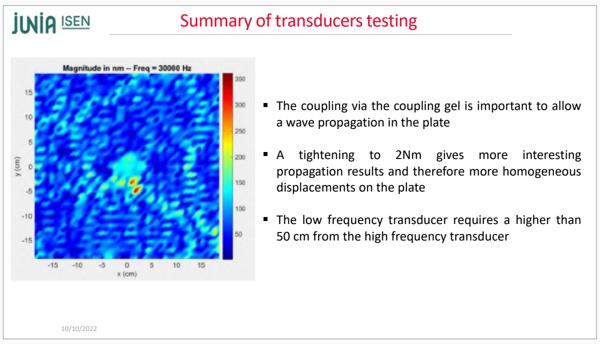
IN SITU TESTING
CONCLUSION


EXUS Fouling prevention by ultrasound guided waves
Acknowledgments
Labellisation :
MAPIEM
UNIVERSITÉ DE TOULON
Members of the MAPIEM laboratory :
André Margaillan (in situ tests)
Claudine Baraquet (laboratory tests)
Lucile Pelloquet/Raphaëlle Barry (inspection help)
Maëlle Molmeret
NOVALL
Novall : Design of waterproof shells
Camille Blanc
MCI
MCI : Electronics Design
Jean-Claude Tillet
sofchem
Sofchem : Supplier of transducers
Pierre-Oliver Jost
This project was supported by :
bpifrance
Grand Est
REGION SUD


THANK YOU FOR YOUR ATTENTION


JUNIA ISEN
Summary of transducers testing
Magnitude in nm -- Freq = 30000 Hz
x (cm)
y (cm)
The coupling via the coupling gel is important to allow a wave propagation in the plate
A tightening to 2Nm gives more interesting propagation results and therefore more homogeneous displacements on the plate
The low frequency transducer requires a higher than 50 cm from the high frequency transducer
10/10/2022

Environmental and economic impacts of invasive aquatic species introduced via biofouling on ships, other marine structures and aquaculture equipment.

MARIO TAMBURRI

Professor, Chesapeake Biological Laboratory

University of Maryland Center for Environmental Science, USA

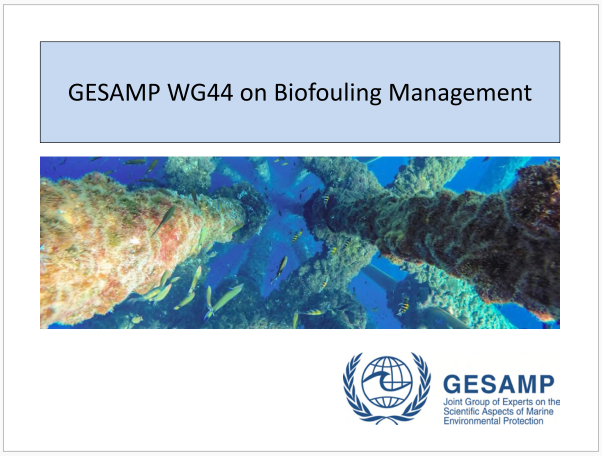
Dr Mario Tamburri received a Bachelor's degree from University of California Santa Barbara, a Master's degree from University of Alabama, and a Ph.D. from the University of South Carolina in biology and marine science. His basic science research focuses on how chemical cues regulate basic biological and ecological processes of aquatic organisms, including larval settlement. Dr Tamburri has worked in environments ranging from estuaries to the deep sea. Recently, he has focused much of his work on new innovations to address environmental problems from climate change to invasive species.

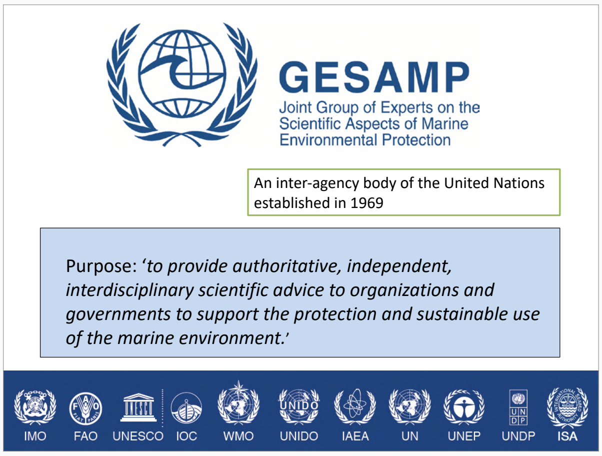
Dr Tamburri is now a Professor at the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, and Director two environmental innovation programs, the Alliance for Coastal Technologies (ACT) and the Maritime Environmental Resource Center (MERC). ACT is a NOAA- and EPA-funded effort dedicated to fostering the development and adoption of effective and reliable sensors and platforms for studying and monitoring coastal, ocean and freshwater environments. Similarly, MERC is a State of Maryland and US Maritime Administration initiative that provides test facilities, expertise, information, technologies, and decision tools to address key environmental issues facing the international maritime industry. Dr Tamburri has published nearly 100 peer- reviewed publications, technical reports and book chapters and has severed on multiple national and international scientific committees, including: an Ocean Studies Board on Ocean Infrastructure at the National Academies; a working group member of the US EPA Science Advisory Board, International Council for the Exploration of the Sea (ICES) and International Organization for Standardization (ISO); and a founding member of Global TestNet.

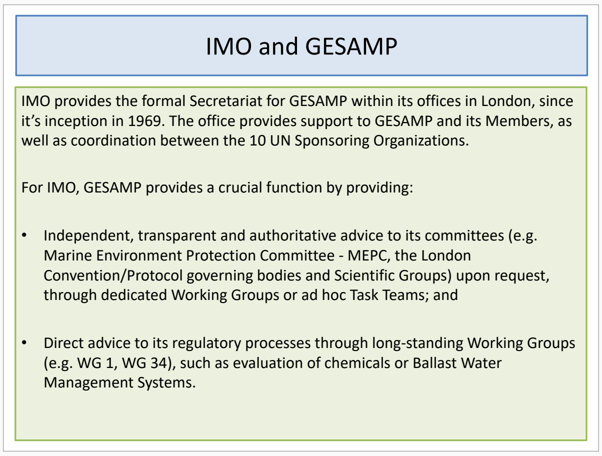
GESAMP WG 44: Biofouling Management

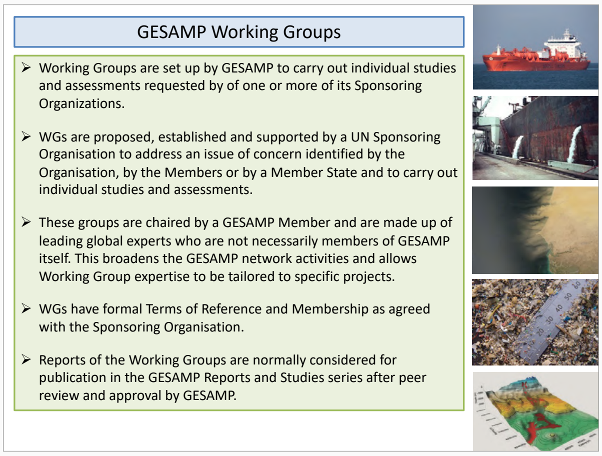
Update on the status of development of the GESAMP WG 44.

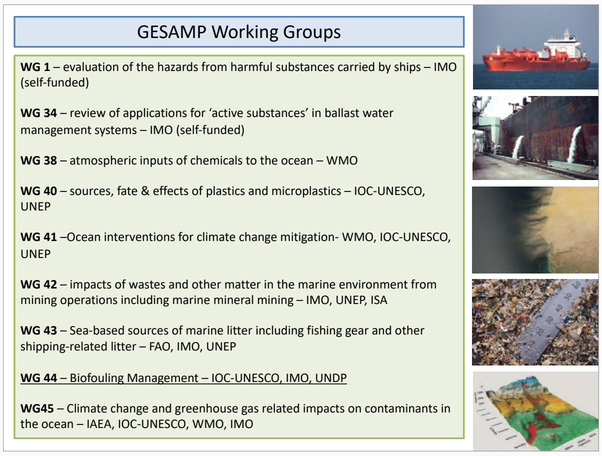
Presentation slides

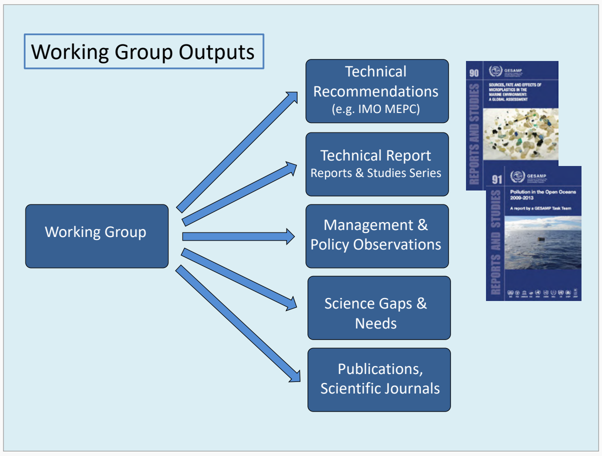












GESAMP WG44

- Objective is to build a broader understanding on introduction and spread of NIS via biofouling across all maritime industries.
- Started work in 2020 and final report by December 2023.
- Terms of Reference:
  1. Comprehensive identification and description of both primary and secondary pathways for the transfer of NIS, including, but not limited to:
     a. fishing (e.g. ships, gear, lines);
     b. aquaculture (e.g. structures, cages, buoys, netting);
     c. shipping (e.g. hulls, niche areas, propellers, ropes, anchors);
     d. other shipping (e.g. recreational boating, recreational fishing, Aids to Navigation);
     e. marine offshore operations (e.g. offshore platforms and structures);
     f. ocean renewable energy generation (e.g. underwater turbines, shafts);
     g. ocean monitoring (e.g. measuring instruments); and
     h. coastal industry infrastructure (e.g. ports, marinas, cooling towers, water purifying units)
  2. Description and assessment of impacts on biodiversity of the introduction and/or spread of NIS via the pathways.
  3. Description and assessment of impact of and costs resulting from the introduction and/or spread of NIS via the pathways (human health, social activities, fisheries, aquaculture, tourism, etc).
  4. An analysis of best management approaches within impacted industries, including the use of emerging technologies, techniques and methods and their efficacy and safety.
  5. Recommendations to reduce or prevent the introduction or spread of NIS.
  6. Identification of data gaps and prioritization for further work.

GESAMP WG44

Current Members

Name	Surname	Institution	Country	Subject
Joop	Coolen	Wageningen University	The Netherlands	Oil and Gas
Andrew	Want	Heriot Watt University	United Kingdom	Renewables
Pedro	Almeida Vinagre	WavEC Offshore Renewables	Portugal	Constructions
Serena	Teo	National University of Singapore (NUS)	Singapore	Aquaculture
Youna	Lyons	Centre for International Law (NUS)	Singapore	Environmental Governance
Nina	Blocher	SINTEF	Norway	Aquaculture
Kamal	Ranatunga	University of Sri Jayewardenepura	Sri Lanka	Ports
Agnese	Marchini	Universita di Pavia	Italy	Marinas
Koebraa	Peters	Stellenbosch University	South Africa	Boating
Mario	Tamburri	University of Maryland Center for Environmental Science	United States	Shipping
David	Smith	Plymouth Marine Laboratory	United Kingdom	Shipping
Marnie	Campbell	Murdoch University	Australia	Biosecurity socioeconomy
Evangelina	Schwindt	Centro Nacional Patagonico	Argentina	Marinas
Hiroshi	Kawai	Kobe University Research Center for Inland Seas	Japan	Bioinvasions
Jung-Hoon	Kang	Korea Institute of Ocean Science and Technology (KIOST)	Republic of Korea	Risk assessments

Jake Rice (Canada) consultant and former members include Katja Broeg (Germany), Pei-Yuan Qian (China), and Anna Yunnie (UK).

More on GESAMP

GESAMP would be pleased to discuss its work and would be happy to demonstrate how it might offer assistance and advise, through Sponsoring Organisations, in relation to any areas of Marine Environmental Protection
www.gesamp.org

Specific questions or comments for WG44 can be submitted to tamburri@umces.edu

Thank you

SARAH CULLOTY

Director, Environmental Research Institute

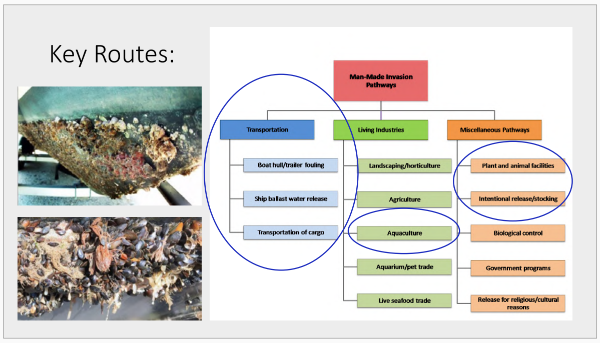
University College Cork, Ireland

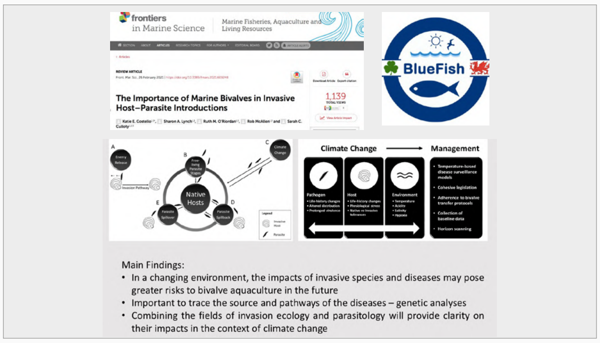
Sarah Culloty has worked on shellfish pathology and diseases for over 25 years having started her career with a PhD, on an emerging disease in oysters, Bonamia ostreae, and its introduction to Ireland in the 1980s. Her work focuses on disease dynamics, epidemiology and understanding the drivers of disease development particularly in bivalve molluscs. In particular she has worked on factors that facilitate disease transmission such as transmission routes and the potential ways that disease can be incidentally transmitted and then maintained in introduced areas. Working at University College Cork she leads a team of PhD students and research staff working on a number of significant pathogens for shellfish. She has published over 100 papers, supervised over 40 masters and PhD students. She is currently Director of the Environmental Research institute at UCC.

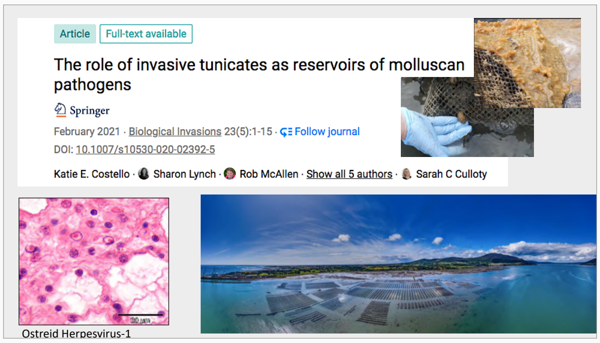
Unintended consequences: Disease and pathogen spread in a global economy

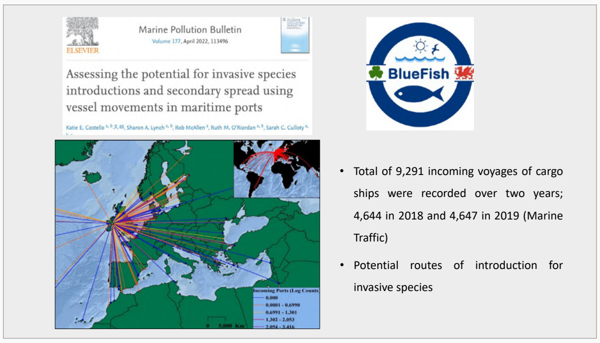
Disease events in the marine environment are increasing due to a range of factors including intensified activity, transport and a changing marine environment. The aquaculture industry has suffered some severe mortality events and losses as the industry has intensified, many due to pathogens and disease. Many of these diseases have been introduced to different regions via aquaculture practices and unintended transport of infected animals. Understanding how these diseases have developed and become established is a primary focus to enable control and eradication methods to be developed. In the shellfish industry in Europe, viruses, bacteria and a range of parasites have become established causing severe impacts. Many of these have spread to Ireland and understanding how they were introduced and established is a focus of the research. Our research has demonstrated that many factors are involved in the initial introduction of the parasite and its establishment. Many marine organisms in the vicinity of the disease can act as unintended carriers or reservoirs of infection, ensuring that the disease is maintained and becomes established in the area and may facilitate being unintentionally transported to new areas. Biofouling organisms due to their close association with aquaculture equipment can act as potential carriers of disease. In addition, invasive species are becoming an increasing challenge due to a changing environment and may facilitate the spread of new or current diseases. The current BLUEFISH project which is focussing on aquaculture and fisheries in the Irish Sea is understanding some of the drivers of infection in that region and consequences into the future for the industry.

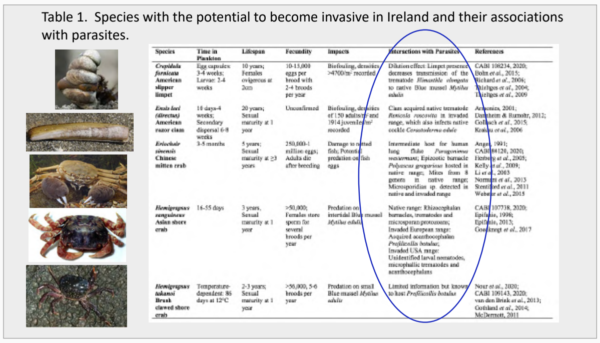
Presentation slides

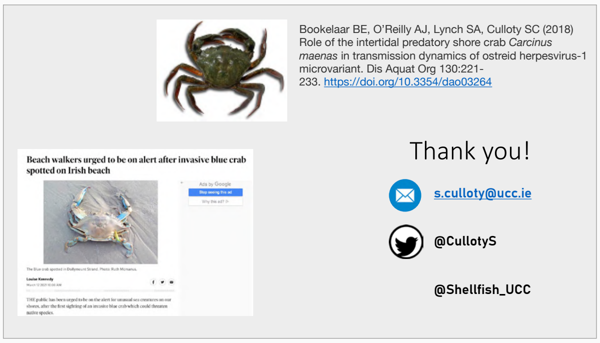












PAULA HOLLAND

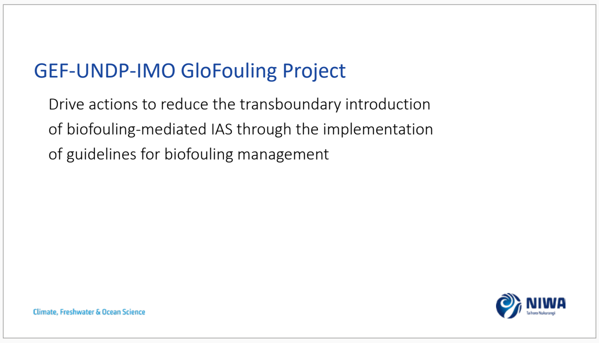
Environmental Economist

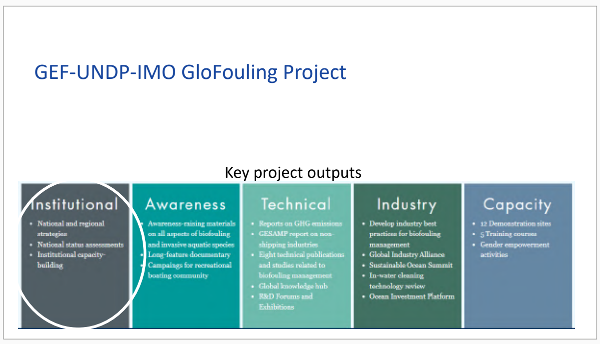
New Zealand National Institute of Water and Atmospheric Research

Paula Holland is an Environmental Economist with the New Zealand National Institute of Water and Atmospheric Research. She has over 30 years' experience conducting economic analysis for sustainable development, covering climate change adaptation, disaster risk management, fisheries and conservation. Her work experience includes work for national government and academia in New Zealand, Australia and the UK, as well as extensive experience with intergovernmental agencies in the Pacific. Paula's work experience covers issues such as cost benefit analysis, economic valuation, and the costing of policies. She also has considerable experience in building the capacity of government staff in natural resource economics.

Guide for the development of Rapid Economic Assessments for Biofouling Management and Invasive Aquatic Species: an overview

Presentation slides





Rapid economic assessment?

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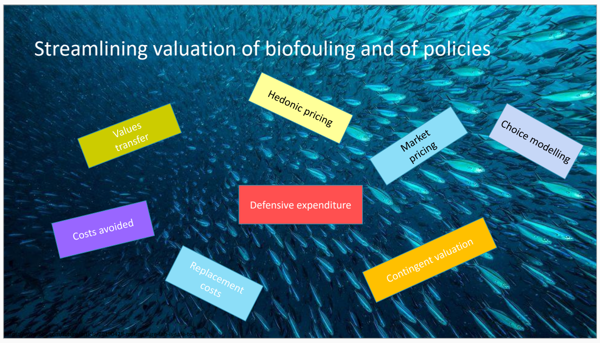
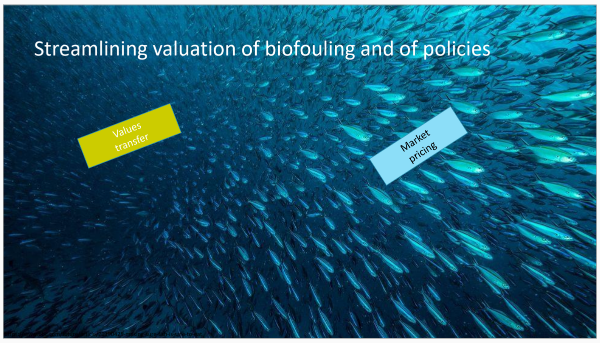
5

- Shipping industry
- Ports and Marinas sector
- Aquaculture sector
- Fishing sector
- Marine renewable energies sector
- Offshore mining sector
- Recreational boating sector
- Tourism sector
- Coastal infrastructure
- Biofuels And Food Components
- Pharmaceuticals and Cosmetics
- Environmental impacts and non-uses
- Recreational Uses

Climate, Freshwater & Ocean Science





Database of other case studies for values transfer

- The *impacts* of IAS on industries and the environment
- The *values* associated with costs and change

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Database of Case Studies

This Database has been created to support calculations in relation to the methodology proposed in the Handbook for Rapid Economic Assessments in relation to biofouling management and IAS, published by the GEF-UNDP-IMO GloFouling Partnerships Project.

List of Economic valuation studies. Information on valuation studies that quantify ecosystem services.
List of Case studies. Information on economic impact cases of IAS, which provide examples in monetary terms of their effects on different maritime industries or ecosystems.

The two lists included in the Database are considered directly usable to transfer cases or values/benefit information to another area. It is the result of an extensive search, screening hundreds of cases and valuation studies and selecting the few that are directly usable. The Database is structured to easily identify the studies available for case or value transfers, select the most appropriate ones, and to have all information at hand to perform any adjustments to the values cited that might be necessary.

INSTRUCTIONS

Value transfers

The **List of economic valuation studies** should be used when no valuation of exist at the national level for a specific ecosystem service that has been identified as impacted by an IAS. In this case, the List of EV studies provides access to over almost 100 international economic valuation studies form marine and freshwater ecosystems that can be used to identify a similar scenario as in the country of study. The list provides the following information:

Authors/name of the study/year.
Marine or freshwater ecosystems: whether the study covers marine or freshwater, or both, ecosystems.
Specific ecosystems covered: which specific eco- systems the study covers (e.g. mangroves or sea- grass beds/meadows).
Ecosystem and study area characteristics: some information on the specific site at question, if avail- able (such as size or whether an assessed wetland is situated in an urban area or a national park; this information is highly dependent on the quality of the study at hand).
Ecosystem services covered: the specific ecosystem services covered by the study (e.g. moderation of extreme events; see also the tables above).
Valuation Method(s) used: the methods used to evaluate the ecosystem services assessed.

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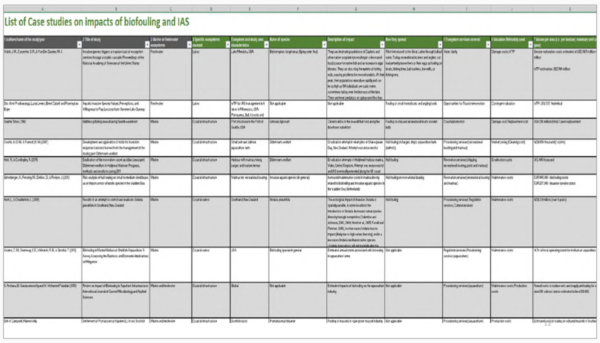

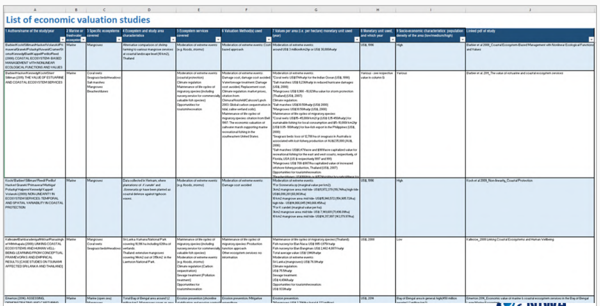

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Challenges

Reduced need for specialist economics knowledge but

- Increased need to understand assumptions and uncertainties
- Indicative values?
- Some uncertainties may remain. Some may be large e.g. how severe will the impacts be?

What don't we know?

And how do we cope without perfect information?

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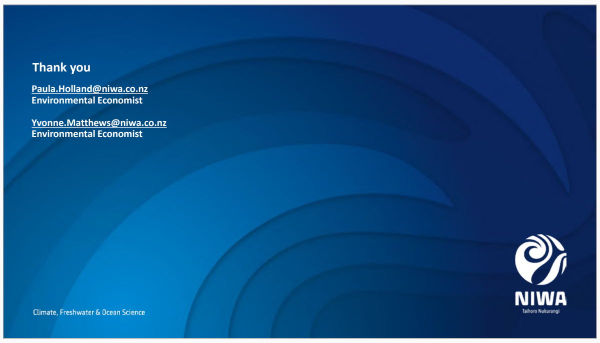
What now?
ARCTIC OCEAN
Greenland
Russia
Canada
United States
Kazakhstan
Mongolia
China
Iran
India
Algeria
Libya
Brazil
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
Australia
SOUTHERN OCEAN


What now?
Brazil
Ecuador
Fiji
Indonesia
Jordan
Madagascar
November 2022+
Refinement and finalisation
Tonga
Mauritius
Mexico
Peru
Philippines
Sri Lanka


Thank you
Paula.Holland@niwa.co.nz
Environmental Economist
Yvonne.Matthews@niwa.co.nz
Environmental Economist
Climate, Freshwater & Ocean Science
NIWA

NICOLA STOKES

Senior Environmental Advisor

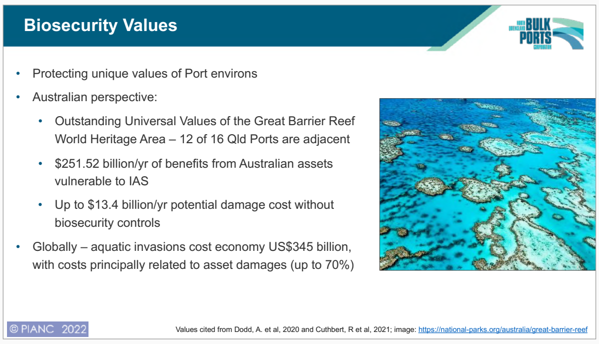
North Queensland Bulk Ports (NQBP)

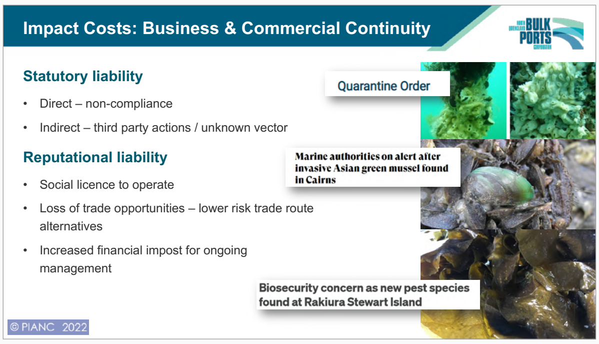
Nicola Stokes is Senior Environmental Advisor at North Queensland Bulk Ports (NQBP). With more than 15 years of experience in environmental management, she has become a national expert on port management of marine pests serving as Co-Secretary on a PIANC working group focussing on invasive alien species on waterborne transport infrastructure.

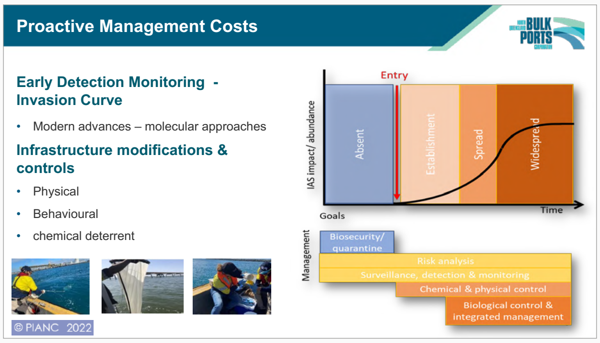
Nicola is instrumental in facilitating environmental assessments including for port developments and working with government departments on policy implementation ensuring the preservation of the environmental values within NQBP's ports. She also represents NQBP in partnerships with research institutes and regulatory bodies for enhanced marine and biosecurity management.

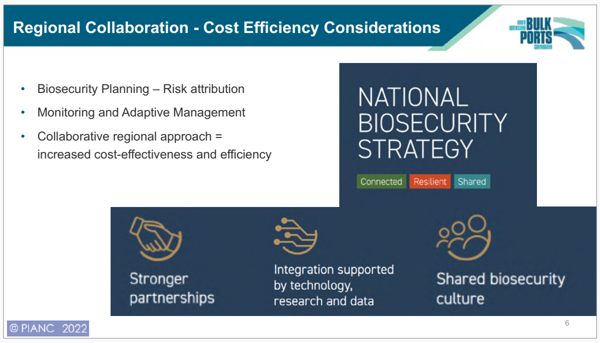
Quantifying the economic impact of an invasive species in ports and harbours.

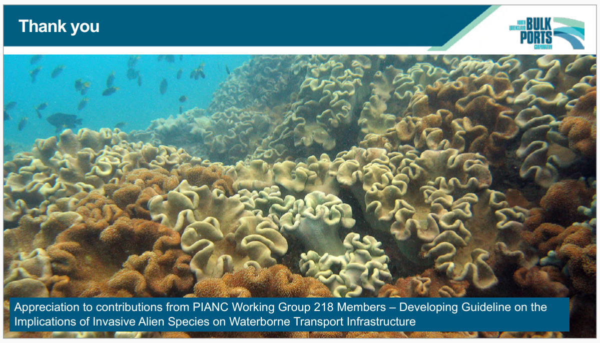
Presentation slides






Proactive Management Costs
BULK PORTS
Early Detection Monitoring - Invasion Curve
Modern advances – molecular approaches
Infrastructure modifications & controls
Physical
Behavioural
chemical deterrent
Entry
IAS impact/ abundance
Absent
Establishment
Spread
Widespread
Goals
Time
Management
Biosecurity/ quarantine
Risk analysis
Surveillance, detection & monitoring
Chemical & physical control
Biological control & integrated management
© PIANC 2022


Regional Collaboration - Cost Efficiency Considerations
BULK PORTS
Biosecurity Planning – Risk attribution
Monitoring and Adaptive Management
Collaborative regional approach = increased cost-effectiveness and efficiency
NATIONAL BIOSECURITY STRATEGY
Connected
Resilient
Shared
Stronger partnerships
Integration supported by technology, research and data
Shared biosecurity culture
© PIANC 2022


Thank you
BULK PORTS
Appreciation to contributions from PIANC Working Group 218 Members – Developing Guideline on the Implications of Invasive Alien Species on Waterborne Transport Infrastructure

SESSION 3

Ocean renewable energy and aquaculture sectors: Challenges and best practices to manage biofouling Part 1 - Ocean renewable energy

RAEANNE MILLER

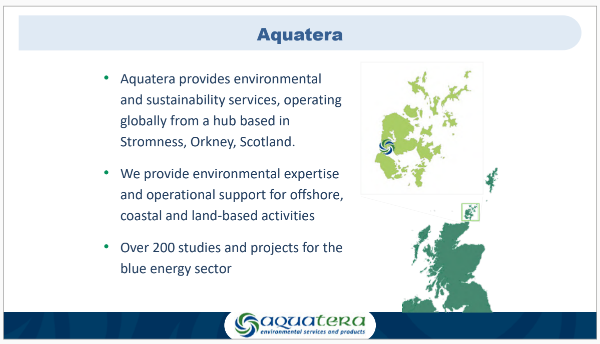
Senior Consultant

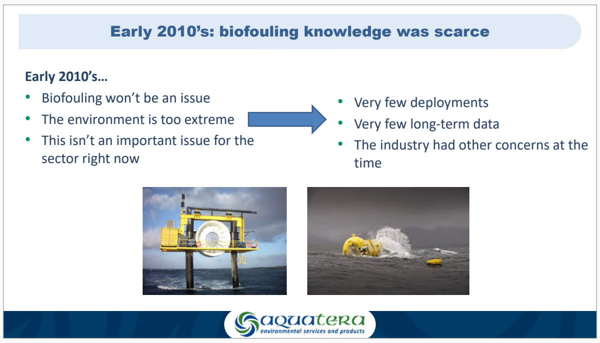
Aquatera Ltd

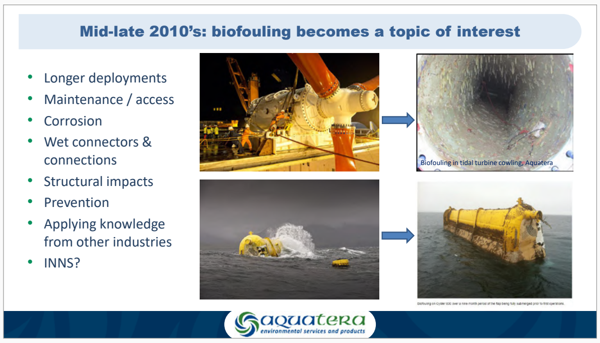
Dr Raeanne Miller is a marine scientist specialising in the environmental effects of coastal infrastructure and development. In the last 10 years Raeanne has delivered research and knowledge exchange supporting wave and tidal energy and climate-related projects across the UK and internationally. She has led strategic initiatives to gather and translate scientific evidence underpinning the consenting of marine energy projects for government and industry collaborations, and for individual renewable energy developers. Raeanne jointly leads the Marine Alliance for Science and Technology for Scotland (MASTS) Marine Renewable Energy Forum, a Scotland-wide hub for marine renewable energy research and knowledge exchange.

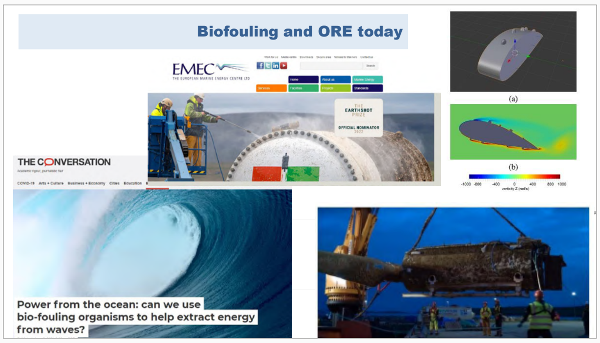
Biofouling and ocean energy: What have we learned in the last decade?

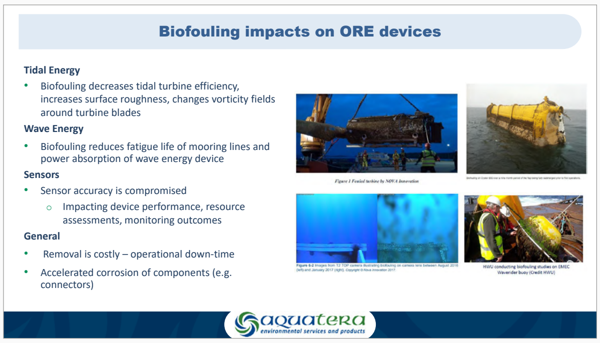
Presentation slides

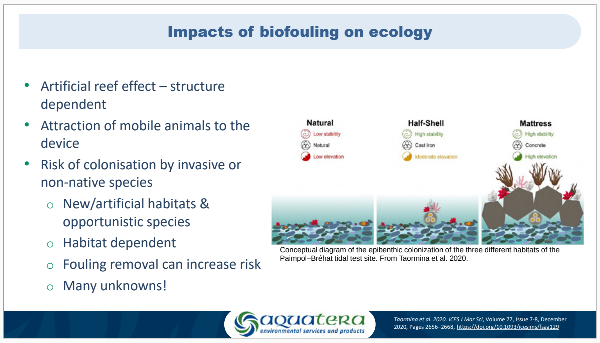



Early 2010's: biofouling knowledge was scarce
Early 2010's…
Biofouling won't be an issue
The environment is too extreme
This isn't an important issue for the sector right now
Very few deployments
Very few long-term data
The industry had other concerns at the time
aquatera environmental services and products


Mid-late 2010's: biofouling becomes a topic of interest
Longer deployments
Maintenance / access
Corrosion
Wet connectors & connections
Structural impacts
Prevention
Applying knowledge from other industries
INNS?
Biofouling in tidal turbine cowling, Aquatera
aquatera environmental services and products


Biofouling and ORE today
EMEC
THE CONVERSATION
Power from the ocean: can we use bio-fouling organisms to help extract energy from waves?
(a)
(b)
aquatera environmental services and products


Biofouling impacts on ORE devices
Tidal Energy
Biofouling decreases tidal turbine efficiency, increases surface roughness, changes vorticity fields around turbine blades
Wave Energy
Biofouling reduces fatigue life of mooring lines and power absorption of wave energy device
Sensors
Sensor accuracy is compromised
Impacting device performance, resource assessments, monitoring outcomes
General
Removal is costly – operational down-time
Accelerated corrosion of components (e.g. connectors)
aquatera environmental services and products


Impacts of biofouling on ecology
Artificial reef effect – structure dependent
Attraction of mobile animals to the device
Risk of colonisation by invasive or non-native species
New/artificial habitats & opportunistic species
Habitat dependent
Fouling removal can increase risk
Many unknowns!
Natural
Half-Shell
Mattress
Conceptual diagram of the epibenthic colonization of the three different habitats of the Paimpol–Bréhat tidal test site. From Taormina et al. 2020.
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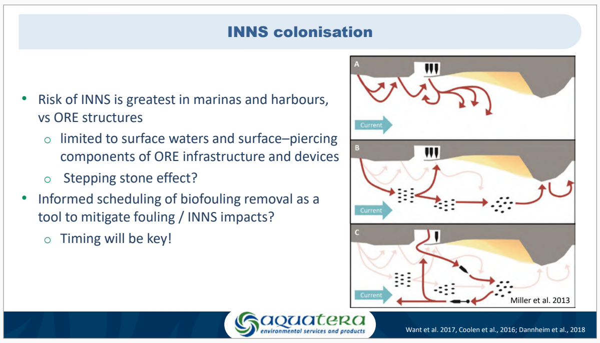
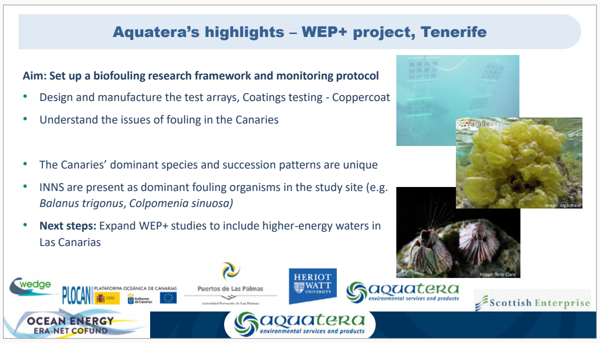
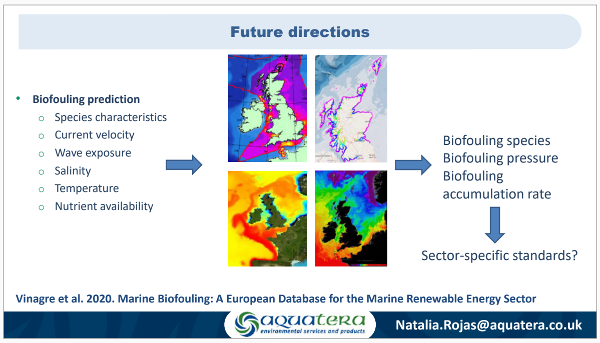
Taormina et al. 2020. ICES J Mar Sci, Volume 77, Issue 7-8, December 2020, Pages 2656–2668, https://doi.org/10.1093/icesjms/fsaa129


INNS colonisation
Risk of INNS is greatest in marinas and harbours, vs ORE structures
limited to surface waters and surface–piercing components of ORE infrastructure and devices
Stepping stone effect?
Informed scheduling of biofouling removal as a tool to mitigate fouling / INNS impacts?
Timing will be key!
A
B
C
Current
Miller et al. 2013
aquatera environmental services and products
Want et al. 2017, Coolen et al., 2016; Dannheim et al., 2018


Aquatera's highlights – WEP+ project, Tenerife
Aim: Set up a biofouling research framework and monitoring protocol
Design and manufacture the test arrays, Coatings testing - Coppercoat
Understand the issues of fouling in the Canaries
The Canaries' dominant species and succession patterns are unique
INNS are present as dominant fouling organisms in the study site (e.g. Balanus trigonus, Colpomenia sinuosa)
Next steps: Expand WEP+ studies to include higher-energy waters in Las Canarias
wedge
PLOCAN
Puertos de Las Palmas
HERIOT WATT UNIVERSITY
aquatera environmental services and products
Scottish Enterprise
OCEAN ENERGY ERA-NET COFUND


Future directions
Biofouling prediction
Species characteristics
Current velocity
Wave exposure
Salinity
Temperature
Nutrient availability
Biofouling species
Biofouling pressure
Biofouling accumulation rate
Sector-specific standards?
Vinagre et al. 2020. Marine Biofouling: A European Database for the Marine Renewable Energy Sector
aquatera environmental services and products
Natalia.Rojas@aquatera.co.uk


Key challenges & solutions
Inconsistent fouling metrics & collection methods, poor data availability
Standardised biofouling recording methodology (e.g. industry SOP) & database
Underway! BioFree project, WEP+, Vinagre et al. 2020
Data collection must be inexpensive
Co-develop with industry partners, & thoroughly test in operational situations
Underway – BioFree, EMEC
Need to streamline information outputs for management decision making
Map existing knowledge & iteratively develop as a resource
Requires more collaboration
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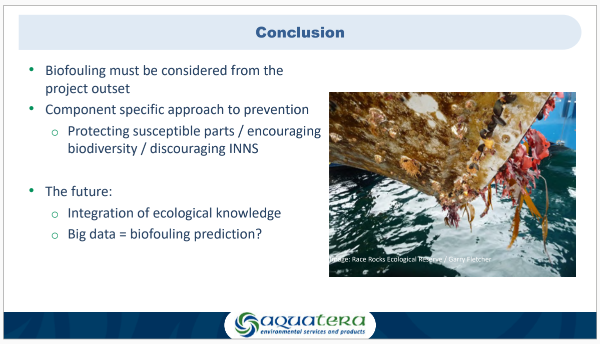
Conclusion
Biofouling must be considered from the project outset
Component specific approach to prevention
Protecting susceptible parts / encouraging biodiversity / discouraging INNS
The future:
Integration of ecological knowledge
Big data = biofouling prediction?
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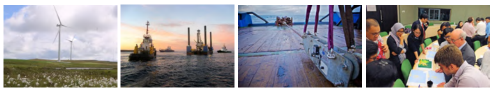
Thank you



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Natalia Rojas - Natalia.Rojas@aquatera.co.uk

aquatera environmental services and products

CATHERINE TAIT

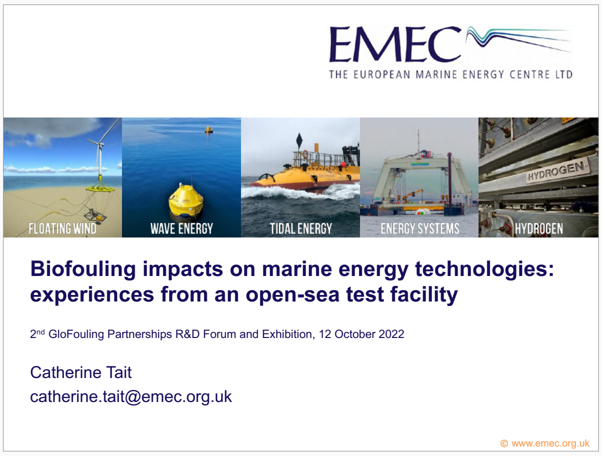
Environmental Officer

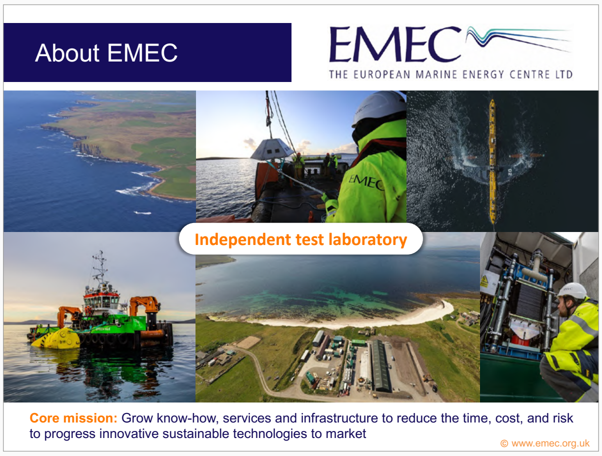
European Marine Energy Centre

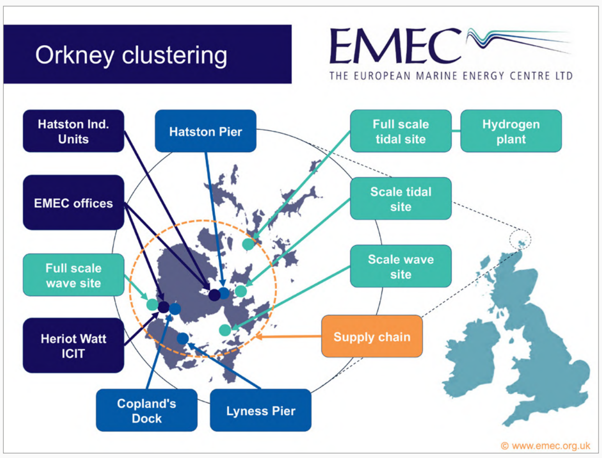
Catherine works within EMEC's Environment and Consents team to deliver environmental monitoring services within projects. She implements environmental monitoring programmes, undertaking offshore fieldwork campaigns including survey design and data collection. Catherine further supports the development of EMEC's technical expertise through technical reporting for use by clients, presenting research findings to stakeholders as well as providing guidance to mitigate, monitor and manage environmental risks associated with activities performed across EMEC's projects and facilities.

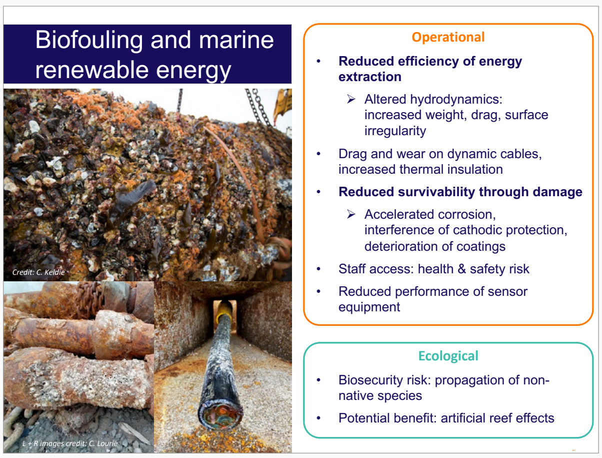
Biofouling impacts on marine energy technologies: experiences from an open-sea test facility

Presentation slides

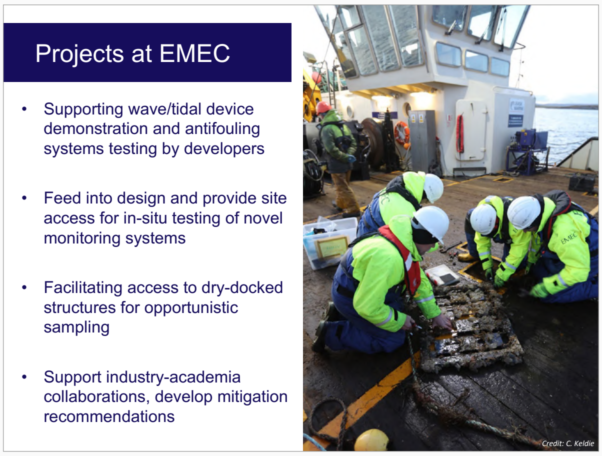


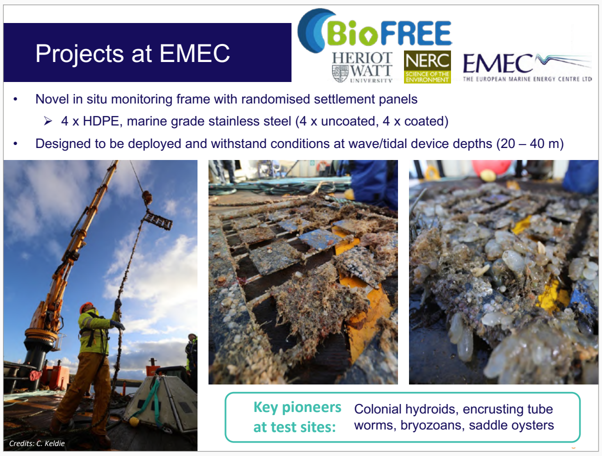


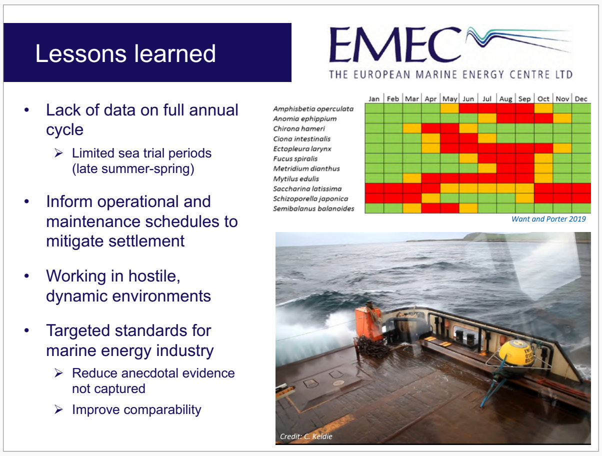





Biofouling and marine renewable energy
EMEC
THE EUROPEAN MARINE ENERGY CENTRE LTD
Management
• Prevention: antifouling considered in device design
• Removal: scheduled maintenance operations
= High associated costs, equipment downtime
Credit: A. Want
Hutchison et al. 2020
Jan
July


Projects at EMEC
• Supporting wave/tidal device demonstration and antifouling systems testing by developers
• Feed into design and provide site access for in-situ testing of novel monitoring systems
• Facilitating access to dry-docked structures for opportunistic sampling
• Support industry-academia collaborations, develop mitigation recommendations
Credit: C. Keldie


Projects at EMEC
BioFREE
HERIOT WATT UNIVERSITY
NERC
EMEC
• Novel in situ monitoring frame with randomised settlement panels
➢ 4 x HDPE, marine grade stainless steel (4 x uncoated, 4 x coated)
• Designed to be deployed and withstand conditions at wave/tidal device depths (20 – 40 m)
Credits: C. Keldie
Key pioneers at test sites:
Colonial hydroids, encrusting tube worms, bryozoans, saddle oysters


Lessons learned
EMEC
THE EUROPEAN MARINE ENERGY CENTRE LTD
• Lack of data on full annual cycle
➢ Limited sea trial periods (late summer-spring)
• Inform operational and maintenance schedules to mitigate settlement
• Working in hostile, dynamic environments
• Targeted standards for marine energy industry
➢ Reduce anecdotal evidence not captured
➢ Improve comparability
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Amphisbetia operculata
Anomia ephippium
Chirona hameri
Ciona intestinalis
Ectopleura larynx
Fucus spiralis
Metridium dianthus
Mytilus edulis
Saccharina latissima
Schizoporella japonica
Semibalanus balanoides
Want and Porter 2019
Credit: C. Keldie


Opportunities
Prioritise gaps
Funding opportunities
Collaborative projects
Knowledge sharing
Credit: WoRMS
Credits C. Keldie


EMEC
THE EUROPEAN MARINE ENERGY CENTRE LTD
FLOATING WIND
WAVE ENERGY
TIDAL ENERGY
ENERGY SYSTEMS
HYDROGEN
Thank you for your attention
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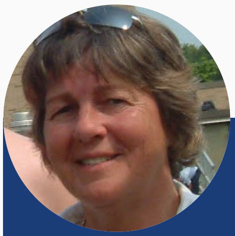
Aquaculture



SANDRA E. SHUMWAY

Research Professor Emerita

University of Connecticut, USA.

Sandra Shumway (PhD;DSc Wales) is Research Professor Emerita at the University of Connecticut, USA. She has authored 180 scientific publications, edited nine books, and is Editor of the Journal of Shellfish Research and Reviews in Fisheries Science and Aquaculture. A former Marshall Scholar, her research is focused on feeding in bivalve molluscs, the control of biofouling in marine aquaculture, and microplastics. She is a Fellow of the American Association for the Advancement of Science and the World Aquaculture Society, an Honored Life Member of the National Shellfisheries Association, an Aldo Leopold Leadership Fellow, and Honorary Fellow University of Wales.

Recommendations and Best Practices for Biofouling Management in the Aquaculture Sector.

As part of the GloFouling Partnerships Project undertaken by the International Maritime Organization (IMO), in collaboration with the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP), a report was prepared as part of a set of reports covering best practices for biofouling management, and addressing invasive aquatic species (IAS) for non-shipping sectors. A summary of the final report: Biofouling prevention and management in the marine aquaculture industry was presented. This report addresses biofouling management in relation to marine aquaculture industry operations, equipment, and infrastructure. It covers shellfish, finfish, and seaweed operations in estuaries and seawater. It does not address freshwater aquaculture activities.

The general focus of the report is on biofouling management. Information regarding general processes of biofouling, the ecological and environmental impacts, economics of management, and the costs estimated to be associated with IAS are beyond the scope of these reports. Although this report focuses on the non-shipping/non-vessel aspects of biofouling and IAS, some of the information may be applicable to vessels involved in marine aquaculture activities.

While offshore aquaculture does rely on vessels to deploy and maintain offshore netting platforms as well as to feed and harvest fish, biofouling species found in and around the farm are the same as those found in the homeports of these vessels. Support vessels for aquaculture operations are local boats, maintained in local waters, and travel short distances, thus they are not potential vectors for NIS. They may, however, serve as settlement surfaces for any biofouling organisms, just as do the aquaculture structures and gear themselves. Biofouling on boat hulls is a hindrance for owners and is regularly eradicated through antifouling coatings and cleaning.

This report was prepared through the compilation, assessment, and synthesis of the information from the marine aquaculture industry on current best practices in biofouling management. This includes outreach, consultation, and discussions with industry representatives. It also includes information from the industry media, market reports and other grey literature, and the scientific literature related to the marine aquaculture industry and biofouling. It is not meant to be a comprehensive review, but rather to provide readers with an introduction to the topic and references for further investigation. This report also identifies many existing documents and guidelines related to best practices for biofouling management, especially those developed specifically by and for the marine aquaculture industry. An Annex is included that lists key best practice references.

Biofouling will remain a ubiquitous factor for aquaculture systems and development of improved methods for its eradication will continue to evolve. There are a multitude of methods and approaches to control biofouling in all forms of aquaculture and there is not, nor is there ever likely to be, one magic solution. Current methods and products used are species- and geographically-specific, and reflect an enhanced concern for environmental and product safety. Aquaculture systems and structures provide habitat for invasive species, but rarely serve as vectors per se for introductions.

The full report is available at:

Biofouling Prevention and Management in the Marine Aquaculture Industry.

Note: If interested in this presentation, it must be requested from the speaker.

ALEXANDRE IMMAS

CTO and Co-Founder

Berkeley Marine Robotics

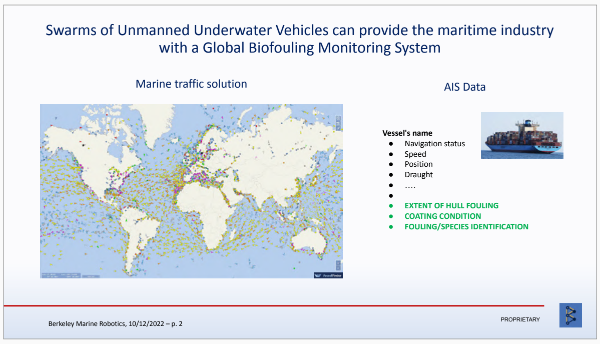
Alexandre Immas received his BSc and MSc in Mechanical Engineering and Physics from Ecole Polytechnique, Palaiseau, France. He then joined the Mechanical Engineering program at the University of California, Berkeley, CA where he received his MSc in Mechanical Engineering in 2012. Following graduation, he worked in the offshore wind industry (2013-2017) before returning to UC Berkeley where he received his PhD in Mechanical Engineering in 2021. He received several awards from the National Science Foundation that led to the creation of Berkeley Marine Robotics, where he is CTO and Co-Founder.

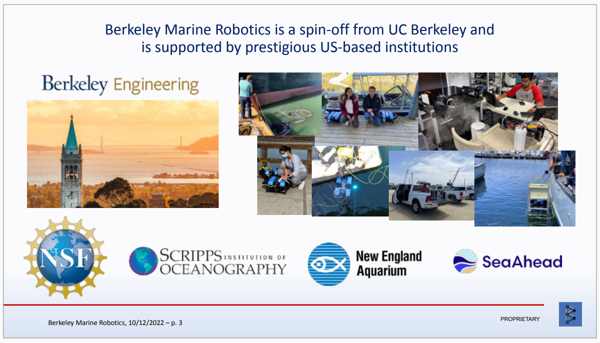
Automated Inspection of Biofouling on Ship Hulls with a Swarm of Unmanned Underwater Vehicles

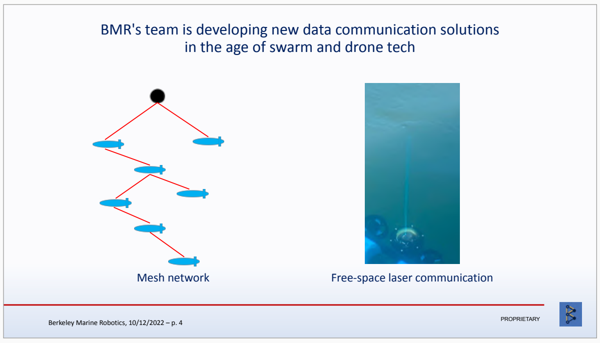
Alexandre Immas, Berkeley Marine Robotics, California/USA
Sushil Tyagi, Berkeley Marine Robotics, California/USA

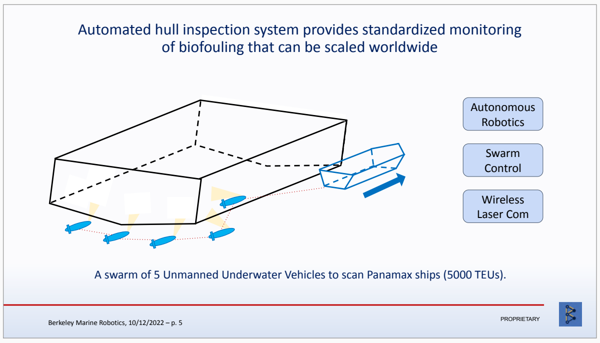
Abstract Berkeley Marine Robotics (BMR) is developing an automated underwater inspection system to provide high-frequency visual data of biofouling on ship hulls for ships and coatings performance managers. Biofouling tracking is highly needed by the maritime industry to optimize cleaning schedules, to monitor innovative antifouling solutions, and eventually to account for fouling risk in ships route optimization. Current robotic solutions have been a poor alternative to divers which remain the main solution to realize underwater inspections but cannot provide data with frequency and quality required for standardized tracking. BMR's automated system consists of a swarm of Unmanned Underwater Vehicles (UUVs) that inspects a ship's hull in a fast, comprehensive and repeatable manner. The UUVs are man portable, fully-actuated and are equipped with laser systems to exchange data wireless as well as to provide accurate underwater positioning. Thus, this technology provides stable wireless underwater platforms, which have been the main technical shortcoming of current Remotely Operated Vehicles (ROVs), enabling the UUVs to capture high-quality and geo-localized pictures of the hull fouling and invasive species. BMR is conducting field tests of its technology with a swarm of Unmanned Underwater Vehicles (UUVs) in the port of Long Beach, California. This paper or presentation will describe BMR's automated underwater inspection system, the setup of the field tests and first results. Challenges to develop swarms with a higher number of UUVs that can be deployed worldwide and their impact on solving the biofouling problem and reducing shipping GHG/CO_2 emissions will also be discussed.

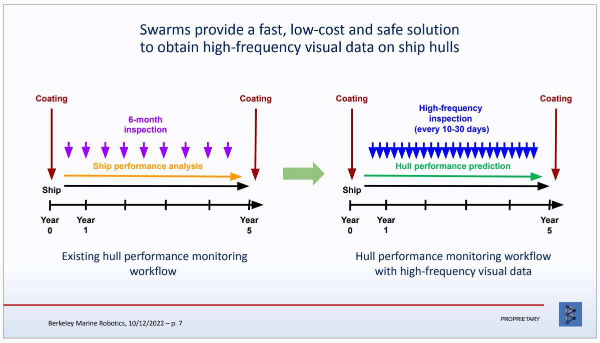
Presentation slides

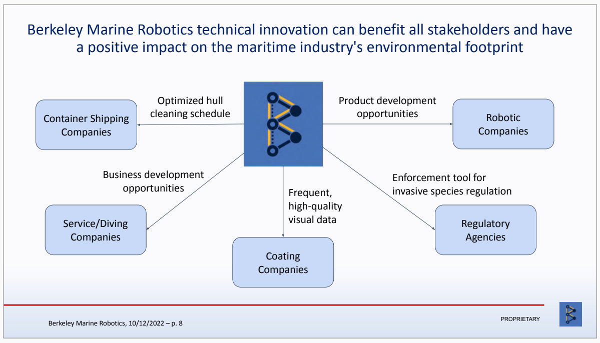












MARIE DALE

Marine biologist and environmental data scientist
AkzoNobel

Marie Dale graduated from the University of Plymouth in 2014 with a 1st class degree in Marine Biology. Since graduating 8 years ago, she has worked for AkzoNobel in the R&D teams, focussing on biofouling; from developing new laboratory and in-field test methods to analysis of complex datasets on environmental, vessel and coating data, all to gain a better understanding of biofouling. In 2019 she began a PhD at Durham University, funded by the Royal Commission of the Exhibition 1851, between the biosciences and computer science departments looking into biofouling as a vector of species translocations.

A data driven route to reducing the risk of invasive species translocated through biofouling on ships.

Shipping accounts for over 80% of global trade. In addition to transferring goods between ports, shipping can also result in the transfer of non-indigenous species. Biofouling is one of the main vectors for the spread of non-indigenous species which may be invasive. Invasive species are a major threat to the world's oceans s they cause biodiversity loss and damage to coastal industry and infrastructure, estimated to cost US$ 100 billion per annum. Up to 69% of aquatic invasive species are introduces through transportation of biofouling. A combination of increased trade and global climate change are expected to exacerbate the problem.

The global fleet is large, and resources are scarce - it is important these are deployed where invasive risk is greatest to have the most impact. By developing models to predict global species distribution and translocation potential through biofouling transportation on ship hulls, the issue can be better understood and mitigation actions can be considered and proposed. This will involve evaluation of viable translocation pathways and how this may evolve with climate change.

Once high-risk translocation routes have been identified through the modelling, individual ships could be subject to an in-water inspection. To make this practicable and cost effective, a route to automated image recognition of no-indigenous species will be presented.

Note: If interested in this presentation, it must be requested from the speaker.

SOLÈNE GUÉRÉ

Vice President

Notilo Plus

Solène Guéré, a biologist by training, has worked for ecologically friendly utilities including desalination, renewable energy, and sustainable agriculture.

Her vision is to empower maritime industries with new technologies that will help them shift to climate-conscious decisions.

As the Vice President of Notilo Plus, she helps ship owners and managers to predict hull maintenance by gathering, organizing, and analyzing all hull data. Notilo Plus combines underwater robotics and AI technology to create underwater inspection reports with ease, simplicity, speed, and consistency. By gathering and structuring hull data to make analysis better, the company opens the door to automated and optimized Biofouling Management Plans. The approach is seen by many stakeholders as a role model of future hull condition monitoring, using smart and connected services to lower carbon footprints and invasive species propagation in shipping.

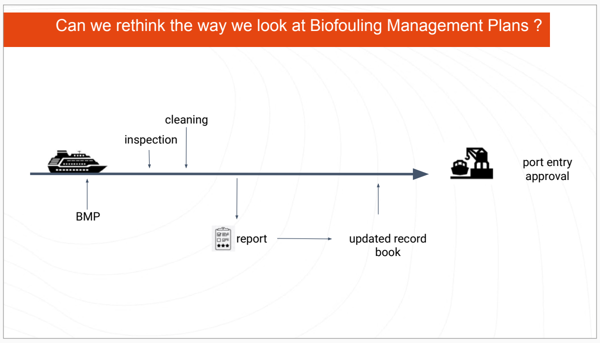
Why rely on cloud-based systems for biofouling management plans?

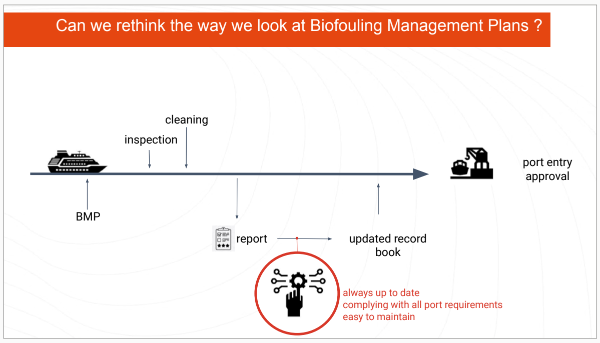
The influence of human activity on biodiversity as well as GHG emissions are being extensively monitored due to environmental concerns. Since hull biofouling accounts for 10% of a vessel's excess fuel consumption and for the spread of up to 70% of non-native aquatic species, various laws in the shipping industry specifically target the monitoring of hull conditions. While Australia and New Zealand are pioneers in this matter, many other countries and international communities will soon impose other more and more demanding regulations. In this context, it is becoming increasingly important, if not indispensable in some places, for all vessels to have a biofouling management plan.

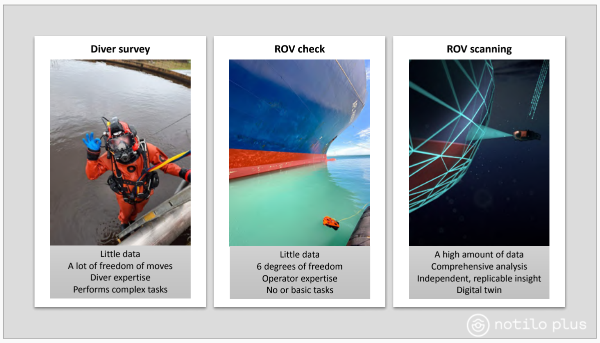
At ship level, those biofouling management plans will require having a precise picture of your hull condition, precisely assessing your former strategy and deciding on a compliant new one, to meet environmental regulations. However, some of this data is already collected by ship managers, during cleaning or inspection; and is otherwise needed, for coating monitoring for example. That's where Notilo Cloud, our AI-powered data analysis solution, comes in: with Notilo Cloud, you can bring together any underwater data you collect, and turn hull videos into a thorough audit of the hull biofouling condition. Having a cloud-based system will also enable ship managers to gather in one place, under a standardized digital format, all hull-related data, to effectively monitor hull information and share it easily.

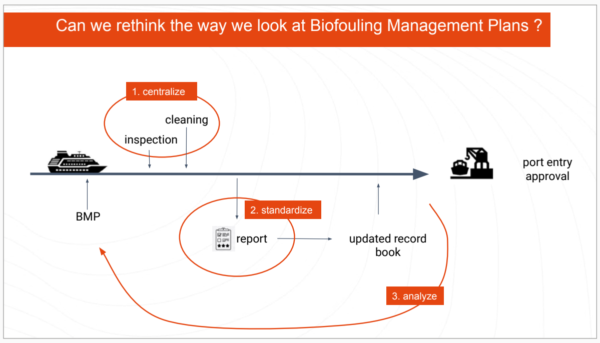
At fleet level, Notilo Plus Cloud platform gives an overview of the fleet condition, allowing a more global monitoring.

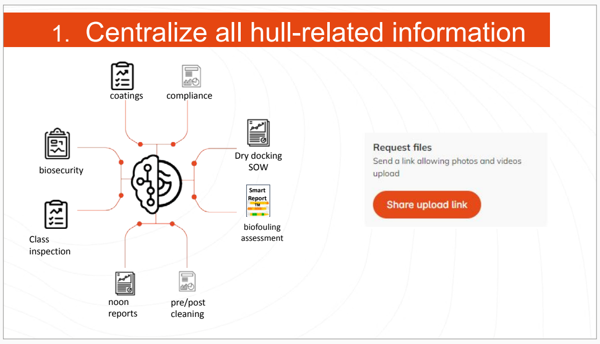
Presentation slides

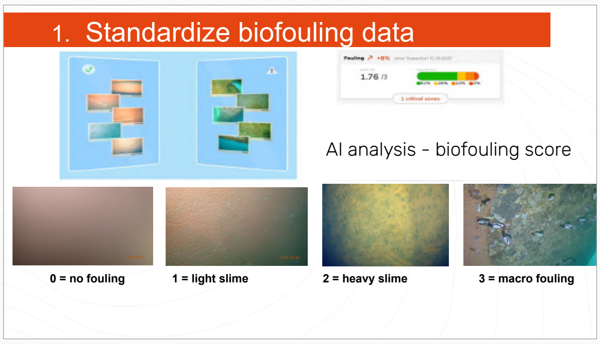


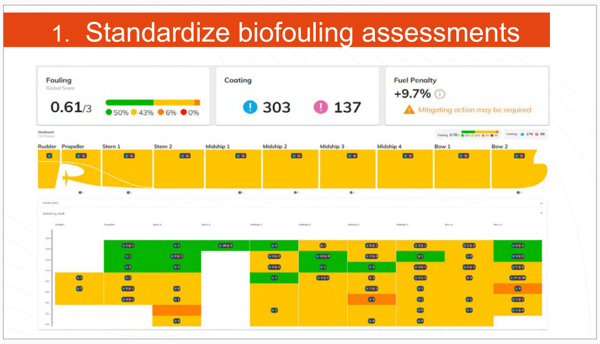


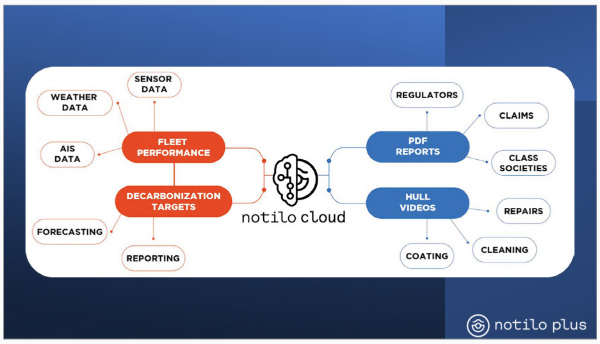


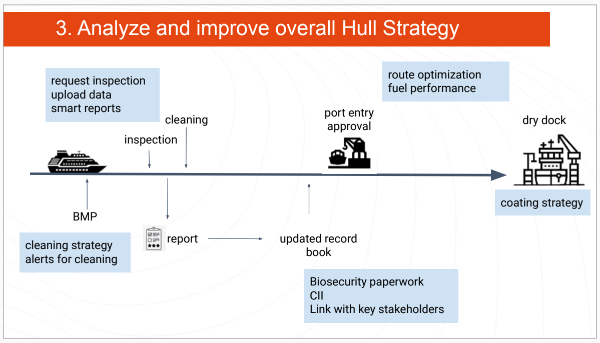











3. Analyze and improve overall Hull Strategy
request inspection
upload data
smart reports
route optimization
fuel performance
cleaning
inspection
port entry
approval
dry dock
BMP
coating strategy
cleaning strategy
alerts for cleaning
report
updated record
book
Biosecurity paperwork
CII
Link with key stakeholders


Lighten the weight on the camel's back
FOURTH IMO
GREENHOUSE
GAS STUDY
Digitalizing Biofouling
Management Plan is acting
towards a more sustainable
blue economy.

LINA CEBALLOS-OSUNA

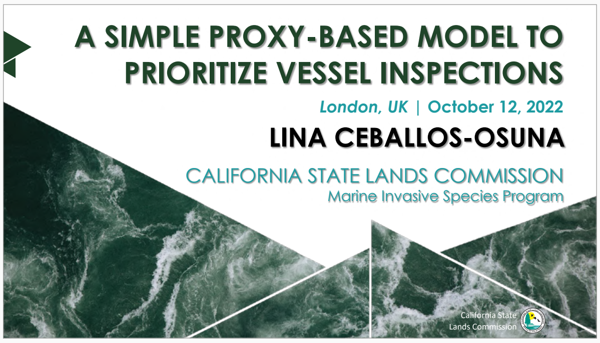
Senior Environmental Scientist

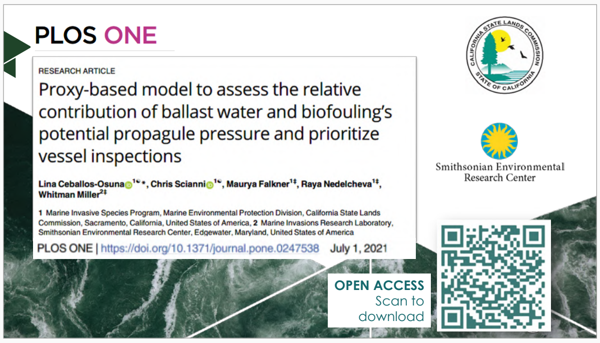
California State Lands Commission

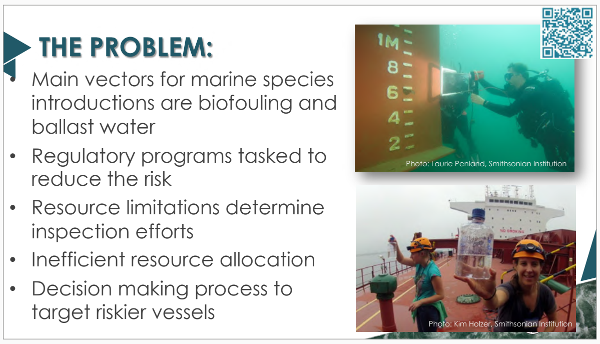
Lina joined the Marine Invasive Species Program at the State Lands Commission as a Senior Environmental Scientist in 2018. Previously, Lina worked at the Marine Invasions Lab within the Smithsonian Environmental Research Center (SERC) as a researcher and taxonomist. During her career, she has gained a lot of experience in invasions ecology, invertebrates taxonomy, environmental protection policy and ecophysiology. Lina received a Bachelor of Science degree in Marine Biology from Jorge Tadeo Lozano University (Colombia, 2004) and a Master of Science degree in Marine Biology at San Francisco State University in 2012.

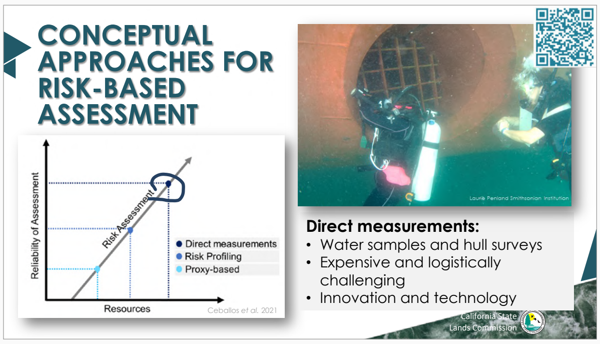
A simple proxy-based model to prioritize vessel inspection

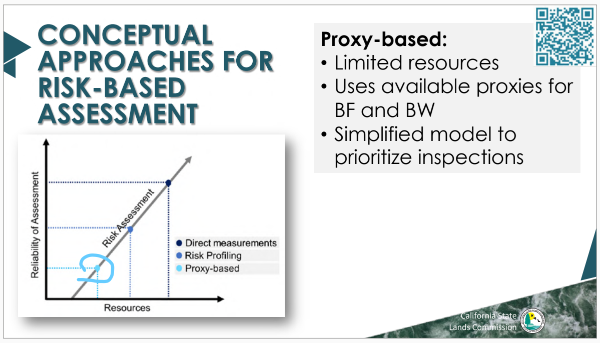
Presentation slides

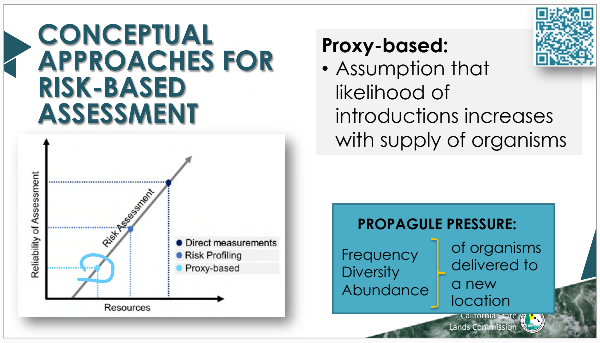


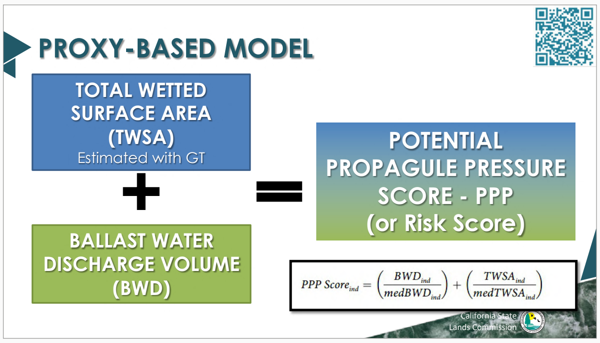


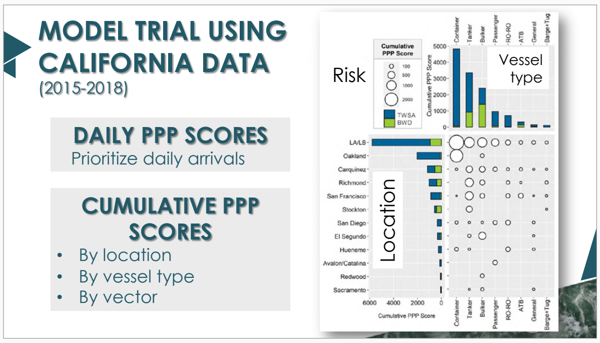


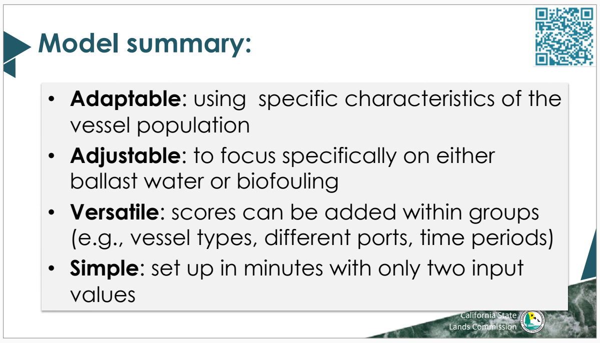


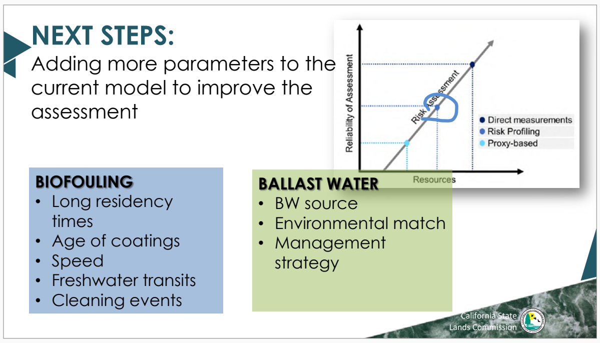

CONCEPTUAL APPROACHES FOR RISK-BASED ASSESSMENT
Proxy-based:
• Limited resources
• Uses available proxies for BF and BW
• Simplified model to prioritize inspections
Reliability of Assessment
Risk Assessment
Resources
Direct measurements
Risk Profiling
Proxy-based
California State Lands Commission

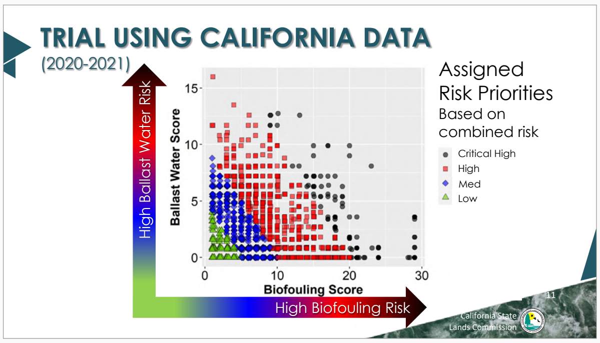

CONCEPTUAL APPROACHES FOR RISK-BASED ASSESSMENT
Proxy-based:
• Assumption that likelihood of introductions increases with supply of organisms
PROPAGULE PRESSURE:
Frequency
Diversity
Abundance
of organisms delivered to a new location
Reliability of Assessment
Risk Assessment
Resources
Direct measurements
Risk Profiling
Proxy-based
California State Lands Commission


PROXY-BASED MODEL
TOTAL WETTED SURFACE AREA (TWSA)
Estimated with GT
+
BALLAST WATER DISCHARGE VOLUME (BWD)
=
POTENTIAL PROPAGULE PRESSURE SCORE - PPP (or Risk Score)
$PPP\ Score_{ind} = \left(\frac{BWD_{ind}}{medBWD_{ind}}\right) + \left(\frac{TWSA_{ind}}{medTWSA_{ind}}\right)$
California State Lands Commission


MODEL TRIAL USING CALIFORNIA DATA
(2015-2018)
DAILY PPP SCORES
Prioritize daily arrivals
CUMULATIVE PPP SCORES
• By location
• By vessel type
• By vector
Risk
Vessel type
Location
Cumulative PPP Score
TWSA
BWD


Model summary:
• Adaptable: using specific characteristics of the vessel population
• Adjustable: to focus specifically on either ballast water or biofouling
• Versatile: scores can be added within groups (e.g., vessel types, different ports, time periods)
• Simple: set up in minutes with only two input values
California State Lands Commission


NEXT STEPS:
Adding more parameters to the current model to improve the assessment
BIOFOULING
• Long residency times
• Age of coatings
• Speed
• Freshwater transits
• Cleaning events
BALLAST WATER
• BW source
• Environmental match
• Management strategy
Reliability of Assessment
Risk Assessment
Resources
Direct measurements
Risk Profiling
Proxy-based
California State Lands Commission


TRIAL USING CALIFORNIA DATA
(2020-2021)
High Ballast Water Risk
Ballast Water Score
Biofouling Score
High Biofouling Risk
Assigned Risk Priorities
Based on combined risk
Critical High
High
Med
Low
California State Lands Commission


THANK YOU & QUESTIONS
LINA CEBALLOS OSUNA
Marine Invasive Species Program
Lina.Ceballos@slc.ca.gov
@CAStateLands
@ceballoslina
California State Lands Commission

YUSIK KIM

CEO

Tas Global Co., Ltd

CEO and founder of Tas Global Co., Ltd. and the chair of Global Industry Alliance of The GloFouling Partnerships project 2022.

Since its establishment in 2014, Tas Global has grown into World's Leading Company in Hull Cleaning Industry based on our innovative technology and service. we make new challenges, contribute to giving the trust of our customers, and finally protect nature and the environment.

Tas Global develops and manufactures the ROVs for underwater hull cleaning, inspection, class survey, propeller polishing, ship repairs, and underwater construction, and is also a chief researcher of the Glo Fouling R&D project (Korea, $14 million, with 7 National institutes, and 3 Universities). Presence in Singapore, expanding to EU, Middle East Asia, and South America by the end of 2022.

An update on research conducted in the Republic of Korea.

Yusik Kim, TAS Global & Korean Ministry of Oceans and Fisheries.

Presentation slides

2 Components of K-BioFouling

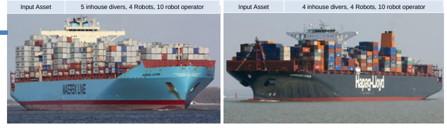
The most efficient IWC robot in the world

- A Expect first IWC robot to pass BIMCO's IWC approval test
- B The most efficient system : LOA 350 m vertical cleaning in 6 hours, at least 2~3 times faster, with capture
- C Most flexible robot that can be used in all ports.

Tas Global IWC Robot

Vessel Name	MAERSK ALFIRK (LOA 337M)
Cleaning scope	Vertical, Bottom hull & Niche area
Constraint	workable hours only 9 hrs. short stay(15hrs), Bunkering/crane interference (6hrs), heavy fouling
Working hours	8 hours (July 2nd 2022)
Input Asset	5 inhouse divers, 4 Robots, 10 robot operator

Vessel Name	Hapag-Lloyd, LEVERKUSEN EXPRESS (LOA 366M)
Cleaning scope	Vertical, Bottom hull
Constraint	following day, one vertical hull cleaning(LOA 255M) & one full hull cleaning (LOA 330M), light fouling
Working hours	10 hours (July 18th 2022)
Input Asset	4 inhouse divers, 4 Robots, 10 robot operator



The only IWC robot that works in fast current, in anchorage

- A Some vessels have limited options for IWC locations
- B Now, IWC in fast current is available, up to 3.0 knots of current, expanding IWC possible locations more two times

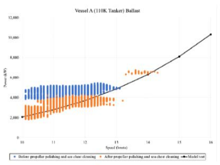
Vessel Name	C. CREATOR (LOA 336M, 156,452 GT)	VL PRIME (LOA 333M, 161,770 GT)
Cleaning scope	Vertical hull cleaning	Vertical hull cleaning
Constraint	cleaning two ships in a roll in spring tide and when current speed reaches 2.5 knots, light fouling	
Working hours	8 hours (1st June 2022)	4.5 hours (2st June 2022)
Input Asset	4 Robots, 10 robot operator	

Capture capability

- A Being environmental is necessary, it is no longer the key point of IWC
- B Capturing alone and filtration alone is a easy technology
- C Rarity is IWC robot's locomotion efficiency with the capturing and filtering

IWC Performance

- A Performance of every in water cleaning is different
- B ISO 19030 based hull and propeller performance results after IWC are being accumulated
- C Goal is to generate cleaning performance' certifiable with arithmetic mean close to dry-docking performance improvement

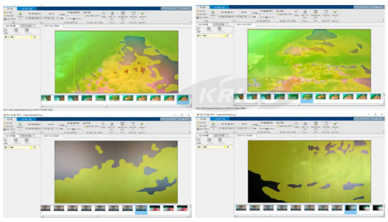


Water treatment system

- A The world's first IWC water treatment system made by world's best BWTS maker, S&Sys
- B 99% filtration of organic and non-organic particles , and world's first IWC melted metal treatment

Artificial Inspection

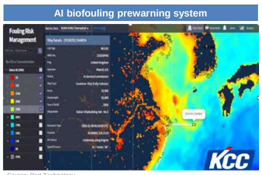
- A Artificial intelligence inspection, 96% accuracy on fouling detection, 99% on species identification
- B Deep learning based algorithm, adjustable for your ocean



K-BioFouling

- A AI pre-biofouling warning system
- B ISO 19030 based hull performance management tool

AI biofouling prewarning system



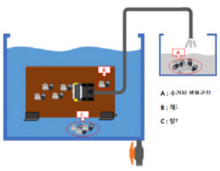
Source: Port Technology

Hull, propeller performance, GHG monitoring

New test standard for biofouling removal, capture, recovery

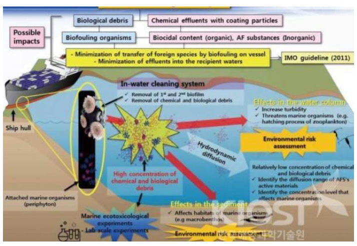
- A IWC standards, BIMCO, Lloyds or modified version of your choice
- B Bio and artificial biofouling creation for testing

BIMCO

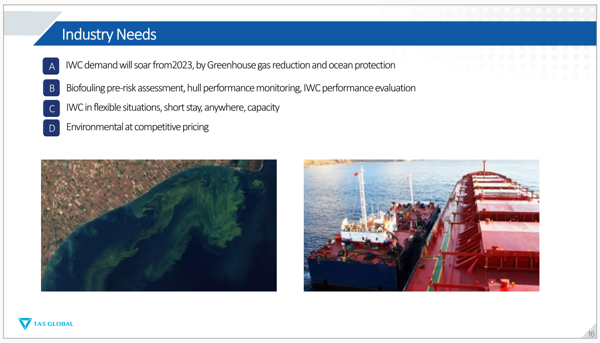


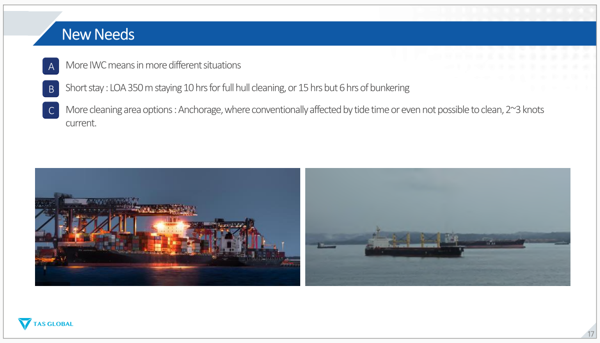
K-BioFouling

- A Environmental risk evaluation, risk management system are being developed

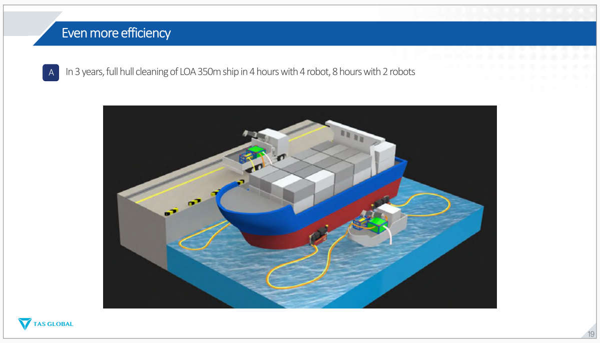


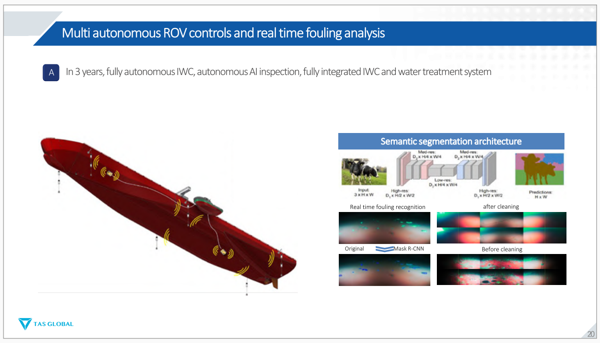

TAS GLOBAL
3
New Needs from
Shipping industry

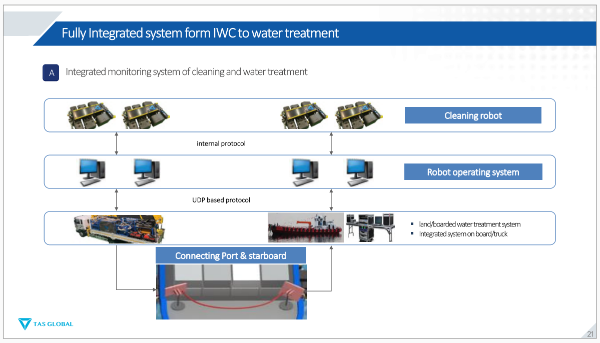

Industry Needs
A IWC demand will soar from2023, by Greenhouse gas reduction and ocean protection
B Biofouling pre-risk assessment, hull performance monitoring, IWC performance evaluation
C IWC in flexible situations, short stay, anywhere, capacity
D Environmental at competitive pricing
TAS GLOBAL

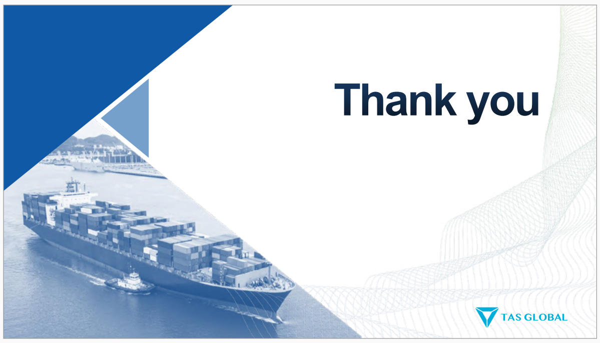

New Needs
A More IWC means in more different situations
B Short stay : LOA 350 m staying 10 hrs for full hull cleaning, or 15 hrs but 6 hrs of bunkering
C More cleaning area options : Anchorage, where conventionally affected by tide time or even not possible to clean, 2~3 knots current.
TAS GLOBAL


TAS GLOBAL
4
In coming years


Even more efficiency
A In 3 years, full hull cleaning of LOA 350m ship in 4 hours with 4 robot, 8 hours with 2 robots
TAS GLOBAL


Multi autonomous ROV controls and real time fouling analysis
A In 3 years, fully autonomous IWC, autonomous AI inspection, fully integrated IWC and water treatment system
Semantic segmentation architecture
Real time fouling recognition
after cleaning
Original
Mask R-CNN
Before cleaning
TAS GLOBAL


Fully Integrated system form IWC to water treatment
A Integrated monitoring system of cleaning and water treatment
Cleaning robot
internal protocol
Robot operating system
UDP based protocol
land/boarded water treatment system
Integrated system on board/truck
Connecting Port & starboard
TAS GLOBAL


Thank you
TAS GLOBAL

Testing performance of technologies and methods to manage biofouling – What are the challenges?

BEV MACKENZIE

Head of Intergovernmental Engagement

BIMCO

Dr Mackenzie is the London-based Representative at the International Maritime Organization for BIMCO and provides the link between BIMCO and IMO and other intergovernmental organisations to ensure that BIMCO's technical expertise can be best utilised by decisions makers.

She has a degree in chemical oceanography and a PhD in physical oceanography from the University of Liverpool, UK and applies that scientific knowledge to help understand the science-engineering-policy interface. She has expertise in operational oceanography and ocean observing and issues relating to maritime industries and the environment including issues such as sea-based sources of marine plastics, climate change and marine pollution.

The challenges of assessing biofouling coverage: Can AI play a role in supporting both industry initiatives and capacity development?

A BIMCO survey carried out in 2021 showed that there is good quality in-water cleaning with capture in ports but a decline in ports with offering in-water cleaning services. This is alongside the need for good quality inspections to be carried out to ensure an accurate assessment of coverage of biofouling. Access to technologies to facilitate and trained inspectors can present significant problems in several areas of the globe.

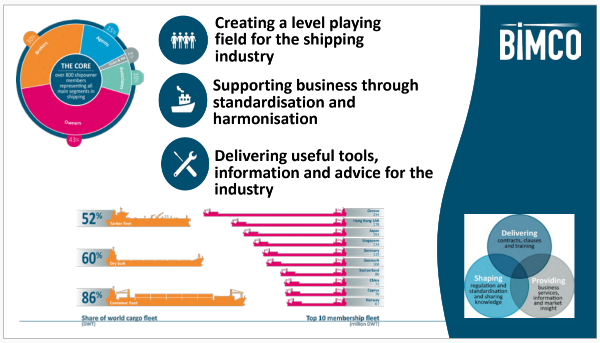
BIMCO have worked with the industry to develop an "Industry standard on in-water cleaning with capture" which helps to ensure that the in-water cleaning of a ship can be carried out safely, efficiently and in an environmentally sustainable way. One requirement of an approval of a cleaning company is that a semi-quantitative assessment of cleaning efficacy is made to determine the amount of biofouling removed. This is done using images and/or videos of selected areas before and after cleaning - assessed for percentage coverage and basic type of macrofouling.

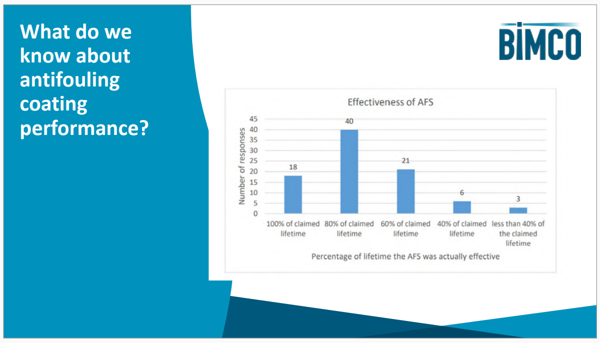
As part of the industry standard process BIMCO have been investigating whether the following can be developed:

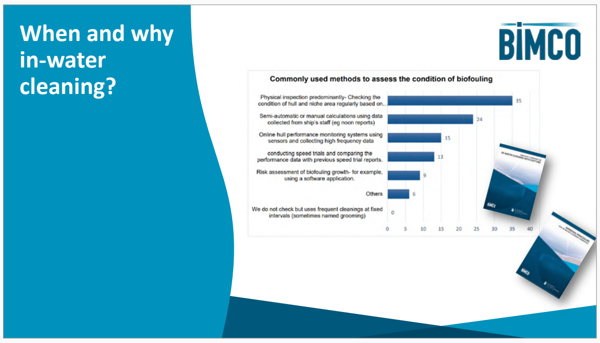
- A method that can automate the classification of images and that is reliable and accurate.
- A method which can estimate a minimum criterion that is achievable through in-water cleaning and provide confidence in the approval process.

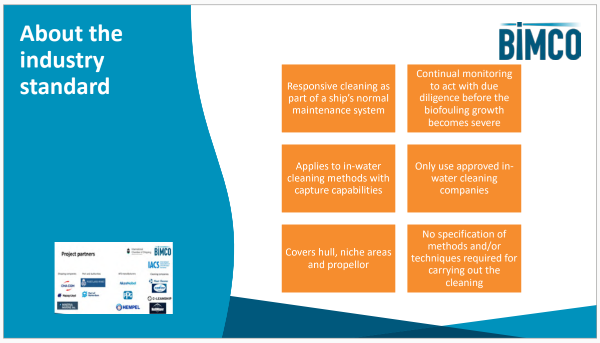
This presentation will highlight the journey taken to look at the feasibility for the use of AI for in-water cleaning approval but also for capacity building for inspections, learnings, challenges and discuss next steps.

Presentation slides

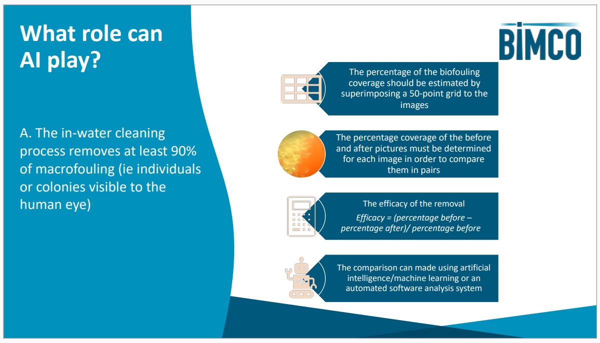


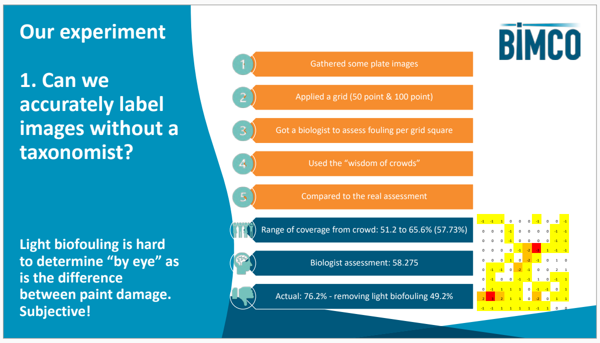


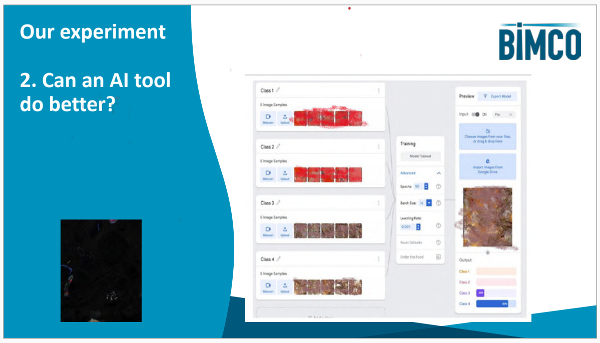


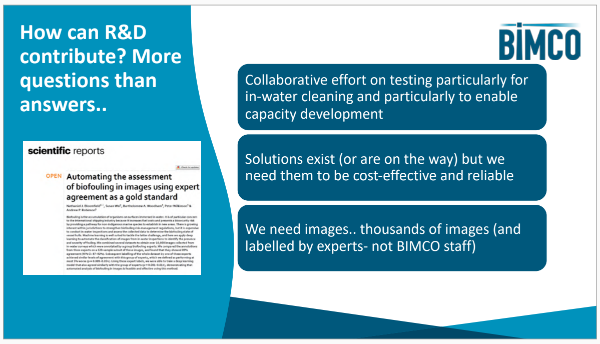


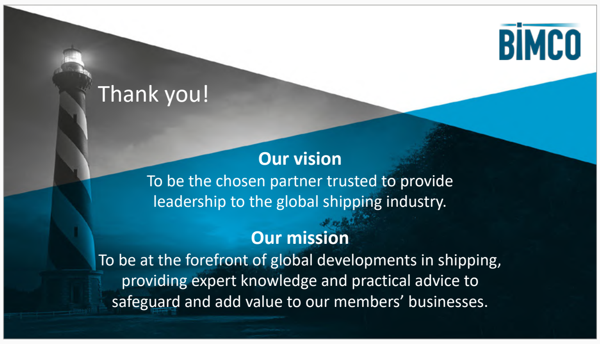

What next?
A pilot….
BIMCO
The cleaning system and working procedures are tested and approved by an independent approval body
The quality systems of the cleaning company will be subject to periodic internal audits and external audits carried out by the approval body
For an approved cleaning company to operate in any given location, a local permit must be issued by the port and other relevant authorities.
To be ready for cleaning and testing in accordance with the Industry standard (Notices of time and place for testing)
To carry out a number of successful tests (Approved cleaning companies)
To get the positive attention (Communication in accordance with plan)
To learn from the experience (Revised Industry Standard and Approval Procedure)


What role can AI play?
A. The in-water cleaning process removes at least 90% of macrofouling (ie individuals or colonies visible to the human eye)
BIMCO
The percentage of the biofouling coverage should be estimated by superimposing a 50-point grid to the images
The percentage coverage of the before and after pictures must be determined for each image in order to compare them in pairs
The efficacy of the removal
Efficacy = (percentage before – percentage after)/ percentage before
The comparison can made using artificial intelligence/machine learning or an automated software analysis system


Our experiment
1. Can we accurately label images without a taxonomist?
Light biofouling is hard to determine “by eye” as is the difference between paint damage. Subjective!
BIMCO
1 Gathered some plate images
2 Applied a grid (50 point & 100 point)
3 Got a biologist to assess fouling per grid square
4 Used the “wisdom of crowds”
5 Compared to the real assessment
Range of coverage from crowd: 51.2 to 65.6% (57.73%)
Biologist assessment: 58.275
Actual: 76.2% - removing light biofouling 49.2%


Our experiment
2. Can an AI tool do better?
BIMCO


How can R&D contribute? More questions than answers..
scientific reports
OPEN Automating the assessment of biofouling in images using expert agreement as a gold standard
BIMCO
Collaborative effort on testing particularly for in-water cleaning and particularly to enable capacity development
Solutions exist (or are on the way) but we need them to be cost-effective and reliable
We need images.. thousands of images (and labelled by experts- not BIMCO staff)


BIMCO
Thank you!
Our vision
To be the chosen partner trusted to provide leadership to the global shipping industry.
Our mission
To be at the forefront of global developments in shipping, providing expert knowledge and practical advice to safeguard and add value to our members’ businesses.

MARIO TAMBURRI

Professor, Chesapeake Biological Laboratory

University of Maryland Center for Environmental Science, USA

Dr Mario Tamburri received a Bachelor's degree from University of California Santa Barbara, a Master's degree from University of Alabama, and a Ph.D. from the University of South Carolina in biology and marine science. His basic science research focuses on how chemical cues regulate basic biological and ecological processes of aquatic organisms, including larval settlement. Dr Tamburri has worked in environments ranging from estuaries to the deep sea. Recently, he has focused much of his work on new innovations to address environmental problems from climate change to invasive species.

Dr Tamburri is now a Professor at the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, and Director two environmental innovation programs, the Alliance for Coastal Technologies (ACT) and the Maritime Environmental Resource Center (MERC). ACT is a NOAA- and EPA-funded effort dedicated to fostering the development and adoption of effective and reliable sensors and platforms for studying and monitoring coastal, ocean and freshwater environments. Similarly, MERC is a State of Maryland and US Maritime Administration initiative that provides test facilities, expertise, information, technologies, and decision tools to address key environmental issues facing the international maritime industry. Dr Tamburri has published nearly 100 peer- reviewed publications, technical reports and book chapters and has severed on multiple national and international scientific committees, including: an Ocean Studies Board on Ocean Infrastructure at the National Academies; a working group member of the US EPA Science Advisory Board, International Council for the Exploration of the Sea (ICES) and International Organization for Standardization (ISO); and a founding member of Global TestNet.

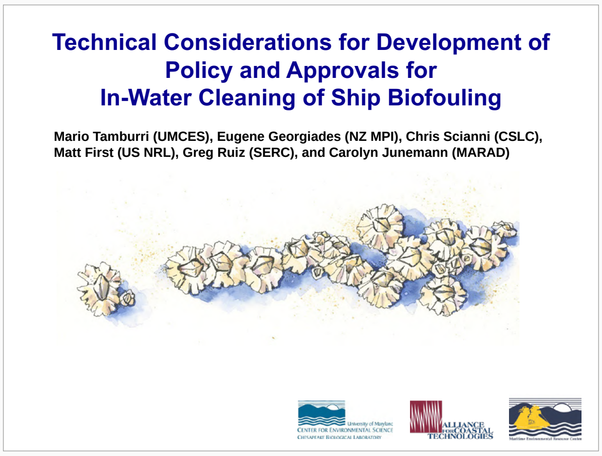
Technical Considerations for Development of Policy and Approvals for In-Water Cleaning of Ship Biofouling

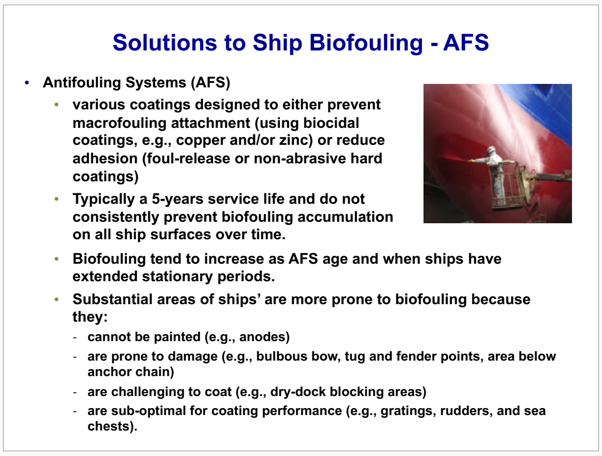
Mario Tamburri, Eugene Georgiades, Christopher Scianni, Matthew First, Gregory Ruiz, and Carolyn Junemann

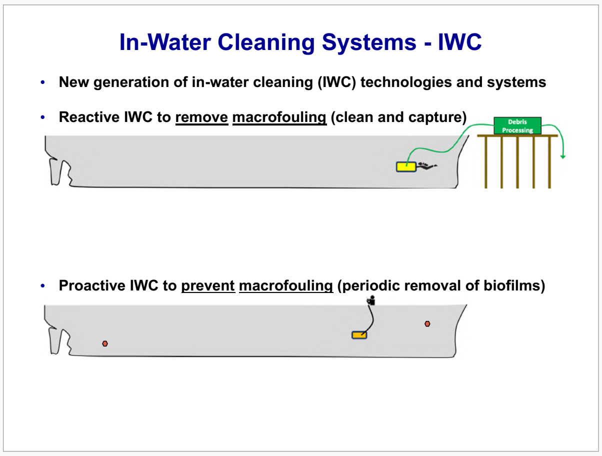
Submerged ship surfaces are often inhabited by diverse sessile and sedentary marine organisms, which can directly impact vessel operations and increase the likelihood of non-indigenous species (NIS) establishment and impacts. In-water cleaning (IWC) systems are now being incorporated into guidelines and policy to help address environmental and biosecurity risks associated with ship biofouling. However, independent, transparent, and predictive testing of ship IWC systems is fundamental to regulatory success. Performance criteria required for IWC approval should focus on the most environmentally protective variables, including presence or absence of macro-organisms (irrespective of species origins or physiological state), and measurable impacts to local water quality (as opposed to percent reductions in the release of IWC debris). Equally important is the need to measure the selected performance criteria with scientifically and statistically sound, quantitative methods to assure regulatory agencies, approval bodies, ship owners/operators, and the public that IWC of ship biofouling can be safe and

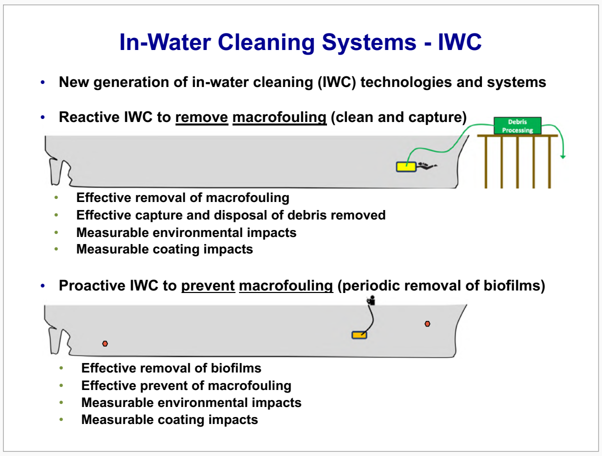
effective. Our presentation will provide advice to help avoid pitfalls in the testing and approval of IWC systems (which can undermine the success of emerging environmental regulations) and will summarize consensus from an ongoing collaborative effort of international subject matter experts to develop standardized and robust IWC system testing guidelines.

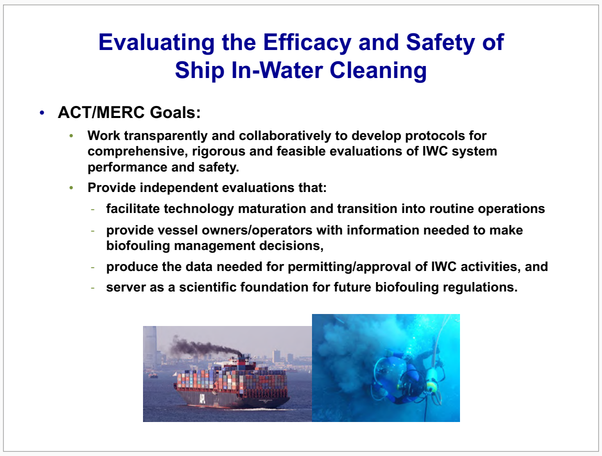
Presentation slides

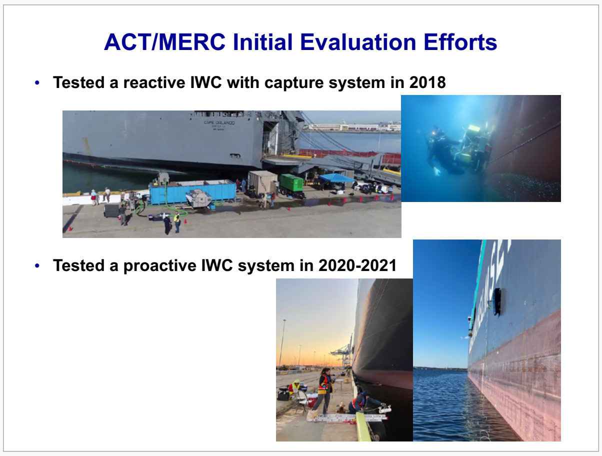












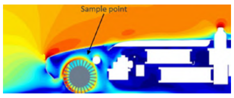
Technical Considerations for Development of Policy and Approvals for IWC

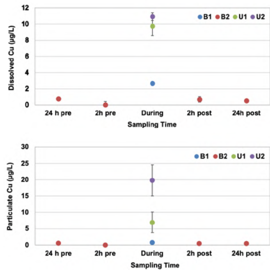
- Performance criteria for IWC approval should focus on environmental protection goals by including:
  - qualified and independent testing;
  - quantitative, robust, and statistically sound data, rather than qualitative observations;
  - water sampling at all critical control points to characterize the release of harmful materials, including dissolved and particulate biocides;
  - measurable and protective endpoints, rather than percent reductions;
  - determinations of presence or absence of macro-organisms, irrespective of species origins or physiological state; and

Tamburri, et al., 2021. Frontiers in Marine Science 8:804766.

Technical Considerations for Development of Policy and Approvals for IWC

- Water sampling at all critical control points to characterize the release of harmful materials, including dissolved and particulate biocides
- Example for proactive IWC

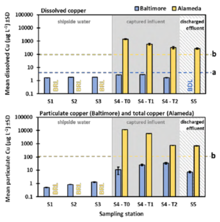




ACT/MERC, 2022. TS-786-22, UMCES 2023-014.

Technical Considerations for Development of Policy and Approvals for IWC

- Measurable and protective endpoints, rather than percent reductions
- Example for reactive IWC with capture



Influent/pre-processing concentrations of total copper was as high as 11,518 (±66.0) µg/L, thus:

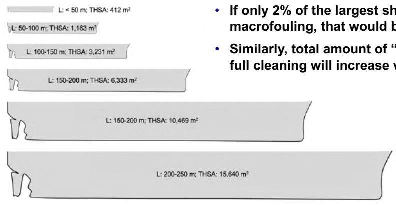
- 90% reduction would result in 1,152 µg/L,
- 95% reduction would result in 575 µg/L,
- 99% reduction would result in 115 µg/L.

Tamburri, et al., 2020. Frontiers in Marine Science 7:437.

Technical Considerations for Development of Policy and Approvals for IWC

- Measurable and protective endpoints, rather than percent reductions

Relationship between ship length (L) and total hull surface area (THSA) (Morrisey et al., 2013)



- If only 2% of the smallest ship's hull has macrofouling, that would be a total of 8 m^2.
- If only 2% of the largest ship's hull as macrofouling, that would be 313 m^2.
- Similarly, total amount of "release" from a full cleaning will increase with ship size.

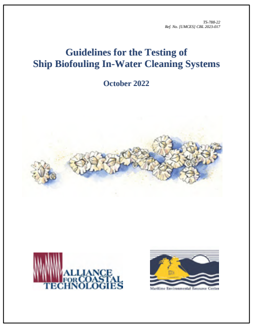
Tamburri, et al., 2021. Frontiers in Marine Science 8:804766.

Technical Considerations for Development of Policy and Approvals for IWC

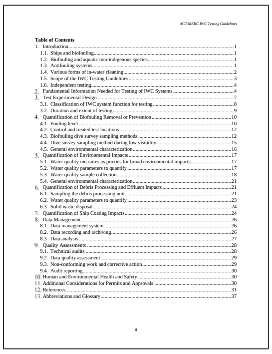
- Determinations of presence or absence of macro-organisms, irrespective of species origins or physiological state
  - Methods for species identification, and live vs. dead and/or viable vs. non-viable, are often challenging and error-prone (lessons learned from ballast water).
  - Presence/absence and magnitude of macrofouling is the primary ship operational concern (drag and fuel consumption) and is a conservative approach.
  - If IWC system includes an effluent disinfection stage to kill or render organisms "non-viable", proper treatment operations (dose and exposure time) can be monitored.

ACT/MERC IWC System Testing Guidelines

- Detailed procedures for standardized independent testing of all forms of IWC systems.
- Specific IWC systems are tested in a way that is appropriate to their design, operational requirements, and service providers' claims.
- Performance criteria or standards are outside the scope of these guidelines.



ACT/MERC IWC System Testing Guidelines



tamburri@umces.edu

GUILLAUME DRILLET

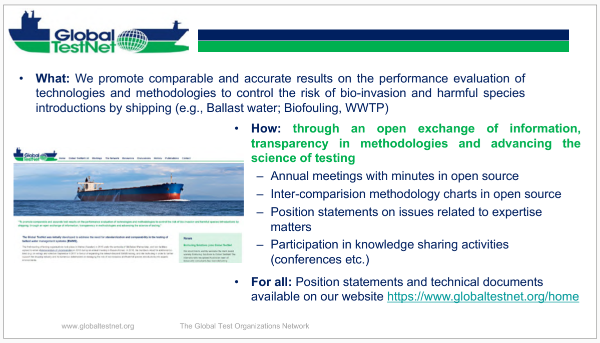
Chair

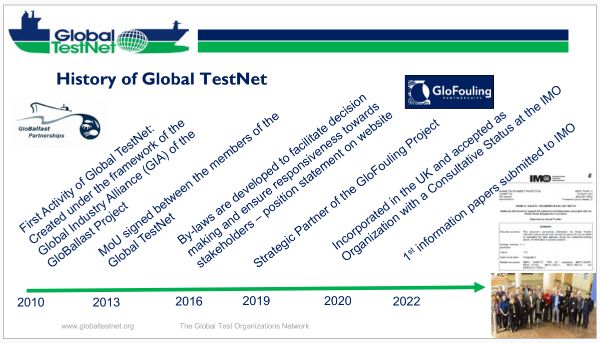
Global TestNet

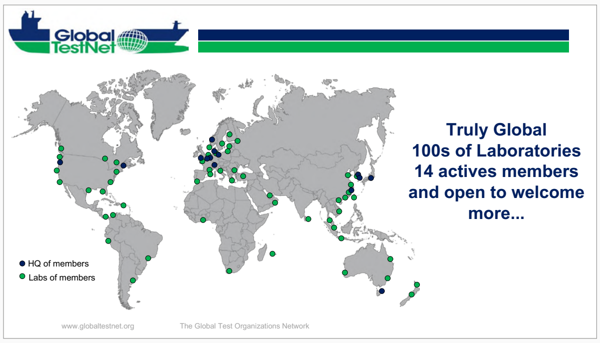
Dr Guillaume Drillet is the Asia-Pacific Manager for the Global Marine Services at SGS. He holds a PhD in Marine Sciences from Denmark and a MSc in Management of Coastal Water Resources from France. His portfolio includes environmental monitoring of coastal waters and sediments (incl. eDNA, marine litter and microplastics, ecotoxicology...), monitoring of discharges incidental to shipping/offshore activities (ballast water, gray, bilge, EGCS, emissions testing...). Since 2016, Guillaume is the chair of the Global TestNet representing testing organization dealing with bioinvasions from shipping at IMO. In 2016, Guillaume was also elected President of the World Aquaculture Society for Asia-Pacific and recently shifted to seat in the WAS board of Director.

Global TestNet and laboratory testing capabilities

Presentation slides





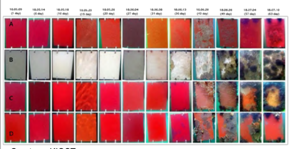


Biofouling related activities

OUR MEMBERS' ACTIVITIES

www.globaltestnet.org The Global Test Organizations Network

Testing of antifouling coatings designed for different hull locations and internal structures



Courtesy: KIOST

- Availability of AAMP certified inspectors
  (NACE and SSPC merged to Association for Materials Protection and Performance (AAMP)
- Testing of coating according to MSC regulations
  - thermal properties, corrosion, abrasion, heat resistance, toxicity, etc.
- Antifouling coating efficacy evaluation
  - Different testing schemes can be implemented for different coating depending of hull locations targets
  - Development of criteria for evaluations as needed

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Biofouling Inspection and Verification

- Biofouling inspections during drydocks or in water inspections
  - Following Guidance from Authorities or Classification societies working on their behalf
  - Following optimized procedures based on decades of experience
- Identification/characterization of biofoulings of ships and plates - expertise in HAOP identification
  - Traditional taxonomy
  - Molecular testing (eDNA)

Courtesy: Biofouling Solution

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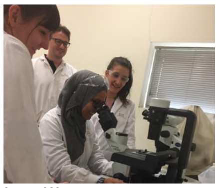
Validation of efficacy and impacts of In-Water Grooming or Cleaning Technologies and Marine Growth Prevention Systems (MGPS)



Courtesy: SGS

Limitations in terms of normalization but recent progress

- There is no type approval testing scheme under IMO
- There are no International Standard from standardization organizations (ISO, EPA, AFNOR) against which labs can be accredited
- But a few standards have been developed (including both equipment and operations):
  - Australia: Draft in water cleaning standard
  - Canada: Draft Voluntary Guidance for Relevant Authorities on In-Water Cleaning of Vessels
  - New-Zealand: Procedures for evaluating in-water systems to remove or treat vessel biofouling
  - BIMCO-ICS Industry standard on in-water cleaning with capture…

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Performance optimization or performance evaluation tests under controlled condition such as capture efficiency for IWCC

Global TestNet facilities can test under accreditation through a network of members' laboratories:

- Test and validate claims (performance evaluation) based on results of testing according to existing criteria (per government or client desires)
  - Test in controlled setup to isolate the capture efficiency of a cleaning unit; or in real life situations
  - For all systems (high pressure, brush cleaning systems etc.)
- Support performance optimization
- Support harmonization
  - Develop and verify more robust testing and suggest new relevant criteria (where possible)
  - Using a stable and accurate quantifiable material
  - Produce results not bias for magnets or thrusters

Courtesy: DHI

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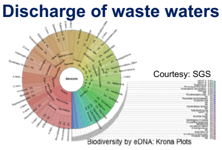
Discharge of waste waters from in-water hull cleaning systems



Courtesy: SGS

Biodiversity by eDNA: Krona Plots

- Biological discharge studies taking into account:
  - Origin type and quantification of biofouling (traditional taxonomy, eDNA…)
  - Characterization/identification of indicator species
- Waste characterization studies
  - Quantification of chemical discharges
  - Evaluation of waste treatment management procedures and efficacy
  - Microplastic analysis

Ecotoxicity evaluation of the discharge of waste waters and particulates from in-water hull cleaning systems

- Monitoring
- Fate assessments (i.e., persistence or biodegradability)
- Effects assessments
  - Whole effluent Toxicity (from operations)
  - Toxicity of individual biocides
- Prediction and modelling,
  - Predicted Environmental Concentration
  - Predicted No-Effect Concentrations

Example of Target biocides
Chlorothalonil
Copper
Copper pyrithione
Copper thiocyanate
Copper (I) oxide
Densil S-100 (TCMS pyridine)
Dichlofluanid
Diuron
Irgarol 1051
Mancozeb
Medetomidine
Octhilinone
Pyridine-triphenylborane
Sea-Nine 211 (DCOIT)
TCPM
Thiram
Tolylfluanid
Tralopyril
Zinc pyrithione
Zineb
Ziram

Courtesy: KIOST

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Support to develop effective Biofouling Management Plans and Record Books

- Two members have developed digital solutions to support compliance tracking and supports in developing Biofouling Management Plans (BFMP) and record books :

VESSEL-CHECK BMP

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Questions and Answer session

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Port perspectives of biofouling management

LUC VAN ESPEN

Environmental Expert

CA/ES Haven van Antwerpen-Brugge/Port of Antwerp

After graduating as a Bio-Engineer at the Katholic University Leuven in 1990 (with a M.Sc.-thesis on anaerobic wastewater treatment), Luc Van Espen started his professional career as a project engineer to construct wastewater treatment plant with several contractors in the private sector.

Afterwards, he has put this experience at the disposal of a few consultants in projects about wastewater treatment and integrated water management.

In 2004, he joined the Antwerp Port Authority, initially to conceive a plant to de-water dredged material from the port docks, and to treat the separated waste water. After an interludium in the topics air quality and noise management, he returned to his "old love" in 2018, by taking up a project on elaboration of testing procedures for permit granting to diving companies that postulate to perform underwater cleaning (propeller polishing & hull cleaning) in the port of Antwerp (and later on: in all Flemish ports). He managed the actual request for permits as well, and was therefore able to experience on site the consequences of one or another prescription in the procedures. Up to now, he is busy in the follow-up of permit requests, as well as in the optimizing of the test procedures and the incorporation of new cleaning technologies into these procedures.

Underwater Cleaning in the Flemish ports: Lessons learned and challenges for the future

Jasper Cornelis, Port of Antwerp-Bruges, Belgium,
Luc Van Espen, Port of Antwerp-Bruges, Belgium,
Jean-Pierre Maas, North Sea Port, Belgium,

ABSTRACT

1. INTRODUCTION

Since 2019, the Flemish ports have a common policy on underwater cleaning, more specifically, a policy for reactive cleaning with capture. (Cornelis, Van Espen, & Polfliet, 2020) This common policy arose from the commitment as ports to reconcile economic, social and ecological interests in a sustainable manner. As pioneers, the Flemish ports want to give innovative companies a chance to offer a robust solution to the fouling problem that has been troubling shipping for a long time. (Doran, 2019; Bertram, 2020) Of course, it is also vital that ports do not ignore their responsibility regarding water quality and the possible spread of alien invasive species.

Key issue is how to maintain the balance between innovation and protection of the aquatic environment. Which framework provides sufficient flexibility and perspective, but at the same time is strict enough to allow proper monitoring and enforcement? And crucial: What is the role of ports in the development and implementation of this framework? At least we hope to inspire other ports, industries and governments. Because we believe we need courageous doers to act now for a better future.

2. EXPERIENCE IN THE FLEMISH PORTS – WHAT HAVE WE LEARNED?

In the meantime, the Flemish ports have almost 4 years of experience with their framework. They still believe in their approach where they also attach great importance to feasibility. However, as expected, there are also many things that can still be improved and some new developments that need to be added.

Since 2019, about 120 hull cleanings and some 280 propeller polishing operations have been carried out in Flemish ports. It is very difficult to make a statement with regard to the number of hull cleaning operations. After a good start in 2019, there were significantly less operations in 2020 and 2021. This may be a consequence of the general crisis brought on by covid-19. In the first half of 2022, we see no change and the number of operations remains below expectations. However, we can report that no less than 42 operations were carried out in the port of Antwerp-Bruges in July 2022.We can only hope that this trend will continue, because when we are honest, the number of shipping companies that actively use these techniques is still relatively limited.

For the propeller polishing operations, it is a different story. In 2020, we saw a good increase, and in 2021 this figure was matched. However, the first half of 2022 is below expectations. Hopefully, we will see a turnaround in the second half of the year.

Some figures are highlighted in the graphs below. Important for 2022 only the data of the first half of the year are included.

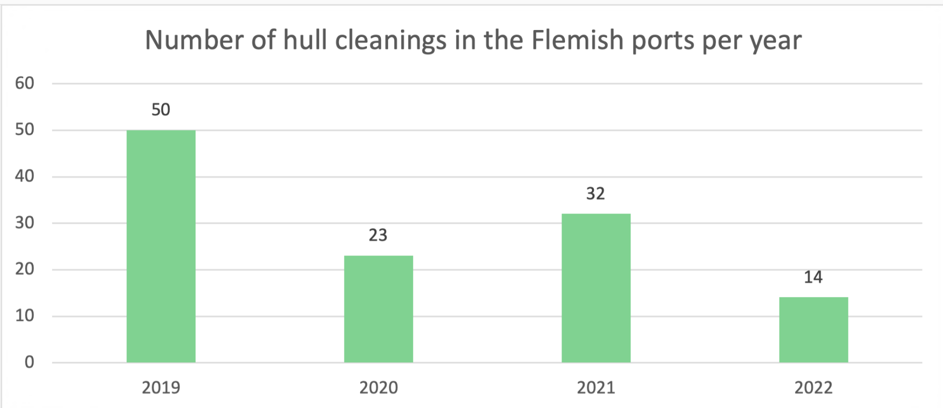

Figure 1: Number of hull cleanings in the Flemish ports per year

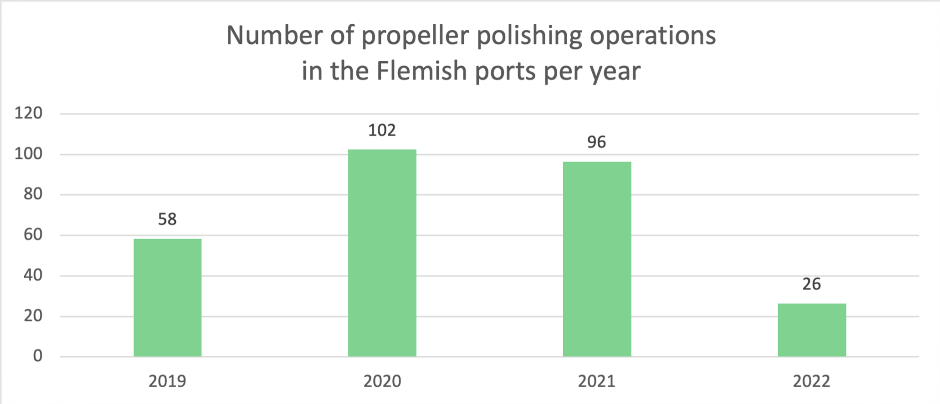

Figure 2: Number of propeller polishing operations in the Flemish ports per year

Another parameter that we consider to be important in the Flemish ports is the interest from the sector. Are there new companies that sign up, do existing companies continue to offer the services or do they expand their services?

It is noticeable that small companies find it difficult to make a name for themselves in the hull cleaning market. Not only is the purchase and development of the equipment a major investment, but the fear of not passing the test and seeing their investment come to nothing is a show-stopper. So for the time being, there are still only 2 operators offering these services in the Flemish ports. There are occasional talks with larger players, but so far nothing has led to a concrete case.

A new development is that one of the two companies, when renewing its licence, has also taken up the challenge of cleaning hard fouling, better known as macro-fouling. In the end, they also succeeded in meeting all the requirements. A summary of the test results can be found below. It is important to mention that despite these good results, we as Flemish ports have already had to issue warnings to this operator. This proves the necessity of continuing to monitor as a regulator.

Table 1: Results of spillage loss (105%) during in-situ test, all results in mg/L

	Average value – baseline	Average value – sampling	Average value – 105%
Aluminium	0,917	0,953	0,963
Copper	0,063	0,023	0,066
Iron	1,233	1,097	1,295
Nickel	0,009	0,012	0,009
Zinc	0,064	0,060	0,067
Suspended matter	14,333	14,000	15,050

Table 2: Results of filter performance during in-situ test, all results in %

	Average
Aluminium	120%
Copper	98%
Iron	107%
Nickel	100%
Zinc	99%
Suspended matter	100%

For propeller polishing, there is a lot of interest from local diving companies. The investment costs are a lot lower than for hull cleaning and that is why many are taking a chance. However, as already reported in 2020, this does not always have a good outcome. Both in terms of suction and filtration performance, we keep finding problems during the test procedure. The idea of increasing the efficiency after a few years has therefore been postponed for a while. However, we are considering imposing a minimum filter standard, for example, the effluent may not contain any particles larger than 0.5 microns.

Specifically, only 4 firms are licensed at the moment, 4 others are trying to get their licenses. In comparison with 2020, we must therefore also note that there is no great increase in the number of companies wishing to offer this service.

3. INTERNATIONAL STANDARD: WHY IS THIS CRUCIAL?

The biggest challenge within the subject of underwater cleaning is, according to the Flemish ports, the fragmented policy. Due to the absence of an international standard, there is not only a lack of a level playing field but there is also uncertainty for all parties involved. We often have the feeling: Are we doing the right thing? We are convinced that this also slows down other ports in their commitment to develop regulations for these applications.

As Flemish ports, we support the notion that if the environmental regulations for underwater cleaning are well crafted, more innovation will come, and the environmental impact would be reduced, leading the profitability of the innovating company increases. (Noordstrand, 2020) By minimising uncertainty, maximising opportunities for innovation and constantly raising the standard, the greatest benefits will be achieved in both environmental and economic terms.

So according to the Flemish ports, in the near future there will be a need to unite the forces of the existing initiatives to publish a fully supported international standard on underwater cleaning. The purpose of this standard should be at least to:

- Define the boundaries of reactive and proactive cleaning in a clear and thoughtful way, taking into account the interests of all stakeholders involved.
- Assure regulatory authorities that no damage is caused to the aquatic environment for which they are responsible. In order to remove all doubt, this requires a well-founded scientific foundation.
- Allow innovative companies to develop their solutions and commercial activities. For this purpose, it is necessary to describe a clear framework for testing and verifying the applications.
- Convince shipowners and operators of the benefits of underwater cleaning and by extension good biofouling management. The benefits gained from following the standard should be documented to inspire others.

4. PRO-ACTIVE CLEANING: THE HOLY GRAIL OF MITIGATION OF SHIP'S HULL BIOFOULING?

In addition to reactive cleaning -when something is dirty we clean it-, there is now also the development of proactive cleaning -by cleaning we prevent something from becoming dirty-. Since ports want nothing more than to receive the 'cleanest' ships, you would expect them to welcome this new development? However, there are not only advantages but also challenges.

With reactive cleaning, there was always a need to capture what was removed. With proactive cleaning, the intention is precisely to avoid the development of harmful organisms on the hull by means of regular cleaning. In this case, there is no need for capture. As ports, we ask ourselves: where is the line between reactive and proactive cleaning? In other words, to what level is it acceptable to clean a ship's hull without capture? Or is it wrong to state that proactive cleaning is always possible without capture?

Some additional concerns:

- When the boundary between reactive and proactive cleaning has been established, a system must be developed to check the requirements in an objective manner. If this assessment is not carried out correctly, there is a high risk of harm to the local aquatic environment. This method must also be verifiable by the regulatory authorities, otherwise it will be impossible to monitor these operations correctly.
- Besides the release of organisms, regulatory authorities as ports are also concerned about the possible release of biocides and paint particles (seen as microplastics). (IMO, 2019) These can have an impact on the local marine environment, but also cause local soil pollution. How can we be sure as ports which coatings are suitable for proactive cleaning? And what is the role of the manufacturers of these coatings?

5. NEW DEVELOPMENTS: THE NEXT STEP?

The development of hard, non-toxic coatings seems to be an interesting option in combination with proactive cleaning. However, we believe that there is little enthusiasm. The shipping industry needs to be made more aware of the possibilities and advantages. Too often, the easy solution is chosen, the known solution. Innovating has its risks, of course, but also benefits. We hope that in the near future major manufacturers will continue to take responsibility and investigate possible solutions that are both ecologically and economically feasible. For ourselves, but certainly also for the higher authorities, we see the role of supporting new players with promising prospects so that they can earn their place in the market.

A similar story can be seen with ultrasound, which could be used to protect niche areas. (Kelling, 2020) The technology has been proving its usefulness in industrial installations for quite some time, but has not yet had a breakthrough in shipping. While in the Flemish ports, infringements are regularly observed on the cleaning of sea chests that are overgrown with macro-organisms. What is the reason why this technology cannot break through? Does the impact need to be mapped out more? And, apart from application in niche areas, is there also a possibility of protecting the entire ship's hull in this way? As ports, we are already looking forward to seeing what this technology can offer us in the years to come.

Finally, when we speak of new developments, we must not forget the power of data and computer models. As a port, we believe it is becoming crucial for ship owners to have correct and adequate data at their disposal. At the same time, it will be a challenge to use that data optimally. For example, to link the performance of a ship to its biofouling management. In addition, it will be possible to make predictions about the status of the ship's hull, the coating, the cleaning operations required, etc. Add to this the fact that it is not inconceivable that ports will request this information in the future before admitting a ship and the added value becomes immediately clear.

6. CONCLUSIONS

The Flemish ports have gathered a lot of knowledge on underwater cleaning from their position as regulatory authorities. However, they realise all too well that they are only a small piece of the puzzle. There is an urgent need for guidelines and boundaries to enable the further development and rollout of these applications and thus enjoy the many benefits they have to offer. They hope that new players feel inspired and that the interest of major partners is stimulated, because only together can we bring this to a successful conclusion.

ACKNOWLEDGMENTS

We thank our colleagues who support us in the operational and administrative follow-up of this project. Special thanks also to Volker Bertram (DNV GL) for his open questions and useful insights that have contributed to the content of this article.

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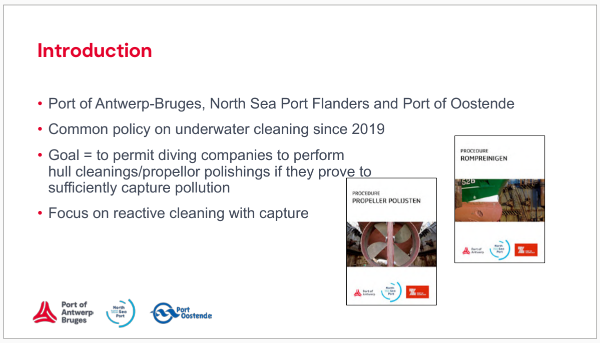
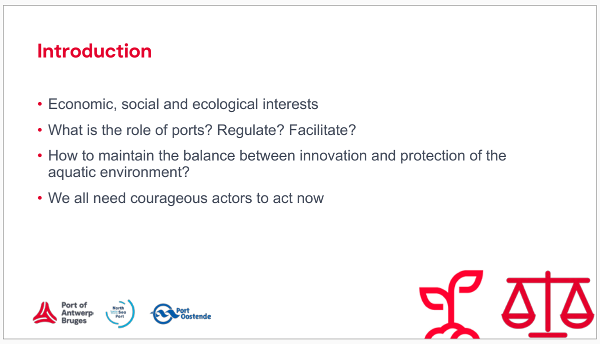
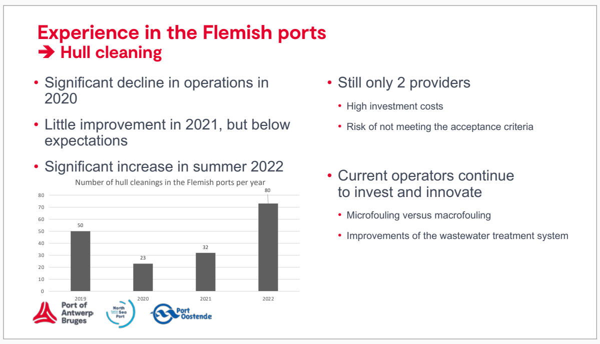
Presentation slides

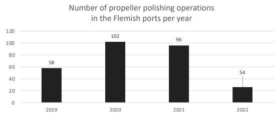






Experience in the Flemish ports
→ Propeller polishing

- Increase in 2020, stability in 2021.
- Decrease in 2022, below expectations
- 4 operators licensed, 4 operators in licensing process



An international standard: Why is this crucial?
→ From a fragmented policy…

- Challenges?
  - Lack of level playing field
  - Uncertainty for all stakeholders
- Solution?
  - Well crafted international regulations that give the opportunity for new innovations
  - Feasible for all stakeholders

An international standard: Why is this crucial?
→ … to an International Standard

- Unite forces for an internationally supported standard. The purpose of this standard should be at least to:
  - Define what needs to be defined so that everyone is talking about the same thing.
  - Assure regulatory authorities that no damage is caused to the aquatic environment for which they are responsible. In order to remove all doubt, this requires a well-founded scientific underpinning.
  - Allow innovative companies to develop their solutions and commercial activities. For this purpose, it is necessary to describe a clear framework for testing and verifying the applications.
  - Convince shipowners and operators of the benefits of underwater cleaning and by extension good biofouling management. The benefits gained from following the standard should be documented to inspire others.

Pro-active cleaning: The holy grail of biofouling mitigation?
→ 'Reactive' versus 'Proactive cleaning': Concerns

- What is the boundary between re-active and pro-active cleaning?
- What about spatial differentiation in fouling rates over the ship's hull?
- Should pro-active cleaning always be possible without capture?
- How to supervise as an authority?
- What with the possible release of biocides and paint particles (seen as microplastics)?

(Some other) New developments

- Hard, non-toxic coatings:
  - Is a world without toxic coatings realistic in the long term?
  - Potential in combination with pro-active cleaning?
- Prevention by Ultrasound:
  - Solution for niche areas?
  - Why isn't this implemented everywhere?
  - Is ultrasound possible as an alternative antifouling system on the entire hull?
- Power of data:
  - To know when a ship has been cleaned
  - To predict when a ship should be cleaned

Thank you for your attention!

Questions?
→ Only 2 adresses:

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Mr. Reza LUDOVIC is a Senior Advisor in charge of Research, Prospective and Development at the General Management of the Maritime and Port Authority of Madagascar. Currently, he is nominated as National Focal Point of GloFouling Partnerships project.

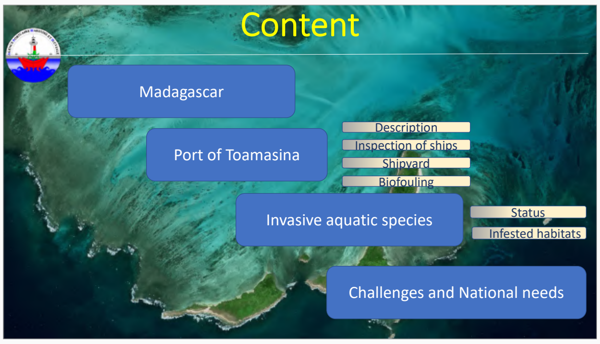
Involved in scientific research for 20 years, he has extensive experiences in environmental and biological research all around Madagascar with many NGOs and public services.

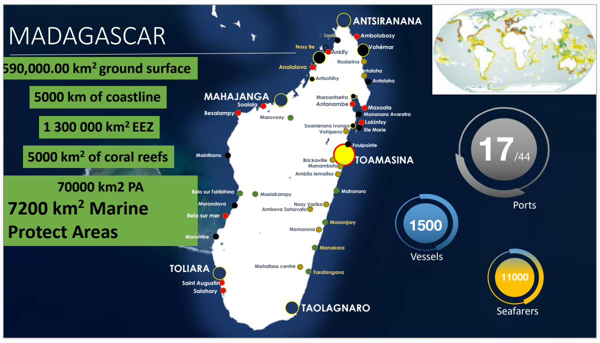
He received his Master of Sciences, at the University of Antananarivo, Madagascar. He also undertook specialized training such as spatial analysis with GIS at Research Department of Missouri Botanical Garden, and Entrepreneurship at the Washington University, Missouri, USA.

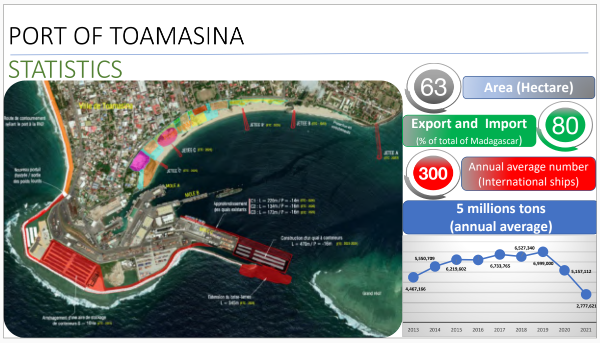
International Port of Toamasina, capacity and organization issues to deal with invasion of Invasive Aquatic Species from biofouling

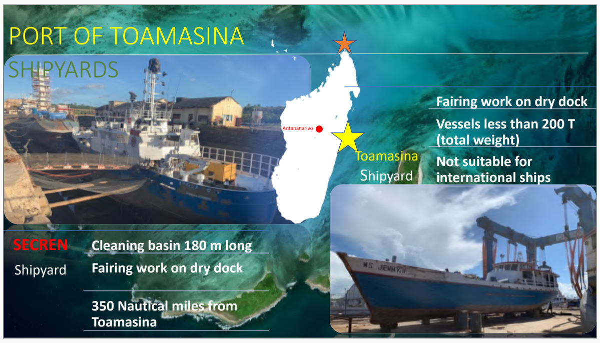
Madagascar, the fourth largest island in the world, is located in the Indian Ocean. The country has over 5000 km of coastland and is connected to international maritime transport via six ports. The biggest port is in Toamasina, on the east coast where 80% of the international traffic is operated. Research supported by the International Maritime Organization on the status of GloFouling in Madagascar in the year 2021 reported that marine invasive species appeared in the port of Toamasina and its surroundings. Based on this research, one other study has been conducted by the port authority to understand the cause of existence of invasive species around the port. Result of study indicated that official inspection of ships is not yet effective and shipyard is not efficient on biofouling treatment. Even if the environmental officer of the port notices a deficiency of a ship's hull related to biofouling, there is no action taken regarding the lack of inspection and lack of technology for biofouling management. Nevertheless, the port manager does not accept in-water cleaning. Regarding the shipyard available inside the port, it is for domestic cabotage where ships are treated on a dry dock. It does not however fit bigger ships. In conclusion, there is no control of biofouling of international ships. The blue economy such as fishing for subsistence and tourism around the port could be threatened by the introduction of invasive aquatic species if no serious action is developed on biofouling management.

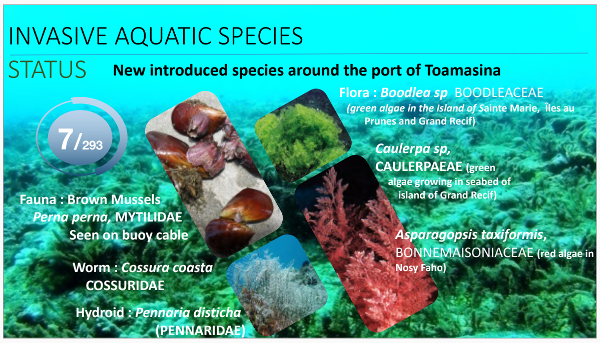
Presentation slides

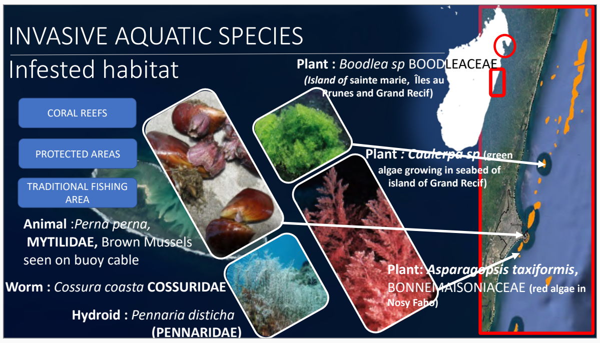


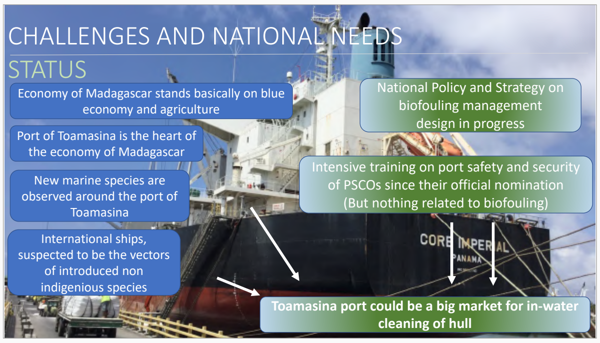












SESSION 7

Increasing the role of women in biofouling management

SANJAM GUPTA

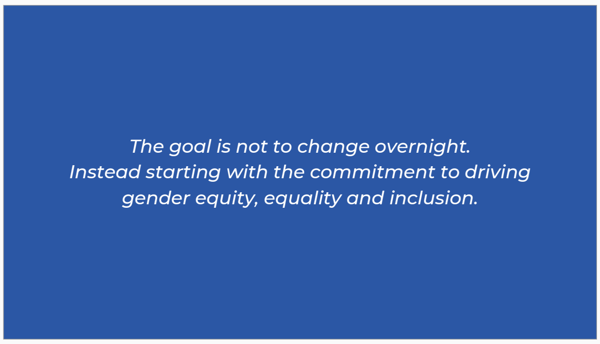
Founder, Maritime SheEO

Director Sitara Shipping Ltd.

Sanjam Sahi Gupta is Director for Sitara Shipping Ltd. and an Advocate for Diversity in the Maritime Industry. She is a founder member of WISTA India and a former Board Member of WISTA International; She is a member of the Executive Board of Directors of the World Maritime University Malmo, Sweden. She has won several awards, the most prominent being the Sandvik Gender Award – for her outstanding contribution and commitment to gender equality. To further her commitment to Diversity in the maritime and Logistics industry she has launched Maritime SheEO to provide solutions to the industry. She is a gender expert empanelled by the UN ESCAP and is committed to driving change for a more inclusive maritime industry.

Charting the route towards inclusive biofouling management

Presentation slides



<u>Objective 1</u>: Gender Equality as a business case in maritime and specifically in biofouling is showcased in all the participating countries.

<u>Objective 2</u>: Qualitative gender data gathered on women's participation in biofouling-related activities by industry in the beneficiary countries.

<u>Objective 3</u>: Monitoring and delivery of IMO project-specific gender commitments.

Objective 1

Diversity has a Business Case

Organisations need to showcase and consistently communicate that there is a business case for gender equality and inclusion of more women in biofouling practices in target countries.

Objective 2

The data gaps are real

It's important to address the data gap of the number of women participating in biofouling related industry and research work.

We need to get baseline data of the number of women participating and at various levels. An analysis of qualitative gender data gathered on women participation in biofouling related activities by industry in beneficiary countries is essential.

Objective 2

Let's Set Goals!

We need to start tracking gender participation so that we can compare, track improvements, and set clear and achievable targets.

We then use these results to create awareness.

Gender balance needs to become a growth imperative rather than a diversity goal.

Objective 2

Let's Walk The Talk

- Organisations need to commit to achieving 50:50 gender ratio
- Encourage gender equality in project training amongst workshop participants
- Follow-up and monitor these gender-specific commitments and targets and report on them to the donor
- Dedicate specific resources to gender equality related work
- Ensure gender multilingualism in all communication, activities.

Objective 1

Forming New Agendas

A new HR agenda needs to be created where gender and diversity form an important pillar, where women are explicitly mentioned and targeted as well.

Topics in which gender and/or women are included need to be for leadership development so women are really able to access leadership positions and focus on employees talent development; and 'quality through diversity'.

What can we do differently?

Objective 3

Social Media Campaigns

Highlight gender-neutral roles and role models as well as a 100 women in Biofouling campaign.

Dedicate a day to women in Biofouling or ensure they are included and present on May 18th.

3 Year Action Plan

3 Year Action Plan

Objective 3

Social Media Campaigns

- Create awareness around the participation of women
- Create aspiration for attracting women in biofouling and inspire existing women to excel
- Highlight the business and sustainability case for women in Biofouling
- Develop competencies to understand the different contributions that are made by both men and women and how they complement each other

October - December (each year)

Objective 3

Distribute Surveys

Survey to be carried out to get data for women in maritime. Here we also ask women for their experiences, to better understand the leaky pipeline mechanism; that is, to focus on women who leave.

January 2023 - December 2025

Objective 3

Creating Networks

- Women in Biofouling subnetwork to be created (could be part of the WIMA network)
- Build an APP connecting women in Biofouling

January 2023 - December 2025

Objective 3

Create Support Systems

- Run a mentorship program to help young women get the mentoring needed to rise in their careers
- Women support each other and make connections
- Run capacity building workshops to improve participation of women
- Implementing mentoring activities at the local context, by collaborating with already existing mentoring activities and by using classical and/or more innovative approaches to mentoring.

January 2023 - December 2025

Objective 3

Leadership Development Programs

In general, the programme will serve women professionals aiming to overcome gender barriers and grow within their organisations.

It aims to create a pipeline of women leaders.

It helps inculcate self-confidence and develop expertise

Thank you!

GloFouling beneficiary countries sharing experience on key initiatives and challenges

GABRIEL ABAD-NEUNER

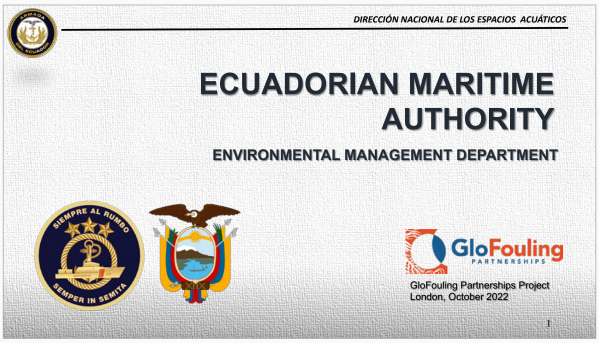
Captain EC Navy / Deputy Director

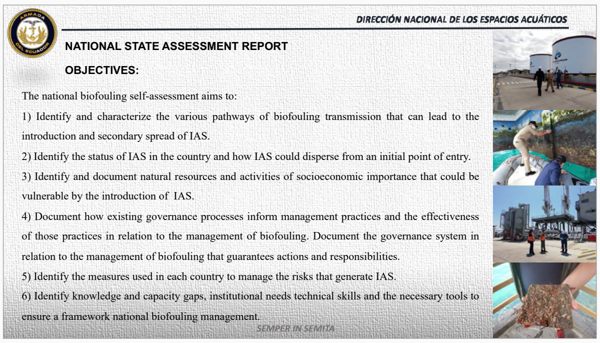
Ecuadorian Maritime Authority

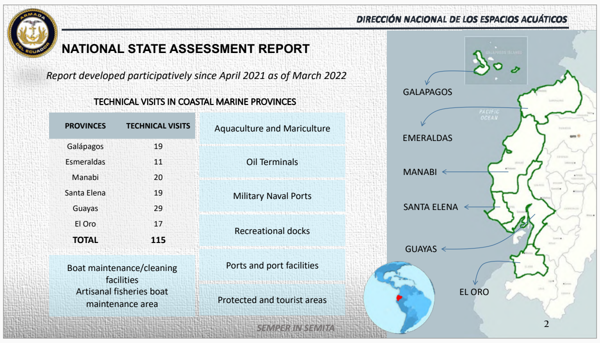
Dr Abad-Neuner, LLM, brings more than 33 years of experience in the naval, legal and maritime fields with an extensive history of leadership and management skills and experience at sea. Since the year 2000 he worked as a lawyer specialized later in International Maritime Law, gaining experience in legal drafting, Treaty Law and International Organizations first from an academic perspective and then since 1996 in a variety of international forums and since 2011 as technical assistant of the Ecuadorian delegation to several general assemblies of IMO until finally serving in the capacity of Permanent Alternate Representative of Ecuador to IMO in 2019 and 2020.

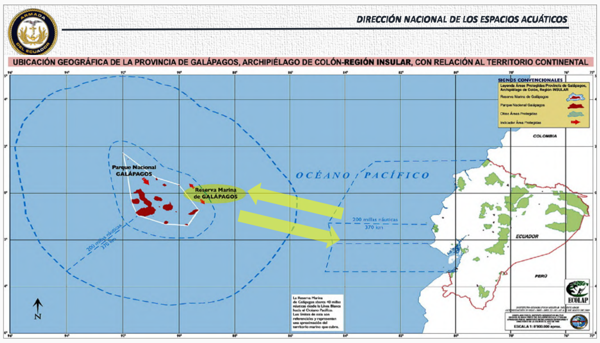
Analysis of the baseline situation in Ecuador for biofouling management in all maritime industries.

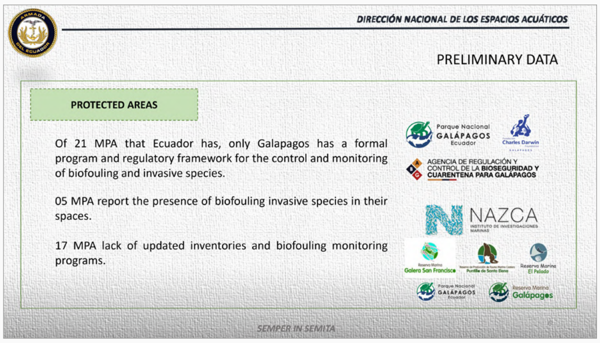
Presentation slides

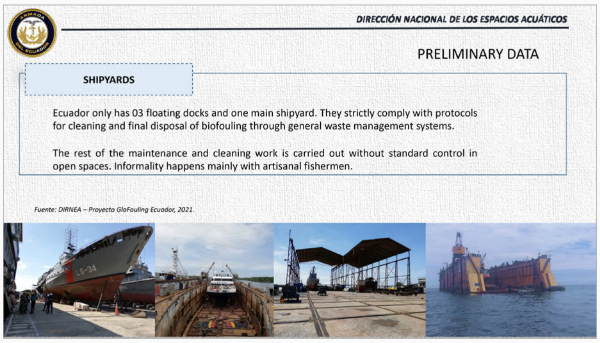




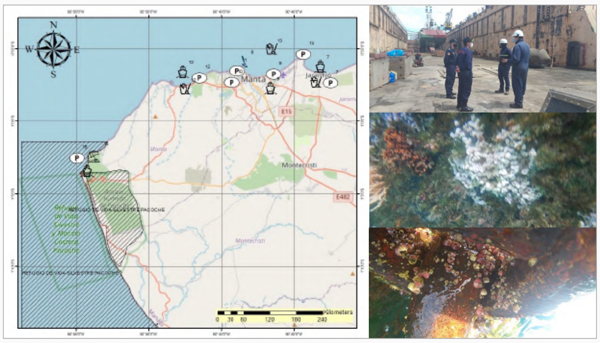

DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
NATIONAL STATE ASSESSMENT REPORT
Report developed participatively since April 2021 as of March 2022
TECHNICAL VISITS IN COASTAL MARINE PROVINCES
PROVINCES | TECHNICAL VISITS
Galápagos 19
Esmeraldas 11
Manabi 20
Santa Elena 19
Guayas 29
El Oro 17
TOTAL 115
Aquaculture and Mariculture
Oil Terminals
Military Naval Ports
Recreational docks
Ports and port facilities
Protected and tourist areas
Boat maintenance/cleaning facilities
Artisanal fisheries boat maintenance area
GALAPAGOS
EMERALDAS
MANABI
SANTA ELENA
GUAYAS
EL ORO
SEMPER IN SEMITA
2

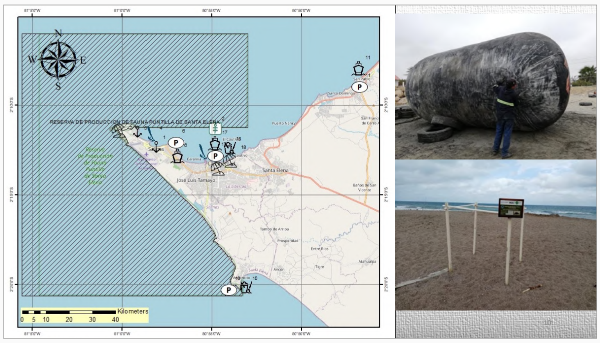

DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
UBICACIÓN GEOGRÁFICA DE LA PROVINCIA DE GALÁPAGOS, ARCHIPIÉLAGO DE COLÓN-REGIÓN INSULAR, CON RELACIÓN AL TERRITORIO CONTINENTAL
OCÉANO PACÍFICO
Parque Nacional GALÁPAGOS
Reserva Marina de GALÁPAGOS
COLOMBIA
ECUADOR
PERU

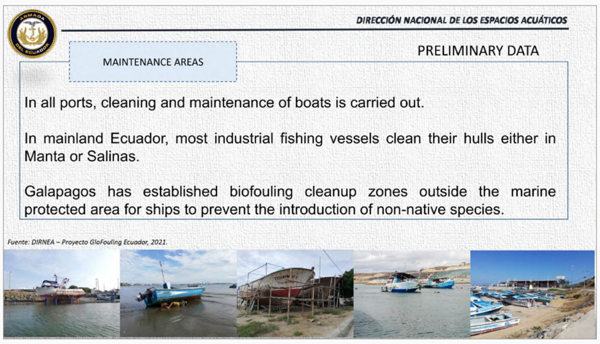

DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
PRELIMINARY DATA
PROTECTED AREAS
Of 21 MPA that Ecuador has, only Galapagos has a formal program and regulatory framework for the control and monitoring of biofouling and invasive species.
05 MPA report the presence of biofouling invasive species in their spaces.
17 MPA lack of updated inventories and biofouling monitoring programs.
Parque Nacional GALÁPAGOS Ecuador
Charles Darwin
AGENCIA DE REGULACIÓN Y CONTROL DE LA BIOSEGURIDAD Y CUARENTENA PARA GALÁPAGOS
NAZCA
SEMPER IN SEMITA

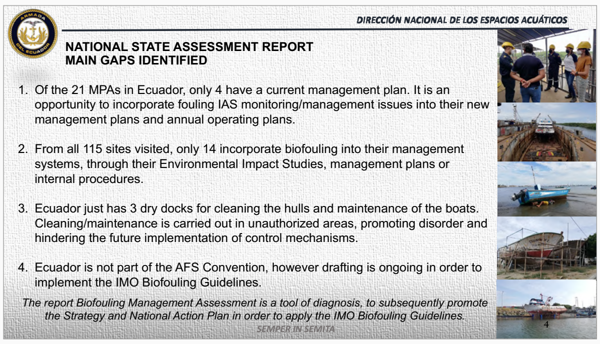

DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
PRELIMINARY DATA
SHIPYARDS
Ecuador only has 03 floating docks and one main shipyard. They strictly comply with protocols for cleaning and final disposal of biofouling through general waste management systems.
The rest of the maintenance and cleaning work is carried out without standard control in open spaces. Informality happens mainly with artisanal fishermen.
Fuente: DIRNEA – Proyecto GloFouling Ecuador, 2021.

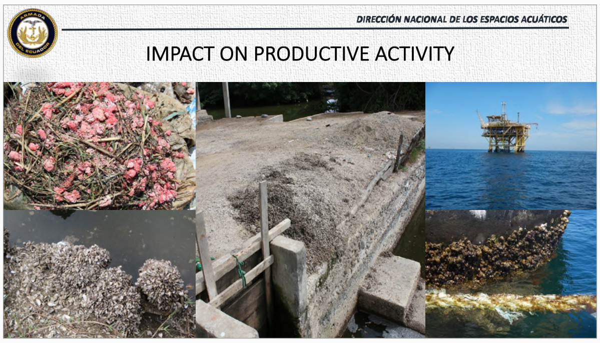

Guayaquil
Durán
Isla Santay
Isla Santa Ana
Kilometers

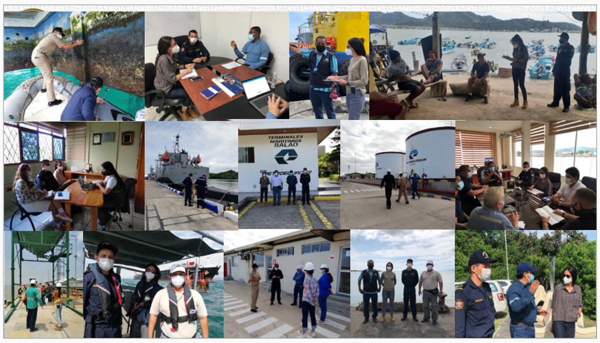

Manta
Kilometers

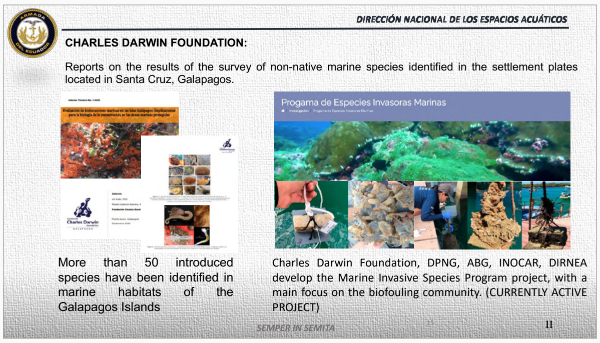

Kilometers


DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
MAINTENANCE AREAS
PRELIMINARY DATA
In all ports, cleaning and maintenance of boats is carried out.
In mainland Ecuador, most industrial fishing vessels clean their hulls either in Manta or Salinas.
Galapagos has established biofouling cleanup zones outside the marine protected area for ships to prevent the introduction of non-native species.
Fuente: DIRNEA – Proyecto GloFouling Ecuador, 2021.

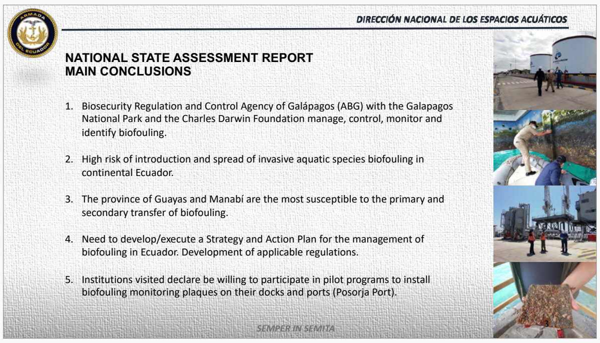

DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
NATIONAL STATE ASSESSMENT REPORT
MAIN GAPS IDENTIFIED
1. Of the 21 MPAs in Ecuador, only 4 have a current management plan. It is an opportunity to incorporate fouling IAS monitoring/management issues into their new management plans and annual operating plans.
2. From all 115 sites visited, only 14 incorporate biofouling into their management systems, through their Environmental Impact Studies, management plans or internal procedures.
3. Ecuador just has 3 dry docks for cleaning the hulls and maintenance of the boats. Cleaning/maintenance is carried out in unauthorized areas, promoting disorder and hindering the future implementation of control mechanisms.
4. Ecuador is not part of the AFS Convention, however drafting is ongoing in order to implement the IMO Biofouling Guidelines.
The report Biofouling Management Assessment is a tool of diagnosis, to subsequently promote the Strategy and National Action Plan in order to apply the IMO Biofouling Guidelines.
SEMPER IN SEMITA
4

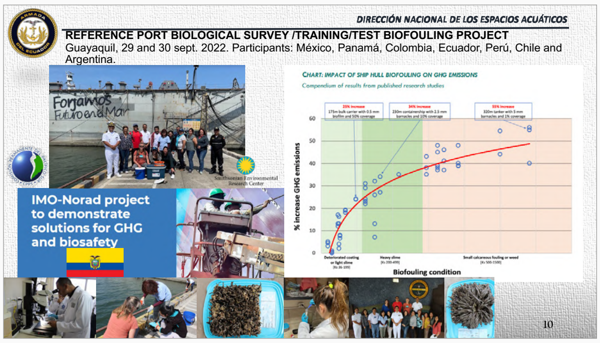

DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
IMPACT ON PRODUCTIVE ACTIVITY




DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
CHARLES DARWIN FOUNDATION:
Reports on the results of the survey of non-native marine species identified in the settlement plates located in Santa Cruz, Galapagos.
Progama de Especies Invasoras Marinas
More than 50 introduced species have been identified in marine habitats of the Galapagos Islands
Charles Darwin Foundation, DPNG, ABG, INOCAR, DIRNEA develop the Marine Invasive Species Program project, with a main focus on the biofouling community. (CURRENTLY ACTIVE PROJECT)
SEMPER IN SEMITA
11


DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
STRATEGIC PARTNERS
YILPORT HOLDING INC.
INABIO
espol Escuela Superior Politécnica del Litoral
Parque Nacional GALÁPAGOS Ecuador
Charles Darwin
ASTINAVE EP
Pintuco El Color de la Calidad
AGENCIA DE REGULACIÓN Y CONTROL DE LA BIOSEGURIDAD Y CUARENTENA PARA GALÁPAGOS
UPSE
SEMPER IN SEMITA
16


DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
NATIONAL STATE ASSESSMENT REPORT
MAIN CONCLUSIONS
1. Biosecurity Regulation and Control Agency of Galápagos (ABG) with the Galapagos National Park and the Charles Darwin Foundation manage, control, monitor and identify biofouling.
2. High risk of introduction and spread of invasive aquatic species biofouling in continental Ecuador.
3. The province of Guayas and Manabí are the most susceptible to the primary and secondary transfer of biofouling.
4. Need to develop/execute a Strategy and Action Plan for the management of biofouling in Ecuador. Development of applicable regulations.
5. Institutions visited declare be willing to participate in pilot programs to install biofouling monitoring plaques on their docks and ports (Posorja Port).
SEMPER IN SEMITA


DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
REFERENCE PORT BIOLOGICAL SURVEY /TRAINING/TEST BIOFOULING PROJECT
Guayaquil, 29 and 30 sept. 2022. Participants: México, Panamá, Colombia, Ecuador, Perú, Chile and Argentina.
IMO-Norad project to demonstrate solutions for GHG and biosafety
CHART: IMPACT OF SHIP HULL BIOFOULING ON GHG EMISSIONS
Compendium of results from published research studies
% increase GHG emissions
Biofouling condition
10


DIRECCIÓN NACIONAL DE LOS ESPACIOS ACUÁTICOS
THANK YOU
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Captain – EC Navy
MARITIME TECHNICAL DIRECTOR
gabad@armada.mil.ec
abadneuner@gmail.com
CELL PHONE: +593 998837435
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
CONTACTS:
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DEPUTY DIRECTOR OF ENVIRONMENTAL MANAGEMENT
NFP GPP
fespinozah@armada.mil.ec
CELL PHONE: +593 990984055
SEMPER IN SEMITA
12

MARIA CECILIA T. DE CASTRO

Commander

Brazilian Navy

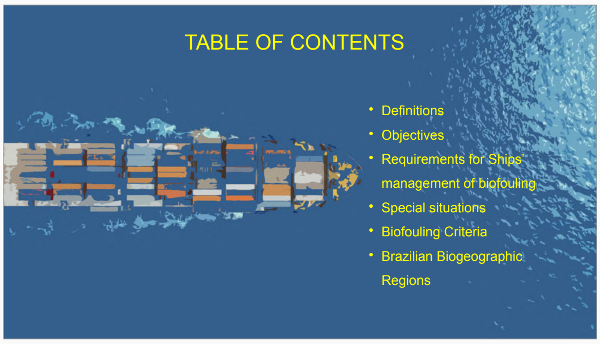
Maria Cecilia Trindade de Castro is a Commander of the Brazilian Navy. She holds a bachelor's degree in Oceanography from the State University of Rio de Janeiro (UERJ), in Brazil, a Master's degree in Environmental Engineering also from UERJ and a PhD in Marine Sciences from the University of Plymouth in collaboration with Plymouth Marine Laboratory, in the United Kingdom. Commander Cecilia currently serves in the Directorate of Ports and Coasts, Representative of the Brazilian Maritime Authority, exercising the function of Head of the Department of Environment for the Coastal Zone and Brazilian Jurisdictional Waters of the Superintendence of Environment.

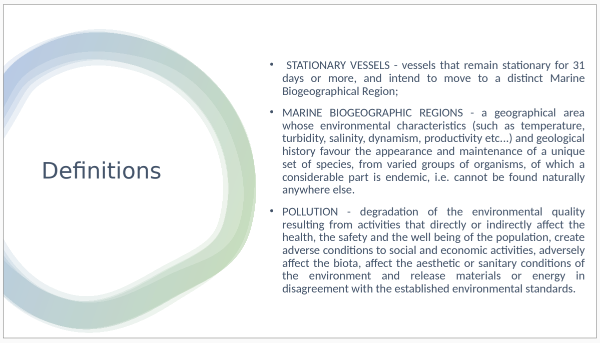
Brazilian Regulation on the Management of Ships' Biofouling

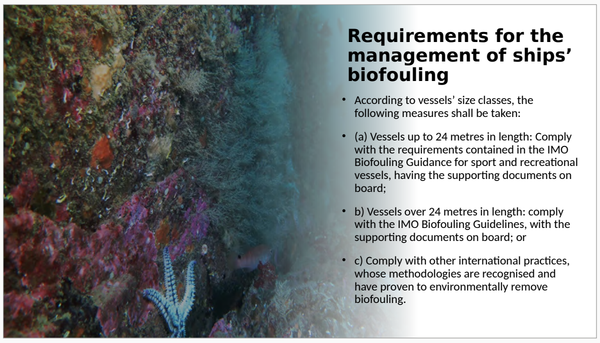
Castro, M. C. T.; Scapolatempore, M. P.; Coutinho, R.

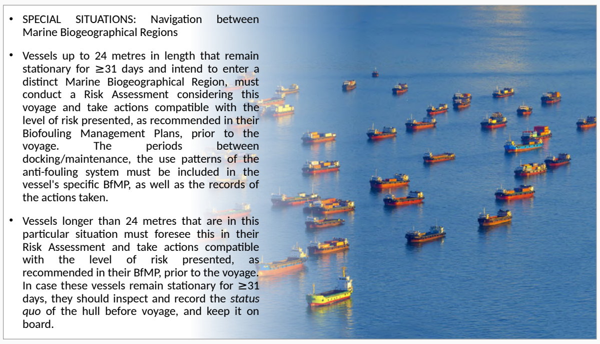
Biofouling on wetted areas of ships is an important vector resulting in the transfer of non-native species (NNS). In order to protect jurisdictional waters from this threat, some countries/states put in place unilateral rules to be compliant by ships entering in their waters. Brazil, as part of the GloFouling project, and with a view to protecting its biodiversity, is also developing a regulation on the subject, based on already in force regulations and previous successful experiences, in addition to the IMO Guidelines, currently under revision. The Brazilian Regulation is going to be applied to all ships entering in Brazilian Jurisdictional Waters (AJB), to the operator or person in charge of vessels that will anchor, moor and/or berth in national waters, or that are brought ashore through the national territory after a voyage originating outside AJB. There is a general requirement that demands vessels to be cleaned before entering in AJB or within 24 hours upon arrival. For regulatory and inspection purposes, compliance to the Regulation is required to be shown through the implementation of the Biofouling Management Plan, the verification of the Biofouling risk assessment evaluation, and the carry out of surveys and hull cleaning, and can be complemented by the inspection of all available records of management measures carried out by the ship. The development and implementation of the Regulation has the main goal of avoiding NNS and foremost improving biosecurity of Brazilian waters.

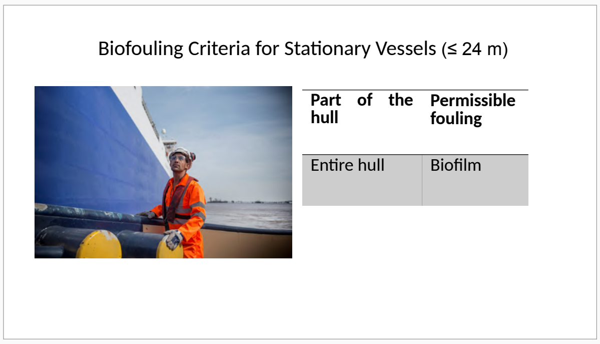
Presentation slides

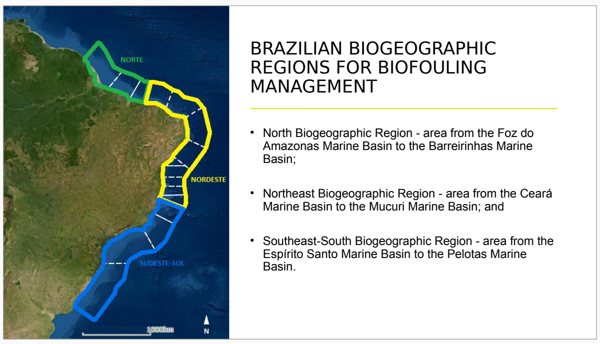


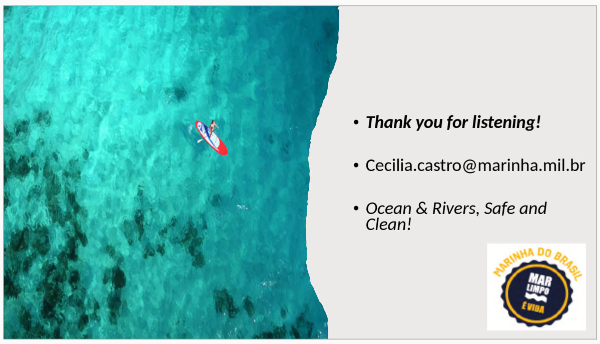












MAHMOUD AHMED

Program Coordinator for marine pollution activities

PERSGA

Dr Ahmed works as a Program Coordinator for marine pollution activities at the Intergovernmental Organisation PERSGA Headquartered in Jeddah, Saudi Arabia. He holds a Ph.D. in Physics and chemistry from the University of Besancon in France. He has dual expertise of over 10 Years in Coastal/Land/Marine pollution management. At PERSGA, he performs a variety of technical, policy, and regulatory work related to marine and coastal environment protection issues and mainly related to pollution prevention, preparedness and response.

He also coordinates and manages the GloFouling Partnerships project in the PERSGA region where Jordan is the leading Country.

Challenges and achievements in the Red Sea and Gulf of Aden.

Presentation slides


Achievements
Regional awareness raising seminar on biofouling management
Teleconferencing organized on 17th June 2021
50++ participants from PERSGA countries attended
enhancing awareness on Biofouling and IAS and to understand the key aspects of the Project and the international regulatory framework to manage marine biofouling
Hybrid National Training course at JAMS (Jordan Academy for Maritimes studies) 26-27 September 2021
pilot training course
The training course package were delivered by a JAMS's instructor.
20++participants attended
the training course package is being mainstreamed in the Academy's programs and syllabuS


Regional Task Force in the PERSGA region-March 2022
1. Established in 2022. It is made up of two representatives from each PERSGA countries.
2. RTF chair (Jordan) elected for two year term.
3. First draft of the regional strategy on Biofouling management completed.
4. Next steps: the endorsement of the draft strategy and its action plan, and the implementation of the first activities identified, followed by another meeting of the regional task force in 2023
5. First meeting on 22 March, 2022. Some activities to be developed during 2023 -2024:
Establish regional baseline information
Raise awareness around the IMO Biofouling Guidelines (including recents developments)
Start processes to develop and implement training on biofouling manage ment tools, in particular biofouling manage-ment plans and biofouling record books and inspection thereof
Provide training on in-water inspection, cleaning and maintenance


2nd Global Project Task Force meeting London, 11-13 April 2022
Coordination and Support provided to Lead Partnering (Jordan)and PCs countries (Djibouti, Somalia, Sudan)
Jordan (LPC) achievements:
Draft biofouling management instructions
Draft national policy for the management of biofouling (underprocess)


Communication material/raising awareness initiatives
Animated video
https://www.glofouling.persga.org
Publication (brochures /leaflets)
News items in website and YouTube channels


Other related activities
Arabic translation of the training course packages on the introduction of Biofouling management, the global guides and the outreach videos
IMO/KSA : Partnership to raise awareness of biofouling for women in Arab States
Regional workshop on Biofouling management to he held in March 2023
Web site: https://www.glofouling.persga.org
– Information about the GloFouling Partnerships Project
– Regional and national activities
– Project Results
– Photo gallery


شكراً
THANK YOU
Merci
PERSGA
www. persga. org
10

Recreational boating and its role as a secondary pathway for invasive aquatic species

MAR SANTOS-SIMON

PhD student

University of the Basque Country (Spain) and University of Pavia (Italy)

Mar Santos-Simón is a PhD student at the University of the Basque Country (Spain) and University of Pavia (Italy) currently working on the ecotoxicological and ecological effects of antifouling coatings. During her training, she was involved in different European institutions, such as the University of Ghent and the Royal Belgian Institute of Natural Sciences (Belgium), and also within the private sector, at Oceans of Energy (Netherlands). Now, with previous experience in taxonomy and environmental monitoring, she is eager to bring those research lines together to produce a useful tool not only in the academic context, but also socially valuable.

Assessment of the effectiveness of different antifouling solutions for recreational boats in the context of bioinvasions.

Mar Santos-Simón[1,2], Jasmine Ferrario[1], Beatriz Benaduce-Ortiz[3], Maren Ortiz-Zarragoitia[2], Agnese Marchini[1]. mar.santos@ehu.eus

[1]Università degli Studi di Pavia; [2]Universidad del País Vasco; [3]Universiteit Gent

In the Mediterranean Sea the recreational boating sector has shown to be a major vector for the introduction of non-indigenous species (NIS) via biofouling. To avoid the growth of these communities, different antifouling solutions are applied, usually accompanied with periodical cleaning of the hulls. Biocide-based coatings (BC) are the most widespread coatings and, despite their effectiveness, some compounds have proven to have adverse effects on the environment. Thus, new commercially available alternatives are being developed, including non-toxic solutions such as foul-release (FR) coatings, among others. The aim of the study was to test the effectiveness of two different antifouling solutions, simulating in a manipulative experiment the maintenance practices adopted by boaters. For this purpose, PVC panels treated with the above-mentioned coating typologies (BC-coated, FR-coated, and not coated: control) were submerged in two marinas of the Gulf of La Spezia (Italy). Samples were manually cleaned when and if required to add an experimental factor that simulates a common behaviour of Mediterranean boaters (maintenance and no maintenance: control), and finally collected at two different periods of submersion, corresponding to high and low boating season, here referred as T1 and T2. Panels were analysed in the lab to determine differences in biofouling community structure (sessile and mobile) in response to the different types of antifouling paint, maintenance habits and season, with a focus on NIS and initial colonizers.

Preliminary results of the sessile component of biofouling (primary colonisers) show significant differences among treatments in the short term (T1) as regards community structure, coverage and total biomass. However, these differences became blurry with time (T2). The bryozoan Watersipora subtorquata was identified as a biocide resistant organism that facilitates the attachment of other organisms. As regards the crustaceans, major components of the mobile community (secondary colonisers), the coating typology did not lead to significant differences among the communities in terms of community structure, but there was a clear tendency as regards maintenance, suggesting that it could be effective regardless the coating type. Still, in terms of diversity, BC coated panels showed significantly lower values compared to both FR and uncoated panels. Interestingly, these panels (BC coated) were dominated by the non-indigenous amphipod Laticorophium baconi. This dominance resulted in a lower diversity and higher NIS/native ratio for BC-coated panels, implying that BC coatings fail in controlling the NIS presence as some species, such as L. baconi, may have developed resistance to copper. FR coatings showed the same pattern as the uncoated controls, but easing the detachment or even self-cleaning by the fall-off of heavy fouling.

These results provide insights towards identification of best practices for boat maintenance and biofouling management.

Key words: biofouling, antifouling paints, manipulative experiment, non-indigenous species, recreational boats, management

Note: If interested in this presentation, it must be requested from the speaker.

JOHN ALONSO

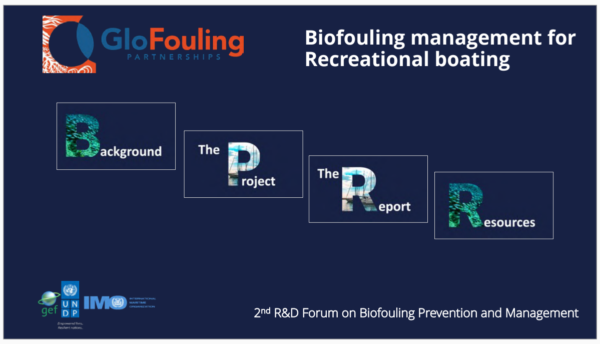
Project Technical Analyst

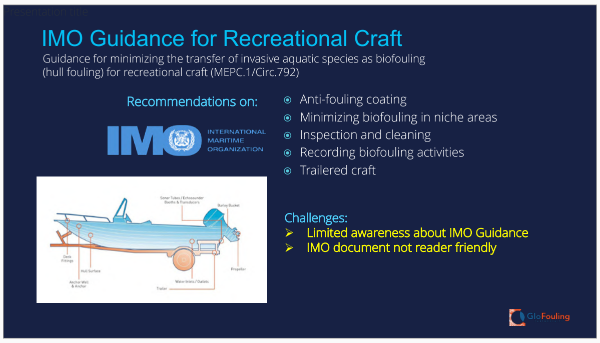
International Maritime Organization

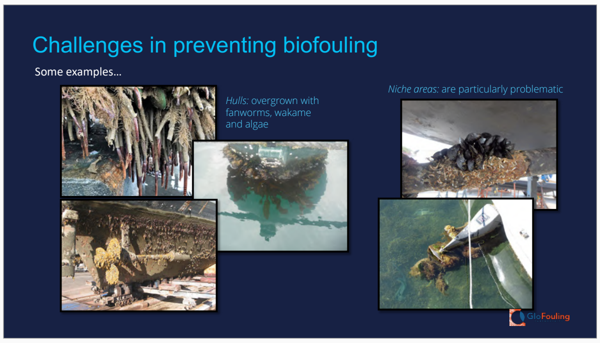
Mr. John Alonso has an academic background in Political Science, Development and Natural Resource Economics. He entered the International Maritime Organization (IMO) in 2011, later joining the GloBallast Partnerships, a capacity-building programme assisting developing countries to reduce the transfer of harmful aquatic organisms in ships' ballast water through the implementation of the Ballast Water Management Convention. During the next two years, John was part of the IMO team that led the design of the GloFouling Partnerships. The GloFouling Partnerships was finally launched in December 2018 and Mr. Alonso is currently the Project Technical Analyst.

Biofouling management for recreational boating

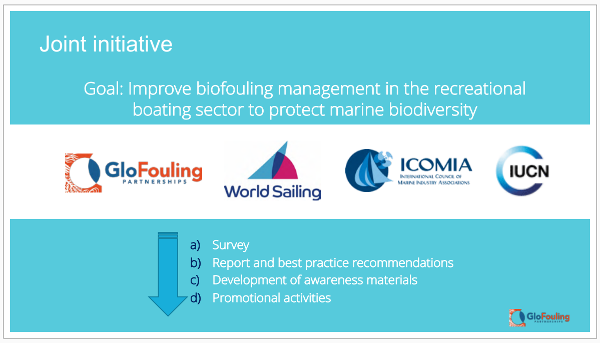
Presentation slides

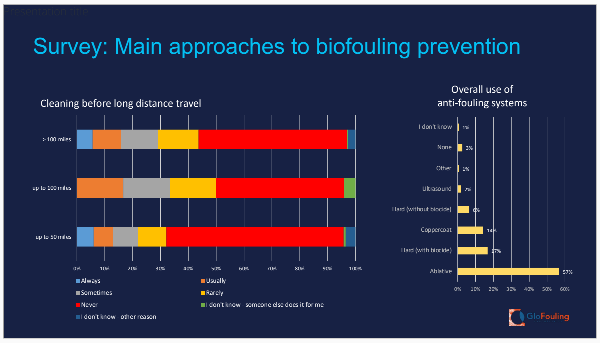


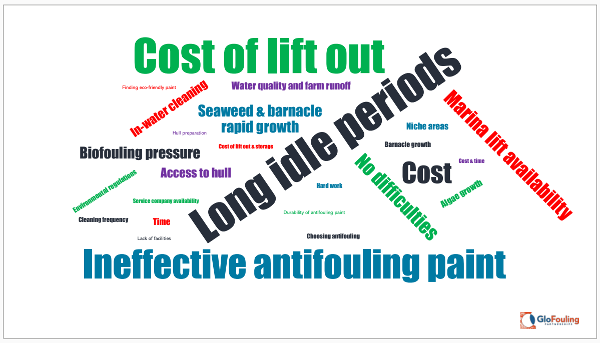

IMO Guidance for Recreational Craft
Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft (MEPC.1/Circ.792)
Recommendations on:
IMO INTERNATIONAL MARITIME ORGANIZATION
Anti-fouling coating
Minimizing biofouling in niche areas
Inspection and cleaning
Recording biofouling activities
Trailered craft
Challenges:
Limited awareness about IMO Guidance
IMO document not reader friendly
GloFouling

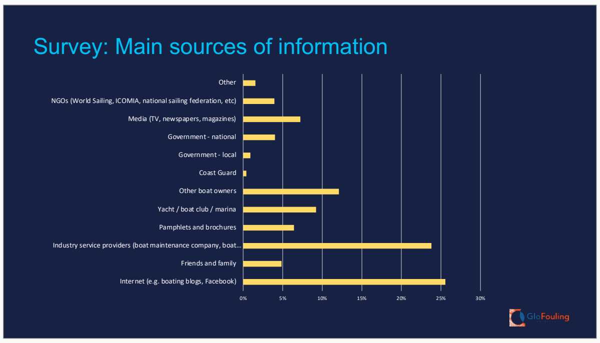

Challenges in preventing biofouling
Some examples...
Hulls: overgrown with fanworms, wakame and algae
Niche areas: are particularly problematic
GloFouling


The Project


Joint initiative
Goal: Improve biofouling management in the recreational boating sector to protect marine biodiversity
GloFouling PARTNERSHIPS
World Sailing
ICOMIA
IUCN
a) Survey
b) Report and best practice recommendations
c) Development of awareness materials
d) Promotional activities
GloFouling


Survey: Main approaches to biofouling prevention
Cleaning before long distance travel
> 100 miles
up to 100 miles
up to 50 miles
Always
Usually
Sometimes
Rarely
Never
I don't know - someone else does it for me
I don't know - other reason
Overall use of anti-fouling systems
I don't know
None
Other
Ultrasound
Hard (without biocide)
Copperoat
Hard (with biocide)
Ablative
GloFouling


Cost of lift out
Long idle periods
Marina lift availability
Seaweed & barnacle rapid growth
Water quality and farm runoff
In-water cleaning
Biofouling pressure
Access to hull
Niche areas
Barnacle growth
Cost
No difficulties
Algae growth
Time
Ineffective antifouling paint
GloFouling

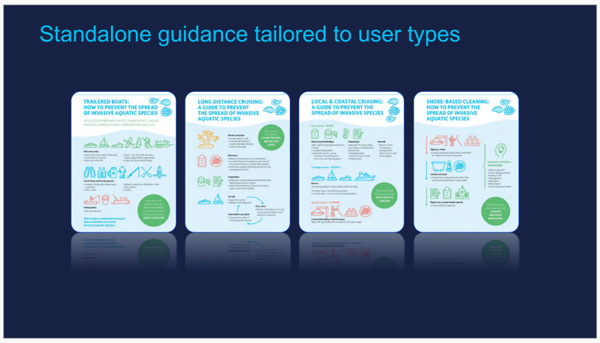

Survey: Main sources of information
Other
NGOs (World Sailing, ICOMIA, national sailing federation, etc)
Media (TV, newspapers, magazines)
Government - national
Government - local
Coast Guard
Other boat owners
Yacht / boat club / marina
Pamphlets and brochures
Industry service providers (boat maintenance company, boat...
Friends and family
Internet (e.g. boating blogs, Facebook)
0%
5%
10%
15%
20%
25%
30%
GloFouling

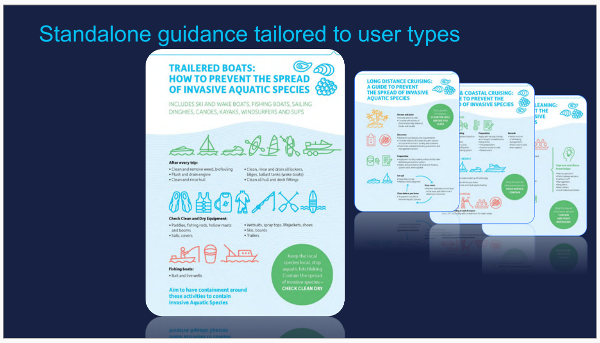

The Report

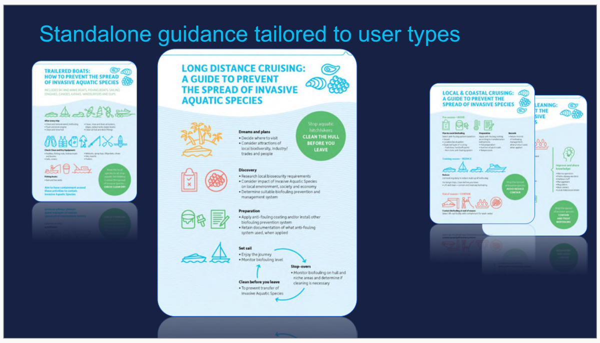

Contents of the report
Role of biofouling as pathway for IAS
Examples of IAS
Existing regulations applicable to biofouling
Key areas for managing biofouling
Overview of biofouling management solutions
Best practices
Links to further resources
Recommendations for engagement and awareness-raising
BIOFOULING MANAGEMENT FOR RECREATIONAL BOATING
Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species


Recommendations and best practice
Description of key areas that need special attention for the purpose of managing biofouling:
Long term afloat vessels
Trailered boats
Portable craft
Clothing
Shore-based infrastructure
Specific recommendations for the main types of recreational vessels:
Guidance for all users of trailer boats, including equipment, personal kit.
Guidance for yachts and motorboats – local coastal / estuary cruising
Guidance for longer distance cruising or deliveries - Yachts and motorboats.
Guidance for Marinas, boat wash down, slipways – boats and trailers
GloFouling


Resources


Standalone guidance tailored to user types


Standalone guidance tailored to user types
TRAILERED BOATS: HOW TO PREVENT THE SPREAD OF INVASIVE AQUATIC SPECIES

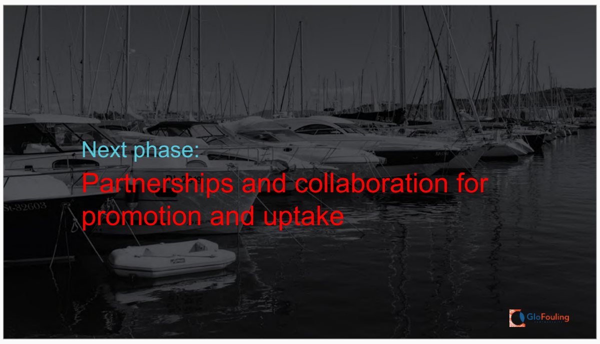

Standalone guidance tailored to user types
LONG DISTANCE CRUISING: A GUIDE TO PREVENT THE SPREAD OF INVASIVE AQUATIC SPECIES


Standalone guidance tailored to user types
LOCAL & COASTAL CRUISING: A GUIDE TO PREVENT THE SPREAD OF INVASIVE SPECIES


Standalone guidance tailored to user types
SHORE-BASED CLEANING: HOW TO PREVENT THE SPREAD OF INVASIVE AQUATIC SPECIES


GloFouling PARTNERSHIPS
HOME
THE PROJECT
THE ISSUE
PARTNERS
GIA
KNOWLEDGE
NEWS
Contact us
Project publications
Choose a link to view and download the publications
BACK to HUB
Biofouling Management for Recreational Boating. Recommendations to Prevent the Introduction and Spread of Invasive Aquatic Species
Published by GloFouling Partnerships. London, 2022.
Download in English


Other awareness materials already available
Short video
Webinar
https://youtu.be/n5KmEuWQBbs
Animation
Virtual reality


Next phase:
Partnerships and collaboration for promotion and uptake
GloFouling


GloFouling PARTNERSHIPS
Biofouling management for recreational boating
Thank you
For more information:
Web: www.glofouling.imo.org
Email: glofouling@imo.org
2nd R&D Forum on Biofouling Prevention and Management

EVANGELINA SCHWINDT

Director of the Coastal Environments Ecology Group (GEAC)

IBIOMAR-CONICET

Dr Evangelina Schwindt is the Director of the Coastal Environments Ecology Group (GEAC) at the IBIOMAR-CONICET. She currently focuses her research on patterns, processes and consequences of marine invasions. Understanding the importance of the prevention and monitoring programs, she also collaborates with national and regional governments in the management decision making process of biological invasions. She was a FAO consultant for the National Strategy for Invasive Exotic Species in Argentina and pool of experts for the second World Ocean Assessment. She serves as Coordinating Lead Author of the IPBES Assessment on Invasive Alien Species and a member Working Group on Biofouling Management (GESAMP).

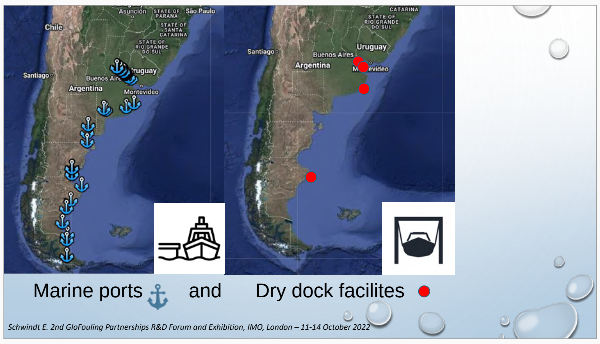
Alternative Hull biofouling management

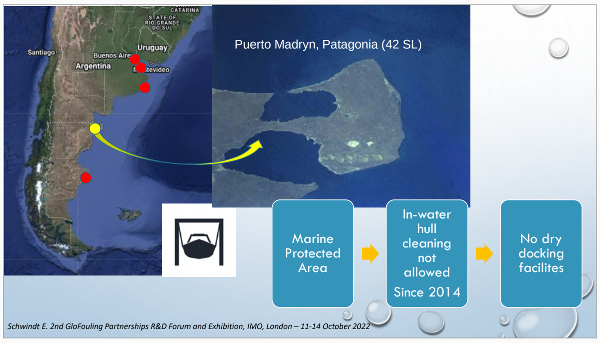
Karen L. Castro[1,2], Clara B Giachetti[1,2], Nicolas Battini[1,2], Alejandro Bortolus[1,3], Evangelina Schwindt[1,2,*]

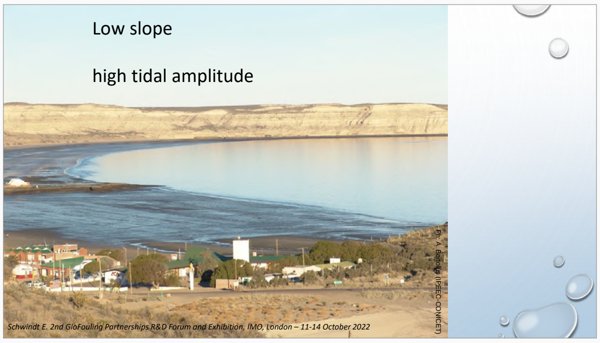
[1] Grupo de Ecología en Ambientes Costeros (GEAC)
[2] IBIOMAR-CONICET, Puerto Madryn, Argentina
[3] IPEEC-CONICET, Puerto Madryn, Argentina

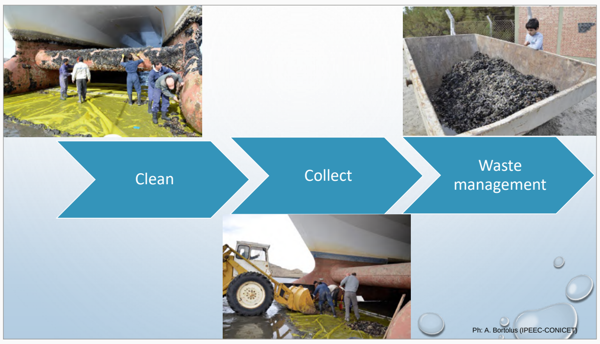
Recreational and many other small vessels favor the introduction and secondary spread of non native species. These vessels can accumulate and transport a high amount of and a diverse biofouling community. Despite this, in many regions, regulations are still inexistent and local shore-based facilities and capabilities are scarce. We present a pioneer case of alternative hull biofouling management. We designed and put into practice a method agreed among stakeholders (Prefectura Naval Argentina, provincial government and port administration) to manually clean a 35-meter-long catamaran, by beaching it in a macrotidal beach of Patagonia, Argentina. During the cleaning, all hull biofouling was removed, it was also collected to prevent organisms from falling on the beach and an appropriate waste management was carried on to avoid the re-entrance of the organisms to the shore. A total of 12.5 m3 of biofouling was deposited in landfill following regulations for fishing discard material. In addition, qualitative and quantitative fouling samples were obtained from different hull locations of the vessel, including niche areas. A total of 53 distinct taxa were identified, including 18 non native species for Argentina, 7 of which had not been previously reported for the study area. This hull fouling management strategy can be used as a convenient biosecurity method to remove hull biofouling from small and medium size vessels when other methods or facilities on the coast are not available. Our results also highlight the importance of cooperation among stakeholders and scientists, and also provide further evidence for the potential risk of recreational vessels as vectors for the secondary spread of marine non native species.

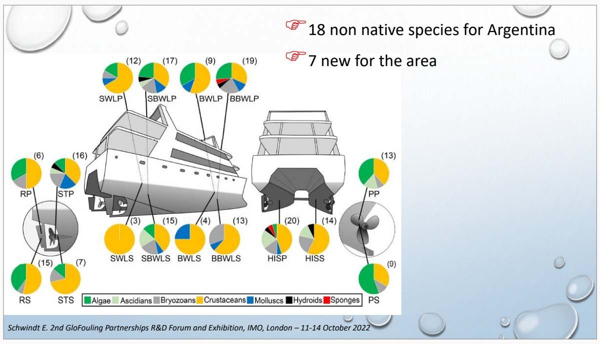
Presentation slides

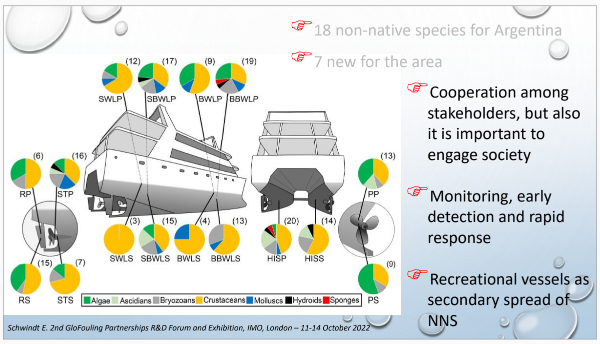


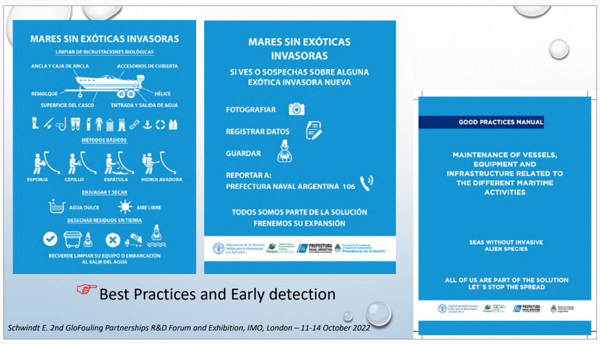












Global Industry Alliance (GIA) for Marine Biosafety: Private sector-led contributions to the global environment agenda

YUSIK KIM

GIA CHAIR

CEO at Tas Global Co., Ltd

CEO and founder of Tas Global Co., Ltd. and the chair of Global Industry Alliance of The GloFouling Partnerships project 2022.

Since its establishment in 2014, Tas Global has grown into World's Leading Company in Hull Cleaning Industry based on our innovative technology and service. we make new challenges, contribute to giving the trust of our customers, and finally protect nature and the environment.

Tas Global develops and manufactures the ROVs for underwater hull cleaning, inspection, class survey, propeller polishing, ship repairs, and underwater construction, and is also a chief researcher of the Glo Fouling R&D project (Korea, $14 million, with 7 National institutes, and 3 Universities). Presence in Singapore, expanding to EU, Middle East Asia, and South America by the end of 2022.

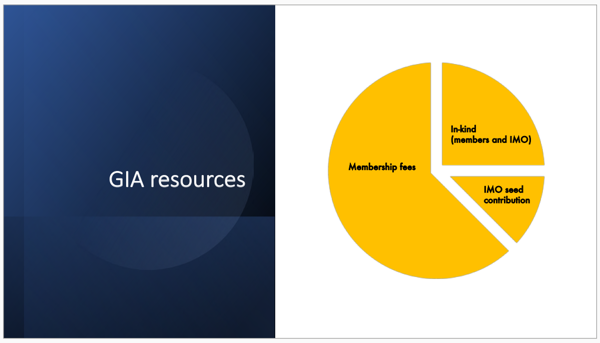
Global Industry Alliance (GIA) for Marine Biosafety: GIA objectives and achievements.

Presentation slides

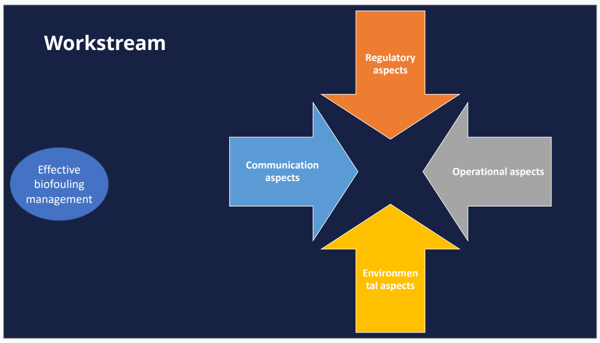

GIA formally established in June 2020
Launched on-line on the World Oceans Day (June 8 2020)
On World Oceans Day, IMO Launches Industry Partnership on Biofouling
Searching for ocean solutions with the private sector
UN entities and private sector join forces to tackle invasive species and reduce emissions

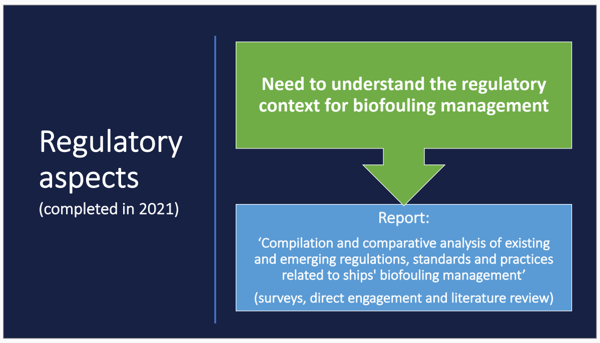

Membership (4 founding members)
In-water cleaning service providers
Marine Growth Preventive Systems
CleanSubSea
ecosubsea
HullWiper
SONIHULL

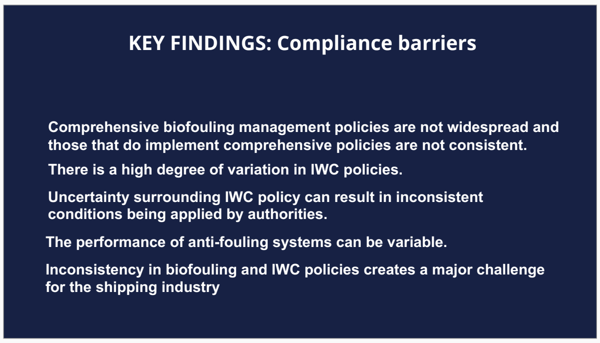

Membership 2022
AF coatings and paints
In-water cleaning service providers
Marine Growth Preventive Systems
Shipowners/ship operators
JSTRA Japan Ship Technology Research Association
AkzoNobel
KCC Marine Coatings
CleanSubSea
ecosubsea
HullWiper
SLM
TAS GLOBAL
SONIHULL
Hapag-Lloyd
Observers
IOGP International Association of Oil & Gas Producers


GIA resources
In-kind (members and IMO)
Membership fees
IMO seed contribution


Logo selected for the GIA
GloFouling
PARTNERSHIPS
Global Industry Alliance

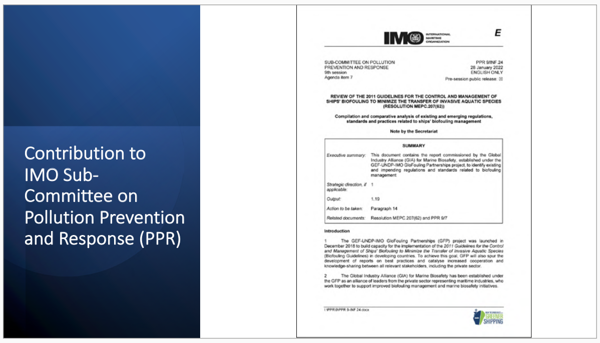

Workstream
Regulatory aspects
Effective biofouling management
Communication aspects
Operational aspects
Environmental aspects

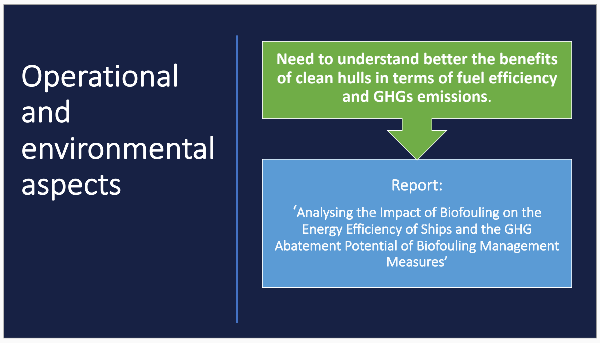

Regulatory aspects
(completed in 2021)
Need to understand the regulatory context for biofouling management
Report:
'Compilation and comparative analysis of existing and emerging regulations, standards and practices related to ships' biofouling management'
(surveys, direct engagement and literature review)

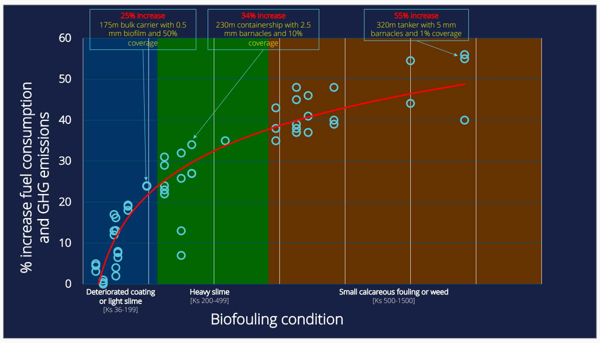

KEY FINDINGS: Compliance barriers
Comprehensive biofouling management policies are not widespread and those that do implement comprehensive policies are not consistent.
There is a high degree of variation in IWC policies.
Uncertainty surrounding IWC policy can result in inconsistent conditions being applied by authorities.
The performance of anti-fouling systems can be variable.
Inconsistency in biofouling and IWC policies creates a major challenge for the shipping industry

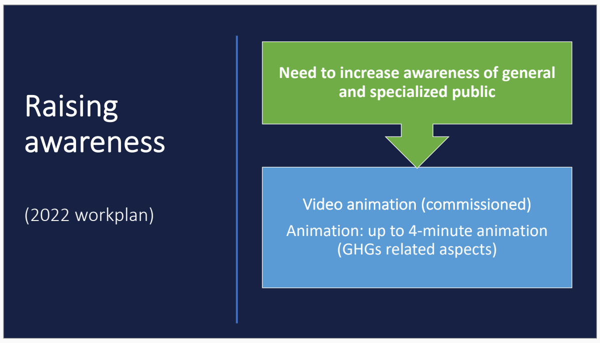

KEY FINDINGS: Policy needs
The review of the Biofouling Guidelines is critical to minimize variation in implementation of biofouling management and in-water cleaning policy.
There are barriers to the implementation of consistent and effective biofouling management policy that cannot necessarily be solved by the review of the Biofouling Guidelines.
Without an overarching international regulation or convention on biofouling management, inconsistencies will continue to occur.

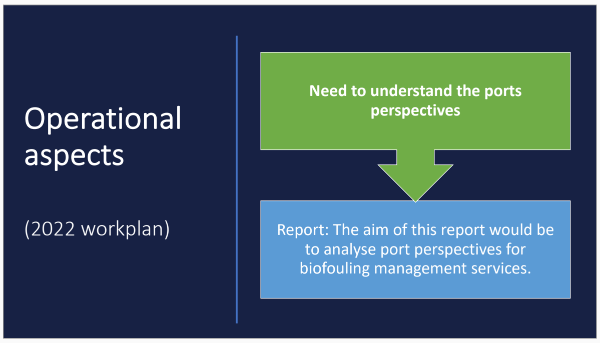

KEY RECOMMENDATIONS
.1
Complete the review of the Biofouling Guidelines to improve their specificity and in-water cleaning guidance
.2
Consider the development of a mandatory international instrument for biofouling, based on the revised Biofouling Guidelines
.3
Develop an internationally agreed IWC performance standard, methods for testing IWC system performance, and identify independent, expert approval bodies for testing IWC systems

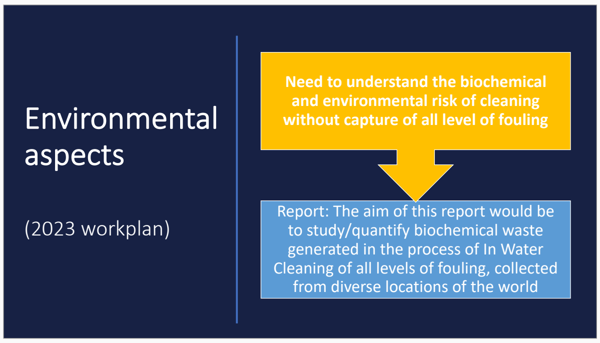

Contribution to IMO Sub-Committee on Pollution Prevention and Response (PPR)
IMO
E
SUMMARY

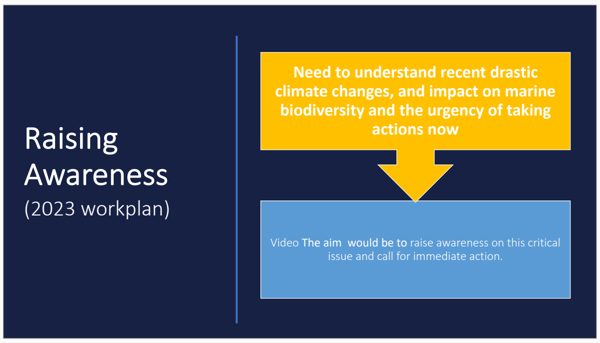

Operational and environmental aspects
Need to understand better the benefits of clean hulls in terms of fuel efficiency and GHGs emissions.
Report:
'Analysing the Impact of Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures'

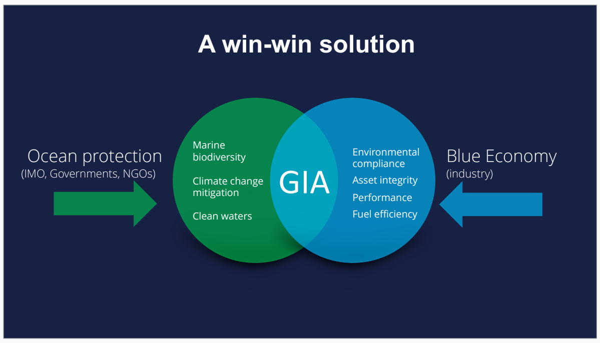

% increase fuel consumption and GHG emissions
60
50
40
30
20
10
0
Deteriorated coating or light slime
Heavy slime
Small calcareous fouling or weed
Biofouling condition


Raising awareness
(2022 workplan)
Need to increase awareness of general and specialized public
Video animation (commissioned)
Animation: up to 4-minute animation (GHGs related aspects)


Operational aspects
(2022 workplan)
Need to understand the ports perspectives
Report: The aim of this report would be to analyse port perspectives for biofouling management services.


Environmental aspects
(2023 workplan)
Need to understand the biochemical and environmental risk of cleaning without capture of all level of fouling
Report: The aim of this report would be to study/quantify biochemical waste generated in the process of In Water Cleaning of all levels of fouling, collected from diverse locations of the world


Raising Awareness
(2023 workplan)
Need to understand recent drastic climate changes, and impact on marine biodiversity and the urgency of taking actions now
Video The aim would be to raise awareness on this critical issue and call for immediate action.


A win-win solution
Ocean protection
(IMO, Governments, NGOs)
Marine biodiversity
Climate change mitigation
Clean waters
GIA
Environmental compliance
Asset integrity
Performance
Fuel efficiency
Blue Economy
(industry)


GloFouling
PARTNERSHIPS
Thank you
For more information
website: www.glofouling.imo.org
Email: glofouling@imo.org
For our latest news, follow us on:

SESSION 11 (PART 1)

Biofouling management and fuel efficiency – Understanding the potential for GHG emissions savings

CAMILLE BOURGEON

Technical Officer. MED: Sub-Division for Protective Measures

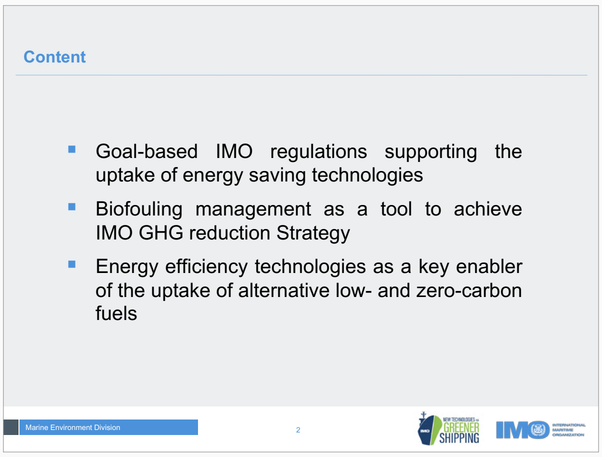
International Maritime Organization

Since 2017, Mr. Camille Bourgeon has been working in the Marine Environment Division of the International Maritime Organization (IMO) to support IMO's action to reduce greenhouse gas emissions from shipping. In his role, he assists in particular intergovernmental negotiations dealing with regulatory issues related to Annex VI of the MARPOL Convention.

Before joining IMO, he performed operational management functions in the French Maritime Affairs Directorate (Ministry of Transport), dealing with safety of navigation, search and rescue and prevention of pollution from ships.

Biofouling management as a tool to achieve IMO GHG reduction strategy

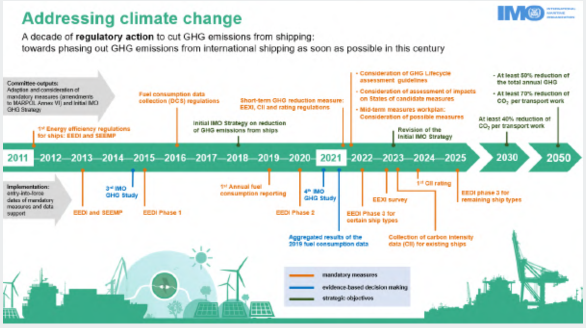
Presentation slides



Goal-based IMO regulations supporting the uptake of energy saving technologies

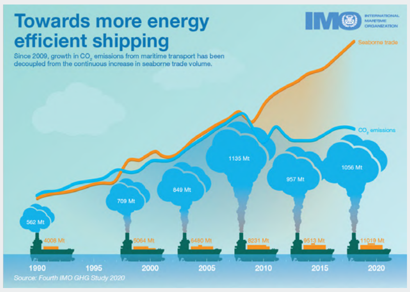
Marine Environment Division

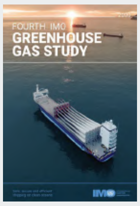
GHG reduction: A decade (2011-2021) of mandatory IMO energy-efficiency requirements in MARPOL



Marine Environment Division 4

Since 2009, CO_2 emissions from international shipping have been decoupled from the growth in seaborne trade





Downloadable from the IMO website

Shipping's total share of global emissions in 2018: 2.89% (up from 2.76% in 2012)

Marine Environment Division 5

2018 Initial IMO GHG Strategy

Vision

- To **phase out GHG emissions** from international shipping as soon as possible in this century

Levels of ambitions

- continue to **strengthen the energy efficiency design requirements** for ships
- **reduce CO_2 emissions per transport work by at least 40% by 2030**, pursuing efforts towards 70% by 2050, compared to 2008
- **peak** GHG emissions from international shipping as soon as possible, and to **reduce the total annual GHG emissions by at least 50% by 2050** compared to 2008

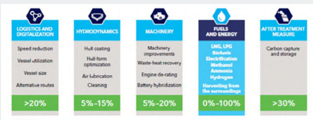
Other key elements

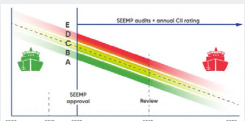
- **Impacts on States** of candidate measures to be assessed before adoption
- Initial Strategy to be **revised by 2023**

Marine Environment Division 6

Short-term GHG reduction measures driving innovation

- **Increasingly stringent requirements** carbon intensity reduction requirements aiming to reduce 40% carbon intensity reduction of global fleet by 2030
- **Mandatory annual goal-based reduction requirements (EEXI/CII):** leaving **compliance flexibility** to owner/operator
- The annual **CII rating (A – E)** calculated on the basis of **actual fuel consumption** is an important tool for the maritime value chain (ports, charterers, financial sector) to **provide incentives**
- Entry-into-force by **1 November 2022**; to be reviewed by 2026





Marine Environment Division 7

Biofouling management as a tool to achieve IMO GHG reduction Strategy

Marine Environment Division

Estimated penetration rate and contribution of selected technologies in the total amount of CO_2 reduction in shipping in 2030 and 2050

Source: ***Fourth IMO GHG Study 2020*****, updated Marginal Abatement Cost Curves**

Technology group	Penetration rate (2018)	Penetration rate (2030)	CO_2 abatement potential (2030)	Penetration rate (2050)	CO_2 abatement potential (2050)
Low-friction hull coating	12.5%	17.5 to 66.5%	0.15 to 1.48%	42.5 to 100%	0.83 to 2.55%
Hull performance monitoring	12.5%	17.5 to 66.5%	0.22 to 2.22%	42.5 to 100%	1.24 to 3.90%
Hull brushing	12.5%	17.5 to 66.5%	0.22 to 2.22%	42.5 to 100%	1.24 to 3.90%
Hull hydro-blasting	12.5%	17.5 to 66.5%	0.22 to 2.22%	42.5 to 100%	1.24 to 3.90%
Dry-dock full blast (old ships)	50%	55 to 100%	0.22 to 2.22%	80 to 100%	1.24 to 3.90%

Marine Environment Division 9

Results of a recent case study

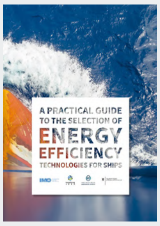
	Total CO_2 emission	Difference compared to *'No cleaning'*	%	Difference compared to *'Always clean'*	%
No cleaning	145,043 t	N/A	N/A	31,796 t	22%
Hull cleaning	129,798 t	-15,245 t	-12%	16,551 t	13%
Propeller Cleaning	143,936 t	-1,107 t	-1%	30,688 t	21%
Hull & prop. Cleaning	129,549 t	-15,494 t	-12%	16,301 t	13%
Ultrasonic antifouling for prop.	142,754 t	-2,289 t	-2%	29,506 t	21%
Hull cleaning + Ultrasonic antifouling for propeller	128,720 t	-16,323 t	-13%	15,473 t	12%
Pro-active cleaning (hull & propeller)	118,425 t	-26,618 t	-22%	5,177 t	4%
Always clean	113,248 t	-31,796 t	-28%	N/A	N/A

Source: GEF-UNDP-IMO GloFouling Partnerships Project and GIA for Marine Biosafety, 2022, *Analysing the Impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures*, Table 17, Difference in the total CO_2 emission with different anti-fouling scenarios (Mediterranean region)

Marine Environment Division 10

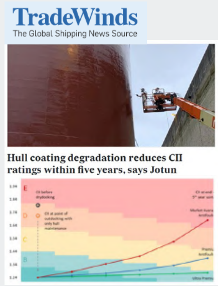
Results of a recent case study

- "A layer of slime as thin as 0.5 mm covering up to 50% of a hull surface can trigger an increase of GHG emissions in the range of 20 to 25%, depending on ship characteristics, speed and other prevailing conditions."
- Key takeaway: **the increase in fuel consumption caused by biofouling exceeds by far the typical improvements that can be achieved through the retrofitting of Energy Efficiency Technologies**
- Recent *Practical guide to the selection of energy efficiency technologies for ships* developed under the Global Industry Alliance (GIA) https://greenvoyage2050.imo.org/download-publications/



Marine Environment Division 11

Role of biofouling management in achieving higher CII rating



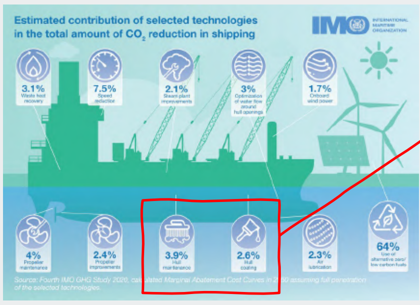
Lloyd's List
Make a CII plan before it is too late, LR warns

riviera
Advanced hull coatings help meet emissions regulations

Ship & Bunker
Vessels Using Hull Performance Solutions See 20% Lower Carbon Intensity: Report

Marine Environment Division 12

Estimated contribution of selected technologies in the total amount of CO_2 reduction in shipping in 2050 (full penetration scenario)



In this scenario, **hull maintenance** and **hull coating** are expected to represent **up to 3.9% and 2.6%** of the overall CO_2 reduction effort in shipping

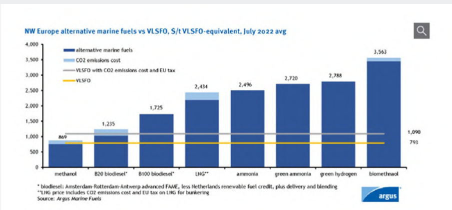
Marine Environment Division 13

Energy efficiency technologies as a key enabler of the uptake of alternative low- and zero-carbon fuels

Marine Environment Division

Role of biofouling management in the context of future GHG regulations

Expected higher price of low/zero carbon alternative fuels makes energy-saving efforts even more important



Marine Environment Division 15

Important work underway at IMO to enable the uptake of low- and zero-carbon marine fuels

- Creating a global level-playing-field that leaves nobody behind
- Supporting first-movers whilst avoiding stranded assets
- Supporting further confidence among all IMO Member States and industry

.1 A strengthened **revised IMO GHG Strategy** setting out the reduction pathways to decarbonize international shipping

.2 **IMO Lifecycle GHG assessment (LCA) guidelines** identifying "well-to-wake" carbon content of alternative low-carbon marine fuels

.3 **Safety framework** to allow for safe use of alternative marine fuels (hydrogen, ammonia, etc.)

.4 **Mid-term GHG reduction measures**, incl. possible **MBMs**, to incentivize the uptake of low/zero carbon alternative fuels

Marine Environment Division 16

Achieving the 2050 level of ambition: Work plan on the development of mid- and long-term GHG reduction measures

Work plan adopted by MEPC 76

Phase I (spring 2021 - spring 2022)

Collation and initial consideration of proposals for measures
- main characteristics, features and scope of application
- emissions reduction potential
- major implications (technical, operational, costs…)
- implementation and enforcement aspects

Phase II (spring 2022 - spring 2023)

Assessment and selection of measures(s) to further develop
- feasibility, effectiveness, impacts on States

Phase III (spring 2023 - dates tbd)

Development of(a) measure(s) to be finalized within (an) agreed target date(s)

Marine Environment Division 17

Proposals for mid- and long-term measures

- To be discussed during ISWG-GHG 13 and MEPC 79
- Proposals for mid-term measures:

technical measures (enhancing the CII framework, GHG fuel standard, etc.)

economic measures (carbon pricing/MBM, IMRB/F, IMRS&F, ZEV incentive scheme, buy-down programmes, etc.)

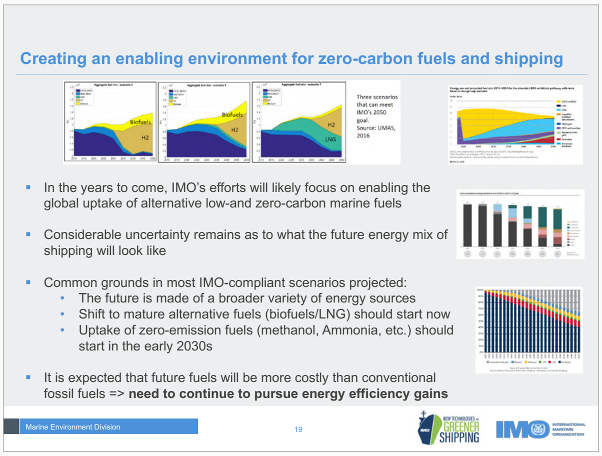
possible **combination** of proposed measures

how to ensure a **fair and equitable transition** (disbursement of carbon revenues, phased/differentiated implementation, corridors, alternative methods of compliance, technology cooperation/transfer, etc.)

including **review** and/or **adjustment mechanisms** in a possible combination/basket of measures

- Towards a possible "**basket of measures**"

Marine Environment Division 18


Creating an enabling environment for zero-carbon fuels and shipping
Biofuels
H2
Biofuels
H2
H2
LNG
Three scenarios that can meet IMO's 2050 goal.
Source: UMAS, 2016
In the years to come, IMO's efforts will likely focus on enabling the global uptake of alternative low-and zero-carbon marine fuels
Considerable uncertainty remains as to what the future energy mix of shipping will look like
Common grounds in most IMO-compliant scenarios projected:
The future is made of a broader variety of energy sources
Shift to mature alternative fuels (biofuels/LNG) should start now
Uptake of zero-emission fuels (methanol, Ammonia, etc.) should start in the early 2030s
It is expected that future fuels will be more costly than conventional fossil fuels => need to continue to pursue energy efficiency gains
Marine Environment Division
19
NEW TECHNOLOGIES for GREENER SHIPPING
IMO INTERNATIONAL MARITIME ORGANIZATION


Revision of the IMO GHG Strategy
The Initial IMO GHG Strategy envisages the adoption of a Revised Strategy in spring 2023
MEPC 77 (November 2021) recognized the need to strengthen the ambition of the Initial Strategy and agreed to initiate the revision of the Initial Strategy with a view to adoption of a Revised Strategy by MEPC 80 in July 2023
MEPC 79 (December 2022) will consider submissions from a wide range of Government and non-governmental organizations
Marine Environment Division
20
NEW TECHNOLOGIES for GREENER SHIPPING
IMO INTERNATIONAL MARITIME ORGANIZATION


Thank you for your attention
IMO INTERNATIONAL MARITIME ORGANIZATION

JOHN ALONSO

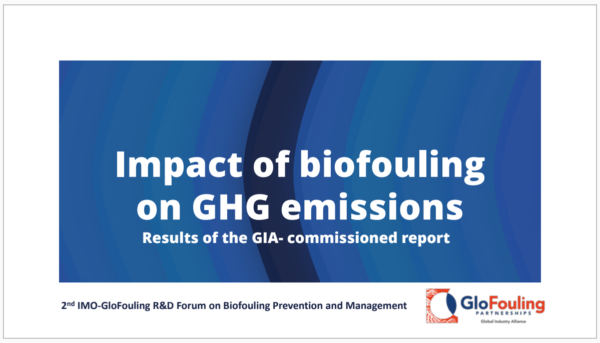
Project Technical Analyst

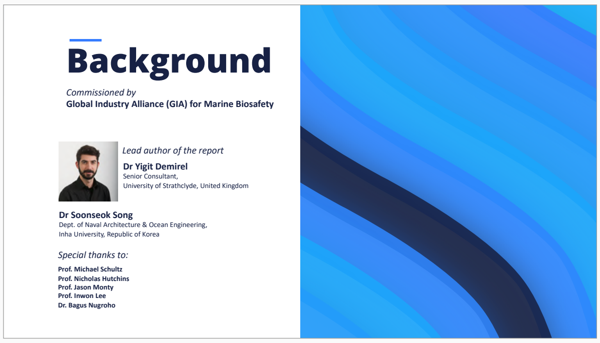
International Maritime Organization

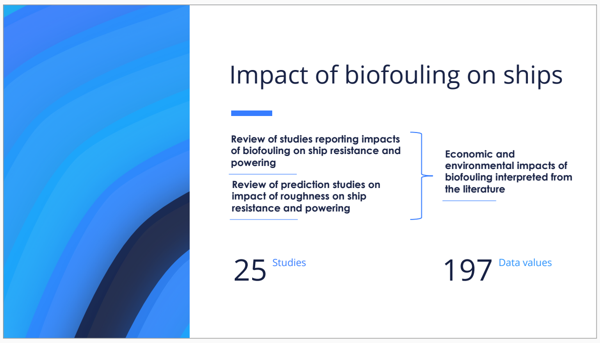
Mr. John Alonso has an academic background in Political Science, Development and Natural Resource Economics. He entered the International Maritime Organization (IMO) in 2011, later joining the GloBallast Partnerships, a capacity-building programme assisting developing countries to reduce the transfer of harmful aquatic organisms in ships' ballast water through the implementation of the Ballast Water Management Convention. During the next two years, John was part of the IMO team that led the design of the GloFouling Partnerships. The GloFouling Partnerships was finally launched in December 2018 and Mr. Alonso is currently the Project Technical Analyst.

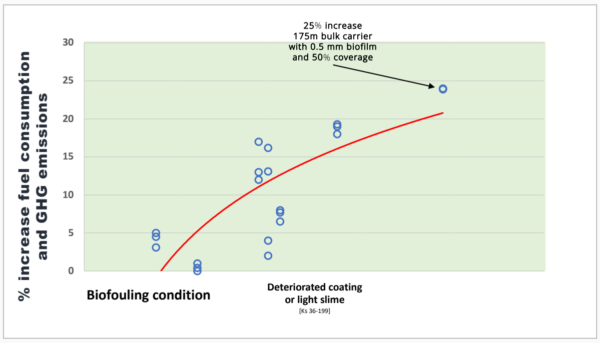
Report on the impact of biofouling on GHG emissions.

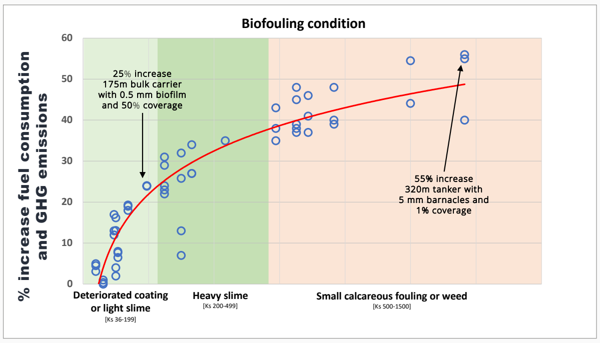
Presentation slides



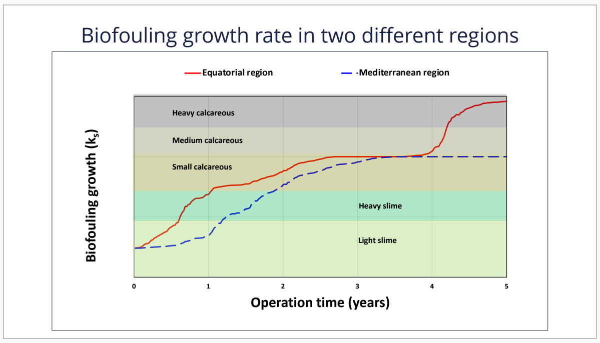


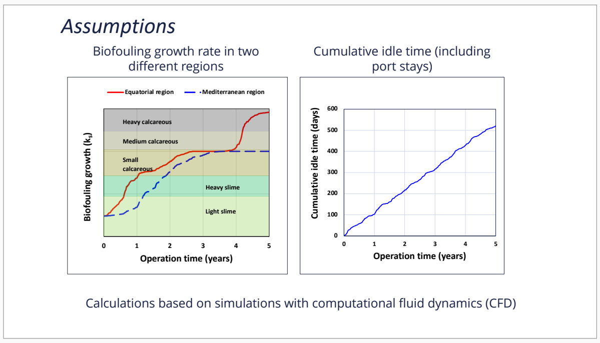

Impact of biofouling on ships
Review of studies reporting impacts of biofouling on ship resistance and powering
Review of prediction studies on impact of roughness on ship resistance and powering
Economic and environmental impacts of biofouling interpreted from the literature
25 Studies
197 Data values

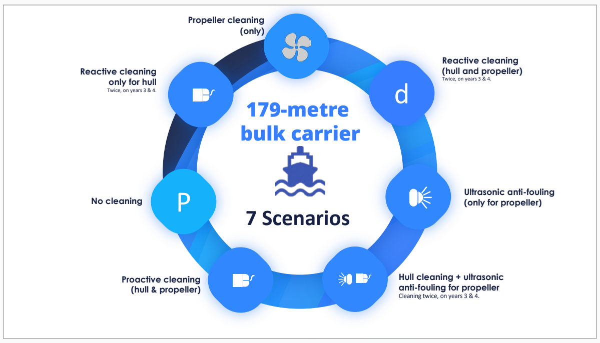

% increase fuel consumption and GHG emissions
25% increase
175m bulk carrier
with 0.5 mm biofilm
and 50% coverage
Biofouling condition
Deteriorated coating
or light slime

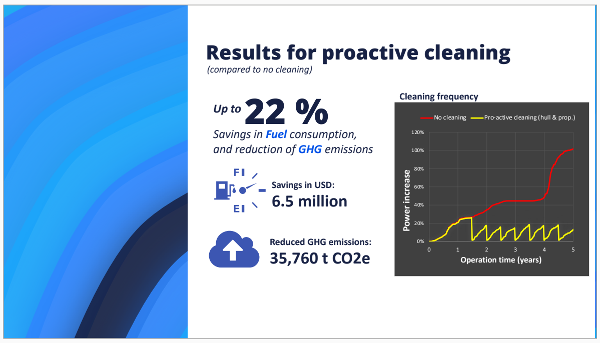

Biofouling condition
% increase fuel consumption and GHG emissions
25% increase
175m bulk carrier
with 0.5 mm biofilm
and 50% coverage
55% increase
320m tanker with
5 mm barnacles and
1% coverage
Deteriorated coating
or light slime
Heavy slime
Small calcareous fouling or weed

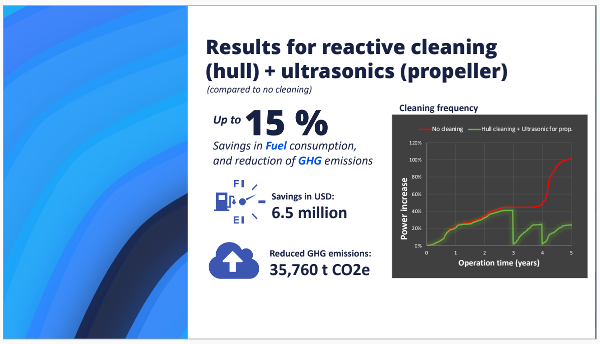

Biofouling
prevention
and management
measures
Assumptions

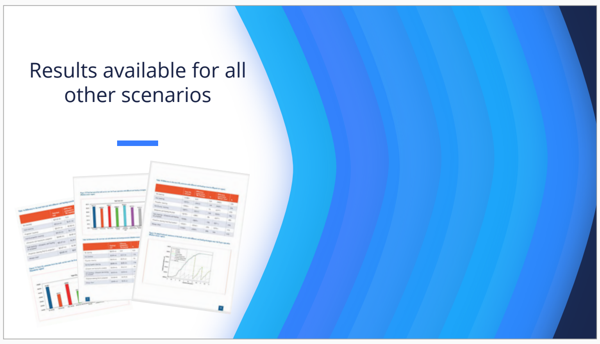

Biofouling growth rate in two different regions
Equatorial region
Mediterranean region
Heavy calcareous
Medium calcareous
Small calcareous
Heavy slime
Light slime
Biofouling growth (k_s)
Operation time (years)


Assumptions
Biofouling growth rate in two different regions
Cumulative idle time (including port stays)
Operation time (years)
Cumulative idle time (days)
Calculations based on simulations with computational fluid dynamics (CFD)


Propeller cleaning (only)
Reactive cleaning (hull and propeller)
Ultrasonic anti-fouling (only for propeller)
Hull cleaning + ultrasonic anti-fouling for propeller
Proactive cleaning (hull & propeller)
No cleaning
Reactive cleaning only for hull
179-metre bulk carrier
7 Scenarios


Results for proactive cleaning
(compared to no cleaning)
Up to 22 %
Savings in Fuel consumption, and reduction of GHG emissions
Savings in USD:
6.5 million
Reduced GHG emissions:
35,760 t CO2e
Cleaning frequency
No cleaning
Pro-active cleaning (hull & prop.)
Power increase
Operation time (years)


Results for reactive cleaning (hull) + ultrasonics (propeller)
(compared to no cleaning)
Up to 15 %
Savings in Fuel consumption, and reduction of GHG emissions
Savings in USD:
6.5 million
Reduced GHG emissions:
35,760 t CO2e
Cleaning frequency
No cleaning
Hull cleaning + Ultrasonic for prop.
Power increase
Operation time (years)


Results available for all other scenarios

STEPHEN RILEY

Global Marine Technical Sales & Support Manager

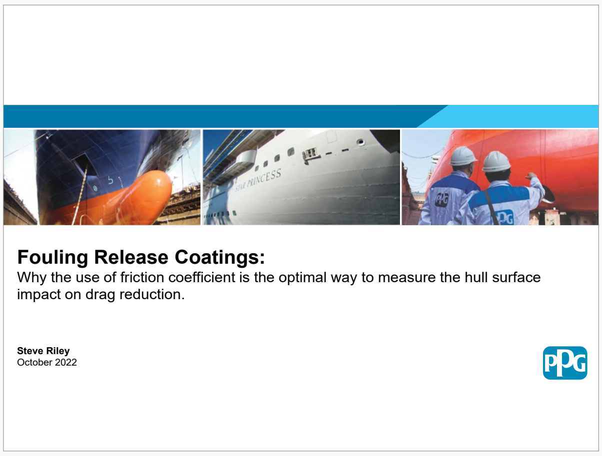
PPG PMC

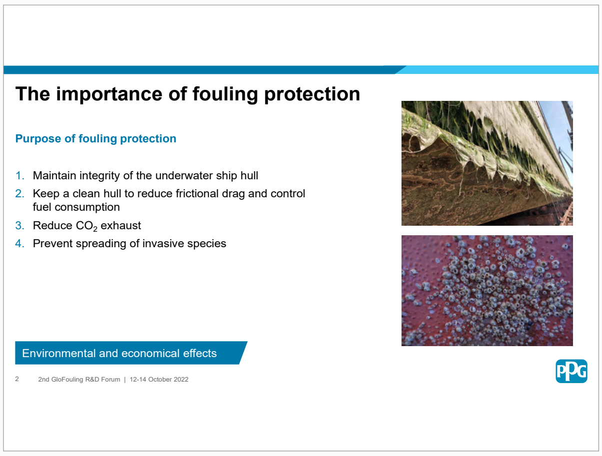
Steve started this role in April 2021 to date. Prior to this, Steve held various positions, including Marine Technical Sales & Support Manager, EMEA for 12 years. Before that he was involved in a Sales role with Key Account responsibilities for the North of England having joined the organization in 2002. Steve graduated from Newcastle-upon-Tyne Polytechnic in 1985 with a BSc (Hons) Applied Chemistry. He immediately started work in the laboratory developing anti-fouling coatings, he moved into a Technical Service role and then on to Sales role before leaving. For the next 10 years he undertook various sales, marketing and training roles within the Industrial Flooring market before returning to the Marine Industry in 2002.

Fouling release coatings: why the use of friction coefficient is the optimal way to measure the hull surface impact on drag reduction.

The negative impact of the biofouling of ship hulls is massive. It adds to the total weight of the vessel and causes hull roughness which increases frictional drag. Therefore, hull roughness is an important parameter in predicting fuel consumption related to biofouling. Rt(50) is a generally accepted parameter when measuring ship's hull profile but it is incomplete to describe the complexity of coated hulls and to calculate their frictional resistance. With this paper we intend to show why it is incomplete as critical parameters such as surface properties, surface energy, texture and waviness of the biofouling release coating are disregarded. It has been shown that fouling release coatings have lower drag resistance than self-polishing antifouling coatings due to their texture and surface characteristics, i.e., low surface energy and high elastic modulus. Therefore, calculating the friction coefficient should be the most comprehensive method to determine the frictional resistance of coated surfaces since it includes other relevant surface characteristics in addition to hull roughness. The outcome of these measurements can be further used for CFD calculations to estimate the hydrodynamic resistance of a ship's hull coated with fouling control coatings

Presentation slides





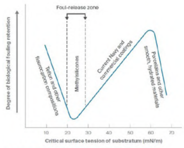
Fouling Release

Release effect achieved with low surface energy, high elasticity and smooth surface

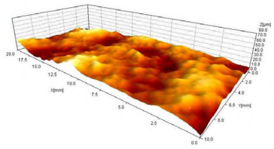
Balance between sufficient elasticity and surface character

Fouling Release

Release effect achieved with low surface energy, high elasticity and smooth surface



Graph 2: Surface behavior of biomaterials: The theta surface for biocompatibility" R.E. Baier, 2006, supports that silicone is the optimal combination of low surface energy and elasticity.



Balance between sufficient elasticity and surface character

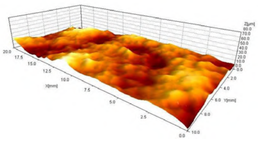
Hull roughness

1. Hull roughness is an important parameter in influencing fuel consumption related to biofouling.
2. Rt(50) is an accepted parameter when measuring ship's hull profile but incomplete
   a. to describe the complexity of coated hulls and
   b. to calculate their frictional resistance.
3. Incomplete because it disregards critical parameters such as surface properties, surface energy, texture and waviness of the coating.

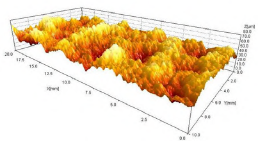
Hull roughness is important but insufficient by itself

Fouling Release vs Antifouling

Wavy surface of fouling release



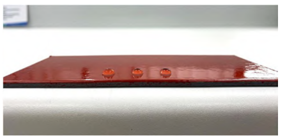
Spiky surface of antifouling



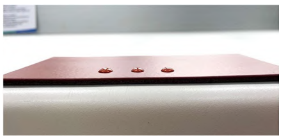
Difference in surface topography should be included in frictional resistance predictions

Fouling Release vs Antifouling

Low surface energy of fouling release



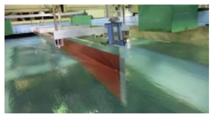
High surface energy of antifouling



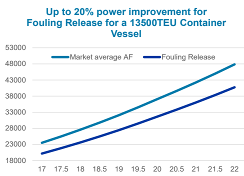
Surface character should be included in frictional resistance predictions

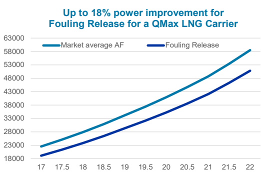
Friction coefficient

1. There are several experimental techniques to measure frictional resistance:
   a. flow measurements on a flat plate in a water channel or tube, or
   b. torque measurements on rotating discs
2. The friction coefficient can be then defined in line with International Towing Tank Conference (ITTC)
3. The outcome of these measurements can be further used for CFD calculations to estimate the hydrodynamic resistance of a ship's hull coated with specific fouling control products



Fouling Release:
EEXI contribution with up to 20% instant power savings*





*following CFD analysis as per EEXI guidelines at scantling draught for different ship models

Summary

1. Fouling Release coatings have lower drag resistance than self-polishing Antifouling coatings due to their texture and surface characteristics.
2. Friction coefficient includes relevant surface characteristics in addition to hull roughness.
3. Friction coefficient is the most comprehensive method to determine the frictional resistance of coated surfaces.

JEAN PRUDHOMME

Defence Equipment Attaché

Embassy of France in the United Kingdom

Colonel (Armament) Jean Prudhomme has been appointed Defence Equipment Attaché at the Embassy of France in the United Kingdom from September 2022. After his engineering studies in Paris, he began working in the French Navy, on the maintenance of ships in their Brittany naval base.

From 2010 to 2019, he was assigned, within the French Defence Procurement Agency (DGA), to three successive positions as programme director in the naval sector, covering preparation, development, production and delivery phases. Before his current appointment, he was heading the technical division of the French Navy In-Service Support directorate.

Results of an in-water hull cleaning programme of the French Navy's aircraft-carrier Charles de Gaulle

Presentation slides

Context

How to balance operational performance, in-service support costs, energy saving and environmental requirements?

Experimentation on French Navy's aircraft-carrier flagship:

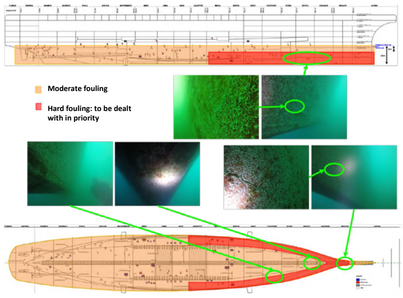
- **expensive high-performance coating: > 10-year duration (hull corrosion protection);**
- **fouling proliferation issue:**
  - comprehensive checks during yearly maintenance periods;
  - divers cleaning in harbour: practical difficulties (dry-docking only every 5 yrs);
  - warming waters and peculiar long-duration station in Toulon harbour in 2020;
- **alteration of propulsive performance measured in 2021, consistent with hull dirtiness.**

After experienced-based advice from the Royal Navy, project team set up: crew members, Toulon Naval Base, industries (Naval Group + ECOsubsea), Fleet Support Service.

Scope definition

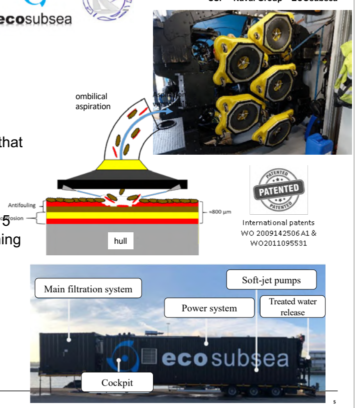
Divers' measurements show strong hull fouling especially forward

All things being equal, fouling deemed to be a major contributor to propulsive performance lowering



ECOsubsea robot

- Robot equipped with 5 cleaning heads with a patented solution that combines hydrodynamic and vacuum forces.
- Each cleaning head consists of 5 soft jet nozzles: adequate cleaning of the coating to avoid being aggressive.
- 3-level filtration :
  - 60m, 20m, 1m;
  - UV treatment.



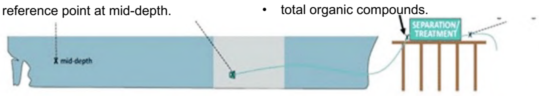
Assessment of environmental risks

Comparative measurements:

- at the cleaning point;
- at the release point;
- reference point at mid-depth.

Analysis of:

- overall metallic particles (iron, zinc, copper, tin);
- total suspended solids;
- total organic compounds.



15 samples analysed; 13 sent to a COFRAC certified laboratory:

- at cleaning point: no pollution measured;
- at release point:
  - 2/13 copper measurements exceeding threshold (5 mg/L);
  - 1/13 suspended solids measurements exceeding threshold (100 mg/L);

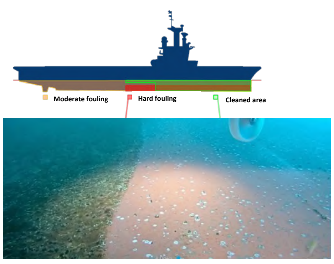
Results deemed very satisfactory by Industry & FR Navy.

Hull cleaning results

Impressive visual improvement of cleaned areas (see picture).

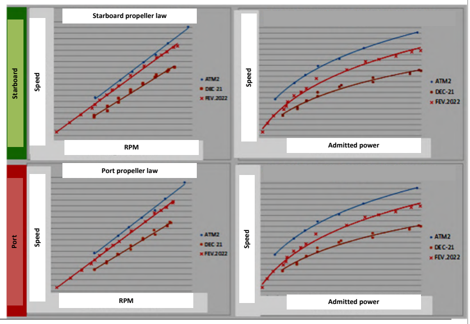
Thickness measurement campaign:

- > 130 measurement points;
- residual thickness greater than the required thickness => no degradation of the antifouling layer.



Propulsion performance results

Significant performance improvement, even though only most-dirty 30% of hull surface treated because of schedule constraints:



Conclusion

Experiment considered as a success on all counts:

- technical & operational performance significant improvement;
- fuel-consumption lowering;
- no coating aggression;
- no environmental side-effect.

Cleaning carried-out in April 2022 on FREMM (destroyer) *Provence* and extended on the majority of remaining parts of aircraft-carrier *Charles de Gaulle* in September 2022.

Update of fouling-treatment policy under consideration for the FR Navy's combat vessels.

MARKUS HOFFMAN

Technical Director

I-Tech AB

Dr Hoffmann joined I-Tech in 2019 in the role of Technical Director following great successes achieved over an eight-year period in the role of Subject Matter Expert Antifouling and R&D Department Manager of Hempel's Antifouling Global Center of Excellence in Barcelona. Earlier in his career, Dr Hoffmann held the post of Team Manager in the specialty chemicals research center at BASF in Ludwigshafen. His academic qualifications include a PhD in organic chemistry from JMU of Würzburg, Germany and a post-doc position at Kyoto University, Japan.

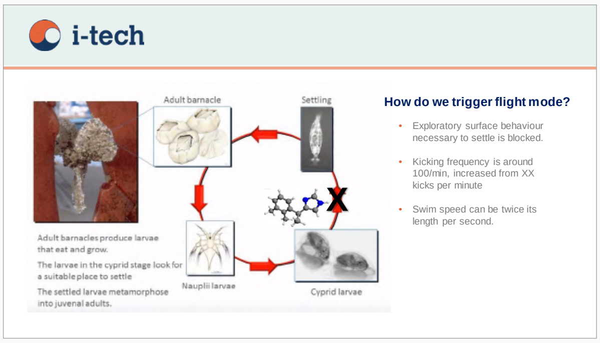
The Impact of 'Fouling Idling' on the Decarbonisation of the Global Shipping Fleet.

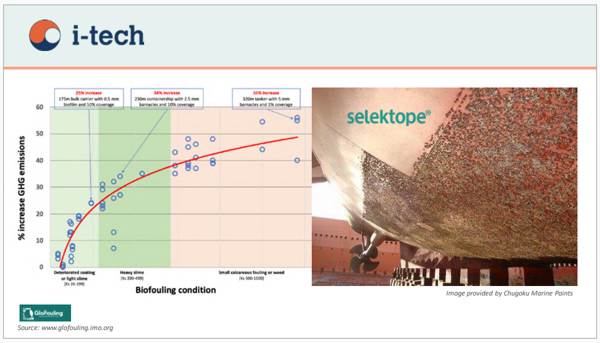
On January 1, 2023, the International Maritime Organization (IMO) will introduce the Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) measures for every ship above 5,000gt in size as a means to reduce carbon emissions from international shipping. In particular, the CII, as an operational index, will be impacted by biofouling load on the underwater hull surface.

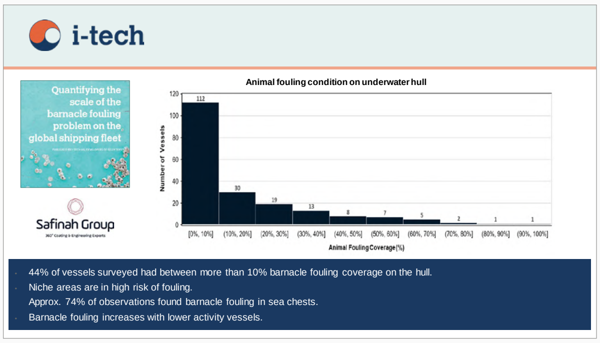
This paper explores the connection between biofouling and ship efficiency. It also presents the key findings and conclusions drawn from I-Tech's extensive research into global fleet idling over the period 2010 to 2020. The focus of this study was to look at vessels where idling resulted in high fouling risk in particular. I-Tech calls this 'fouling idling'   The results of this study gave novel insight into idling trends between industry sectors, quantifying the true level of idling in the global fleet over the past decade. It also examined idling period length against water temperature and fouling pressure.

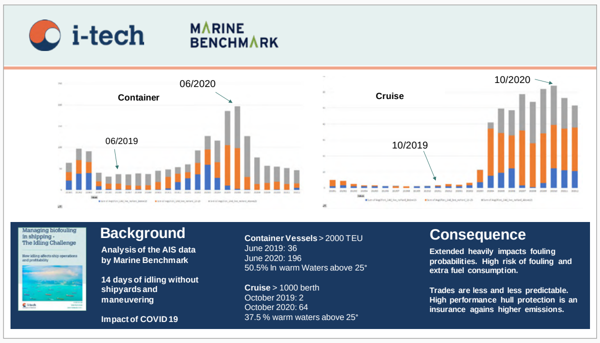
The antifouling biotechnology, Selektope® is also discussed for its role as an insurance technology when used in antifouling coatings for vessels at risk of suffering the negative impacts of 'fouling idling'. Recent advancements in the R&D efforts of I-Tech to expand and support the use of Selektope® in a wider range of antifouling coating system types to boost hard fouling prevention protection are shared.

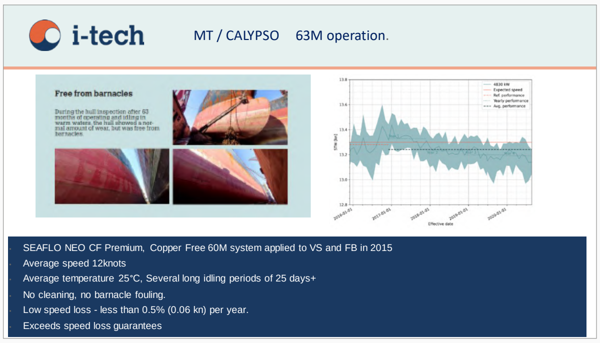
Presentation slides

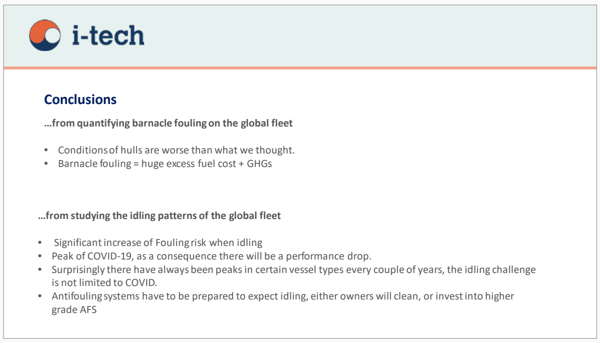

i-tech
How do we trigger flight mode?
Exploratory surface behaviour necessary to settle is blocked.
Kicking frequency is around 100/min, increased from XX kicks per minute
Swim speed can be twice its length per second.
Adult barnacle
Settling
Adult barnacles produce larvae that eat and grow.
The larvae in the cyprid stage look for a suitable place to settle
The settled larvae metamorphose into juvenal adults.
Nauplii larvae
Cyprid larvae


i-tech
% increase GHG emissions
Biofouling condition
selektope®
Image provided by Chugoku Marine Paints
Source: www.glofouling.imo.org


i-tech
Quantifying the scale of the barnacle fouling problem on the global shipping fleet
Safinah Group
Animal fouling condition on underwater hull
Number of Vessels
Animal Fouling Coverage (%)
44% of vessels surveyed had between more than 10% barnacle fouling coverage on the hull.
Niche areas are in high risk of fouling.
Approx. 74% of observations found barnacle fouling in sea chests.
Barnacle fouling increases with lower activity vessels.


i-tech
MARINE BENCHMARK
Container
06/2020
06/2019
Cruise
10/2020
10/2019
Background
Analysis of the AIS data by Marine Benchmark
14 days of idling without shipyards and maneuvering
Impact of COVID 19
Container Vessels > 2000 TEU
June 2019: 36
June 2020: 196
50.5% in warm Waters above 25°
Cruise > 1000 berth
October 2019: 2
October 2020: 64
37.5 % warm waters above 25°
Consequence
Extended heavily impacts fouling probabilities. High risk of fouling and extra fuel consumption.
Trades are less and less predictable. High performance hull protection is an insurance agains higher emissions.


i-tech
MT / CALYPSO 63M operation.
Free from barnacles
SEAFLO NEO CF Premium, Copper Free 60M system applied to VS and FB in 2015
Average speed 12knots
Average temperature 25°C, Several long idling periods of 25 days+
No cleaning, no barnacle fouling.
Low speed loss - less than 0.5% (0.06 kn) per year.
Exceeds speed loss guarantees


i-tech
Conclusions
…from quantifying barnacle fouling on the global fleet
Conditions of hulls are worse than what we thought.
Barnacle fouling = huge excess fuel cost + GHGs
…from studying the idling patterns of the global fleet
Significant increase of Fouling risk when idling
Peak of COVID-19, as a consequence there will be a performance drop.
Surprisingly there have always been peaks in certain vessel types every couple of years, the idling challenge is not limited to COVID.
Antifouling systems have to be prepared to expect idling, either owners will clean, or invest into higher grade AFS


Thank you for listening
i-tech
selektope®

DARREN R. JONES

ESG Director

Sonihull

Darren is a Chartered Director who has led multiple organisations.

Darren is ESG Director of Sonihull-NRG Marine, the market leading ultrasonic antifouling provider to the global marine industry. Darren was founding Chair of the IMO GloFouling GIA. He is a director of Develop Consulting and Director of Environment, Infrastructure and Transport for the Centre for The New Midlands.

Darren currently sits as a lay advisor on the governing body of Arden Gem NHS CSU. Darren has been President of a large Chamber of Commerce and Entrepreneur in residence at Coventry University.

Can we, and should we, fast track new technologies to deal with biofouling?

The focus of the impact of biofouling on the environment has for decades been on invasive species. The work of the GloFouling project, and particularly its GIA has now drawn focus onto the material effect biofouling has on Green House Gas Emissions.

The findings of the commissioned, definitive, report on GHG emissions due to vessel inefficiency born of biofouling shows that the impact is the equivalent to something in the region of one third of the emissions of the German economy.

There are now new technologies in cleaning, in ultrasonics and in coatings that can have a dramatic impact on this. The Maritime industry is notoriously conservative at adopting new technologies, often waiting for regulation.

Regulation in shipping takes many years. How do we square this with a climate emergency?

Covid showed that in a true emergency, regulators can move swiftly as they did for vaccine approval.

This presentation will look at the following:

- What can we learn from the vaccine fast tracking?
- How can we encourage vessel operators and ports to adopt better, and greener, new technologies and systems at pace?
- How can we make class and other certifications an enabler for new tech rather than a financial and time obstacle?
- How do we make biofouling a top of mind, priority issue?
- What does an emergency timetable for change look like?

Who takes the lead?

Presentation slides

Biofouling
Adopting new technology:

If it is a Climate Emergency Can We Learn From a Global Crisis?

Darren R Jones
ESG Director Sonihull®

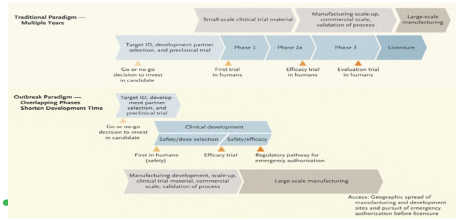
What do I know?

ESG Director: Sonihull® Leading Ultrasonic Antifouling System

Non Exec Director: Arden Gem CSU NHS England

Founding Chair: IMO Glofouling GIA

Vaccines: The New and The OLD

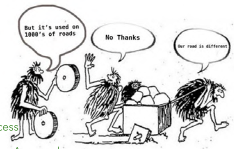


The Global Picture of Stakeholders

- Pharma Companies — JV'd and Partnered
- National Regulators (60+) — Met daily not 6 monthly
- Testing Partners — Mobilised and shared data at scale
- Independent Evaluation Partners — Mobilised and shared data at scale
- Delivery Partners Hospitals/Clinics 1000's all with different rules
  Standardised and shared best practice

"New" Tech in Maritime: Sonihull's Journey

- 14 Year Journey
- Start with trials on recreational
- After 6 years move to commercial



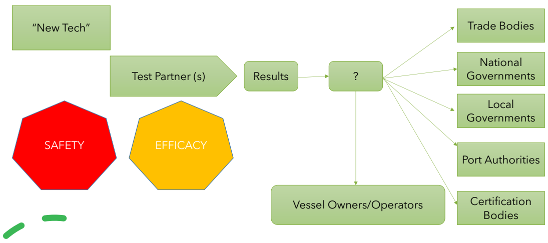
Approach Vessel operator — Up to 7 year process
Asked for proof
Agree a trial (x years) — Often Ask for Class Approval
Complete trial
Begin fleet role out — Won't share data as gives commercial advantage

5000 vessel years of use is not enough?

The Global Picture of Stakeholders

- IMO
- National Government
- States/Provinces
- Port Authorities
- Flag Nations
- Certification Bodies
- Trade Bodies
- Ship Owners
- Ship Operators

A Different Way?



Barriers

- Is this an emergency?
- Don't let perfection be the enemy of good.
- 70% is better than 0% - Does it have to be 100%

Conclusion

- Where there is a will there is a way
  Is there the will?
- It cannot be business as usual
- Innovation = Invention + Adoption
  Maritimes issue is Adoption

SESSION 12

Policy aspects – How can policy respond to biofouling management challenges?

THEOFANIS KARAYANNIS

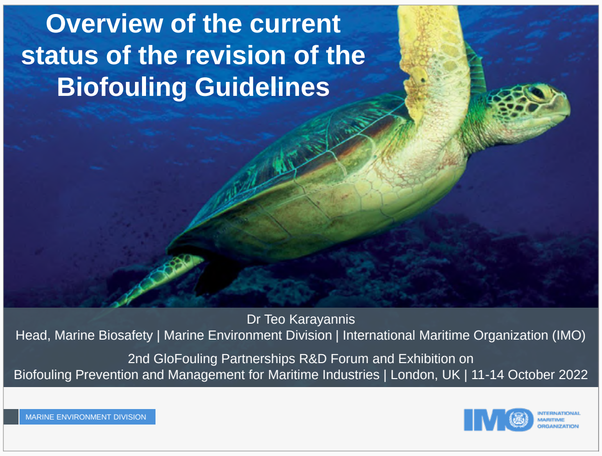
Head, Marine Biosafety

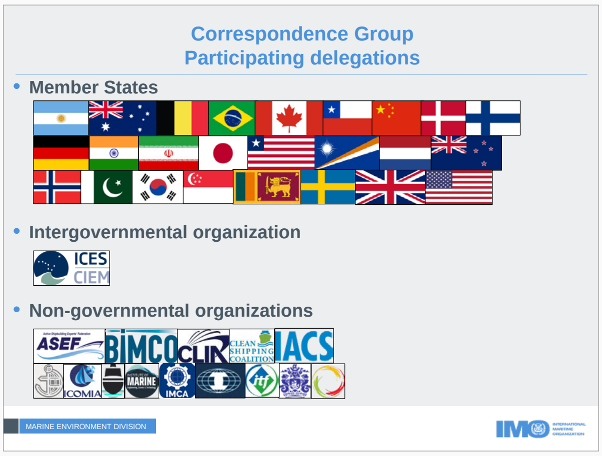
IMO

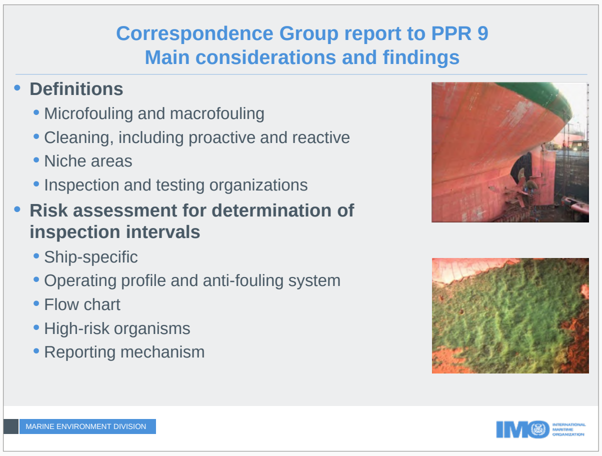
Dr Theofanis (Teo) Karayannis joined the Marine Environment Division of the IMO Secretariat in March 2014 and since August 2017 holds the position of Head, Marine Biosafety, being in charge of biosafety-related topics (ballast water management, anti-fouling systems and biofouling management) and the associated IMO instruments (the BWM and AFS Conventions and associated guidelines, and the Biofouling Guidelines). He is also the IMO Secretariat's focal point for various ongoing activities, including inter-agency partnerships, related to marine biosafety and biodiversity. Until July 2017 he was also involved with matters related to ship energy efficiency and greenhouse gas emissions from shipping. Prior to joining IMO he worked for Lloyd's Register, as a Senior Specialist in the Strategic Research and Technology Policy Group, and prior to that he held a position in the Marine Pollution Prevention and Cargoes Department of the Greek national maritime Administration. He also has previous experience as a naval architect and marine engineer at a ship design firm; as a university researcher; and as a lecturer at a seafarers' training academy. Dr Karayannis has a Diploma in Naval Architecture and Marine Engineering from the National Technical University of Athens (Greece) and a PhD in Ship Science from the University of Southampton (UK).

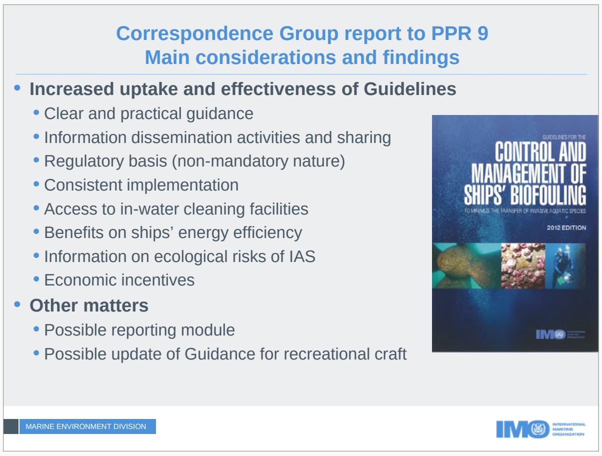
Overview of the current status of the revision of the Biofouling Guidelines

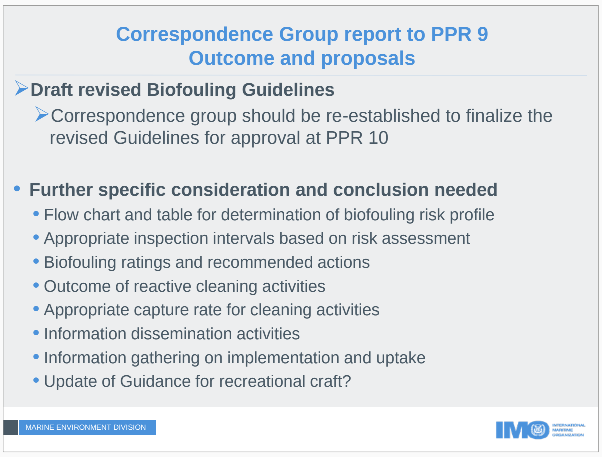
Presentation slides











PPR 9
Commenting and information submissions

- **Commenting documents (proposals for further consideration)**
  - China: interval between inspections
  - Bahamas, India, Japan, Panama, ICS and BIMCO: implications of cleaning in dry dock; recommended actions for cleaning of niche areas
- **Information documents (may be considered by CG)**
  - Chile: national measures for prevention of biofouling
  - ICS, BIMCO and INTERTANKO: in-water cleaning standard
  - Belgium: hull cleaning procedure in Belgian ports
  - Argentina: national actions to address biofouling
  - GloFouling: existing and emerging regulations, standards and practices

Outcome of PPR 9
Consideration of Correspondence Group report

Main decisions

➢ Continue work by revising the Guidelines based on the revised draft prepared by the Correspondence Group

➢ Correspondence group re-established; aim to finalize the draft revised Biofouling Guidelines with a view to approval by PPR 10

➢ Consideration of outstanding issues highlighted in CG report to inform the further work of the Correspondence Group

Outcome of PPR 9
Consideration of Correspondence Group report

Issues that received most attention

➢ Inspection intervals and associated risk assessments to determine them
- Split views on longer vs shorter intervals and associated implications (operational/economic and environmental)

➢ Proactive/reactive cleaning and related capture rates
- Split views on required capture rates and on need for capture at proactive cleaning

ICES CIEM

Discussions currently ongoing in the Correspondence Group!

ASEF BIMCO CLIA CLEAN SHIPPING COALITION IACS COMIA MARINE IMCA

International Maritime Organization

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LILIA KHODJET EL KHIL

Project Technical Manager

GloFouling Partnerships project, IMO

After obtaining her PhD in Maritime Law (Aix-Marseille, France), Dr Lilia Khodjet El Khil joined IMO at its regional office in the Mediterranean (REMPEC) where she spent nine years as a Programme Officer supporting Mediterranean coastal States to strengthen their capacity to implement regulations and good practices for marine environmental protection. Lilia was awarded the "Mérite Maritime" from the French government in recognition of her work at REMPEC. In 2010, Lilia relocated to Montreal, Canada, where she took the position of Interim Director, Environment, at the Shipping Federation of Canada, a trade association representing international shipping in Canada, where she engaged with Governments and guided members through complex regulatory and compliance issues. She later joined the CSL Group Inc., a major Canadian shipping company operating worldwide, where she held the position of Manager, Sustainability and Government Relations, to implement sustainable development standards in the company and advocate for domestic shipping's interests at national and international levels.

Lilia launched her own consultancy business, Maritimis Consulting, in 2016. She provided services to the industry, governments and non-for-profit organizations on environment issues related to shipping. In June 2019, she joined IMO headquarters in London to lead one major IMO project dealing with marine biosafety, namely the GloFouling Partnerships project.

Supporting the uptake of IMO Guidelines in Developing Countries

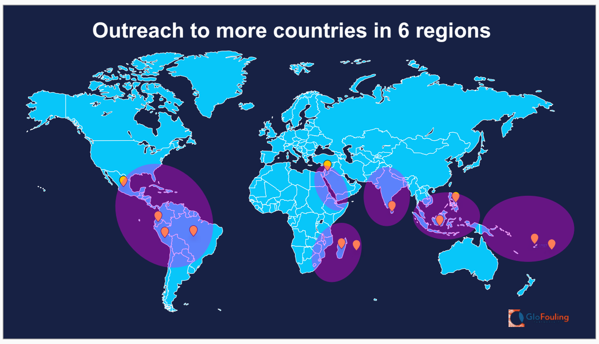
Presentation slides


the Project
National reforms
Training
Resources
GloFouling


the Project

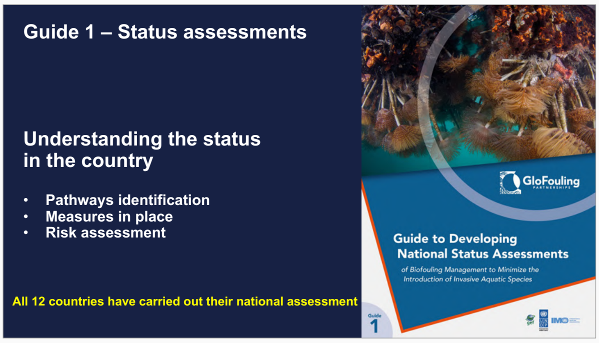

Joint initiative
Funding
Implementation
Execution
Implementing partners
Project goal
Assist developing countries to implement the IMO Biofouling Guidelines and minimize introductions of invasive aquatic species
CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING
41m
US$
Co-financing
6.9m
US$
GEF grant
6
years
2019-2025
SDGs
GloFouling


Targeted action in 12 Lead Partnering Countries
Mexico
Ecuador
Peru
Brazil
Madagascar
Jordan
Sri Lanka
Mauritius
Philippines
Fiji
Tonga
Indonesia
GloFouling


Outreach to more countries in 6 regions
GloFouling


National reforms


Biofouling management journey in Lead Partnering Countries
12 Lead Partnering Countries and 6 regions
4. National Strategy and Action Plan
3. Rapid Economic Impact Assessment
2. National Status Assessment
1. National Task Force
Raise awareness
GloFouling

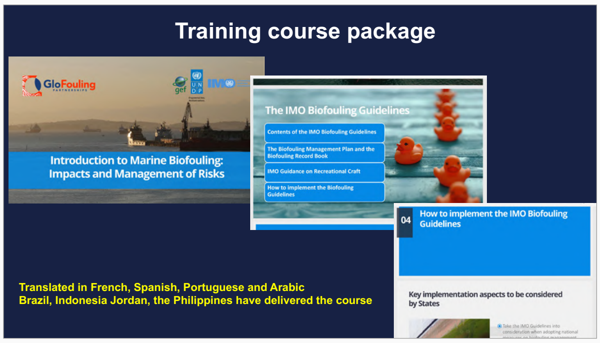

Guide 1 – Status assessments
Understanding the status
in the country
• Pathways identification
• Measures in place
• Risk assessment
All 12 countries have carried out their national assessment
GloFouling
Guide to Developing
National Status Assessments
of Biofouling Management to Minimize the Introduction of Invasive Aquatic Species
1


Guide 2 – Economic Assessments
The business case for action:
the economic of things
• Methodologies for economic assessments
• Cost analysis per sectors
• Cost of implementation of policies
All 12 countries have nominated national experts
GloFouling
Guide to Developing National
Rapid Economic Assessments
of Biofouling Management to Minimize the Introduction of Invasive Aquatic Species
2


Guide 3 – National strategies and action plans
Policy & governance arrangements
• Policy direction
• Consultation of stakeholders
• Adoption of measures
• Preparing for implementation
All 12 countries have started developing measures
GloFouling
Guide to Developing National Biofouling Strategies
on Biofouling Management to Minimize the Introduction of Invasive Aquatic Species
3

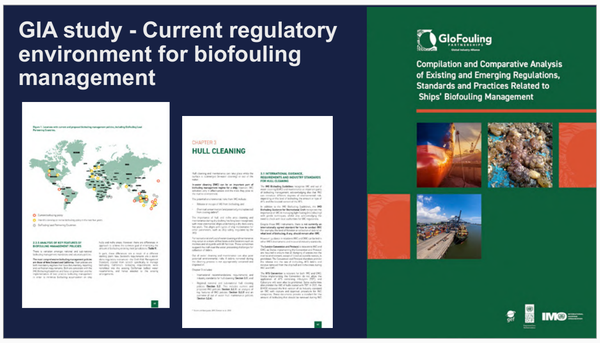

Keeping countries aware of policy developments at IMO
o We keep countries updated with developments regarding the revision of the IMO Biofouling Guidelines (updates on PPR meeting outcomes)
o We encourage countries to contribute to the work of the Correspondence Group in charge of revising the Guidelines
o Brazil and Indonesia are members of the Correspondence Group


Training


Training course package
GloFouling
Introduction to Marine Biofouling: Impacts and Management of Risks
The IMO Biofouling Guidelines
04 How to implement the IMO Biofouling Guidelines
Key implementation aspects to be considered by States
Translated in French, Spanish, Portuguese and Arabic
Brazil, Indonesia Jordan, the Philippines have delivered the course


eLearning course developed in cooperation with WMU
eLearning course on biofouling management ready and available for countries to use
Module 3 Contents
Click on each menu item to learn more about the topic.
1 Ship Types and Operational Pattern
2 Invasive Species
3 Protection and Mitigation
Lilia Khodjet El Khil
Project Technical Manager


Resources


GIA study - Current regulatory environment for biofouling management
HULL CLEANING
GloFouling
Compilation and Comparative Analysis of Existing and Emerging Regulations, Standards and Practices Related to Ships' Biofouling Management

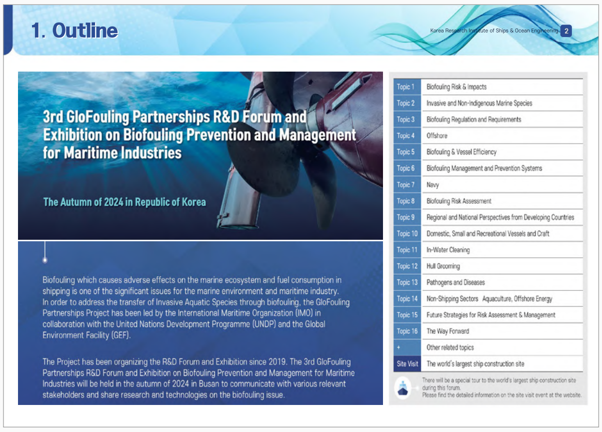

GloFouling
PARTNERSHIPS
The journey continues ….. until May 2025!
For more information:
Web: www.glofouling.imo.org
Email: glofouling@imo.org

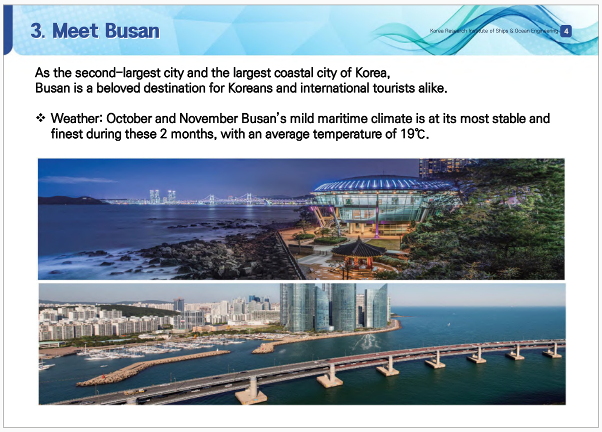
The 3rd GloFouling Partnerships R&D Forum on Biofouling Prevention and Management

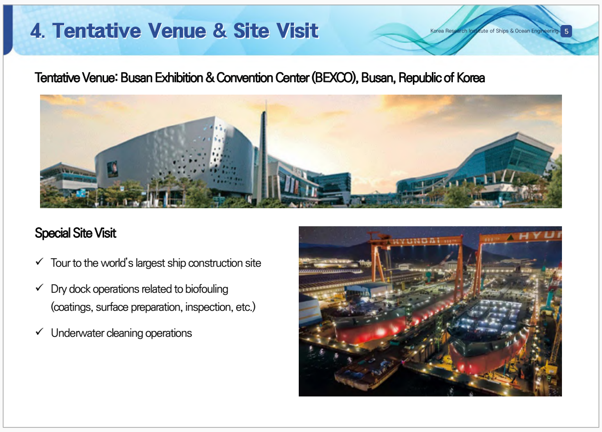
SEONG-YEOB LEE AND HOYOON KIM

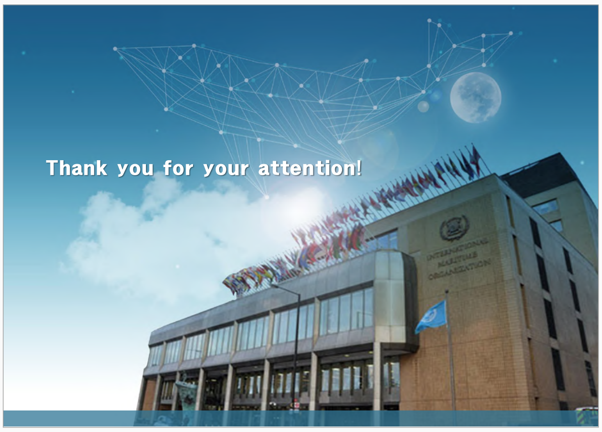
Korea Research Institute of Ships and Ocean Engineering (KRISO)

Presentation slides









CHAIRS OF SESSIONS & PANELLISTS

SESSION INDUSTRY PANEL – WORLD OCEAN COUNCIL (WOC)

Facilitating green investment to support innovation and technology development for biofouling management

Chair of Session: **PAUL HOLTHUS**

PAUL HOLTHUS

Founding President & CEO

World Ocean Council (WOC)

Paul works with the private sector and market forces to develop practical solutions for achieving sustainable development and addressing environmental concerns, especially for marine areas and resources.

His experience ranges from working with the global industry associations or directors of UN agencies to working with fishermen in small island villages. Paul has been involved in coastal and marine resource sustainable development and conservation work in over 30 countries in Europe, Asia, the Pacific, Central America and Africa. As a consultant on sustainable development and environmental management, he has worked with companies, industry associations, UN agencies, international NGOs and foundations on sustainability, especially in the areas of oil/gas, fisheries, aquaculture, standards and certification.

Past roles include: Deputy Director for the Global Marine and Coastal Program of IUCN – The World Conservation Union; founding Executive Director of the Marine Aquarium Council (an international standards-setting, certification and capacity-building organization bringing together industry/fishers, conservation and international agencies for sustainability in this global marine fishery, aquaculture and trade); Senior Officer in the Nature Conservancy's Asia-Pacific Program; Senior Program Officer of the UNEP South Pacific Regional Environment Programme (SPREP).

Paul is a graduate of the University of California and the University of Hawaii, with advanced degrees in coastal/marine resources and international business.

PANELLISTS

TONY FOSTER

CEO/CIO

Marine Capital Ltd

Tony Foster is the CEO-CIO of Marine Capital, a boutique asset manager focused solely on the marine industry. The firm offers both investment management services and physical vessel operating capability across a range of shipping sectors. Clients, past and present, include institutional investors, corporates, sovereign entities and ultra-high net worth individuals. Tony has spent his whole career in shipping, after graduating from Oxford in law, and been involved in broad range of commercial activities including the IPO of a major listed shipping company and the acquisition of another in a state privatisation. Marine Capital is at the forefront of several commercial decarbonisation initiatives within shipping. He founded MCL in 2003.

BIRGIT M. LIODDEN

Founder & Chief Mermaid

The Ocean Opportunity Lab (TOOL)

Founder of first global ecosystem for innovators within ocean & renewable energy, recently launching the world's first interactive map and resource match platform connecting startups & established players to accelerate sustainable innovation.

Liodden holds 17 years of entrepreneurship & global leadership roles in maritime. Chair of the Norwegian Association for Environmental Boats, board member of TECO2030, Aqua Bio Technology, Greenstat, Bellona Foundation, Kuniko (ASX) and TheFactory - covering hydrogen infrastructure, circular mining, sustainable finance and environment.

Background includes Sustainability & Ocean Director of Oslo Business Region/European Green Capital 2019, Director of Nor-Shipping, founder of YoungShip International, Global PM systems & processes at Wilh. Wilhelmsen. Liodden has pioneered change initiatives focused on next gen, diversity & entrepreneurship, founder of the first global maritime entrepreneur award, and the first mentor program for women in maritime.

In 2018 she interviewed President Barack Obama in Oslo, and awarded a number of national and international prizes for her leadership.

DIANE GILPIN

Founder/CEO

Smart Green Shipping

Diane Gilpin leads Smart Green Shipping (SGS), a purpose-driven for-profit systems design house working to drive immediate, scalable, positive change in the global shipping fleet.

SGS works collaboratively across the shipping eco-system and brings-in adjacent technologies and industries. In 2018/19 SGS led an InnovateUK supported collaborative feasibility analysis quantifying the benefits of retrofitting its FastRigTM wingsails onto a ship importing biomass into the UK . Fuel and GHG emissions savings were verified, as saving at least 20% per annum by the University of Southampton,. Simultaneously, with European Space Agency support, SGS has developed its TradeWind App which quantifies the value of the wind on any ship on any route - a key enabler to drive rapid market adoption of wind-assist technology.

Diane sits on UK Department for Transport Clean Maritime Council; is a European Green Shipping Expert for EU Waterborne Transport Platform; a BBC 'Woman of Power' 2020; a recipient of InnovateUK's 'Women in Innovation' Award; winner of the 2021 International Windship Association's 'Outstanding Contribution' Award.

MICHAEL VAN NIEKERK

Chief Impact officer

NorthStar Impact Funds

Michael is currently the Chief Impact Officer at NorthStar Impact Funds and the founding director of independent Responsible Investment advisory firm, Peakview Strategy.

He has over 30 years of experience in large complex corporates working with the most senior level executives and their teams.

He is an independent adviser specialising in:

- *Responsible investment – strategy, ESG and Impact Investment*
- *Corporate Sustainability – strategy, execution and projects*
- *Pensions, wealth and asset management strategy and M&A*

Recent advisory clients include Woolworths Ltd, AMP, HESTA and Rest superannuation funds.

Michael has held at senior strategy and finance roles at number of leading organisations including AMP, ABC, Consolidated Press Holdings and was a consultant at Andersons.

ANDREW SMITH

Co Founder and Director

Greenbackers Investment Capital.

Andrew ran the £103m Renewable Energy Investment Fund by Scottish Investment Bank, was Head of Investment for DP Energy, co founded Greenbackers Investment Capital, and founded the Deja Blue consultancy.

Greenbackers delivered the largest technology showcase at COP26 and are currently delivering their 2022 Program - the Climate Tech Tour taking clean, climate technologies to investment hotspots around the world.

Andrew is a board member of the Marine Energy Council registered Expert with the European Commission a member of the FTech2Zero working Group, a member of the expert panel advising the EU on its new Innovation Fund, a member of the United Nations' Sustainable Blue Finance Initiative of the World Ocean Council, Ocean Energy Europe, an assessor for the Solar Impulse Foundation's 1000 Solutions program and a Global Scot.

SESSION 3 – OCEAN RENEWABLE ENERGY AND AQUACULTURE SECTORS: CHALLENGES AND BEST PRACTICES TO MANAGE BIOFOULING

Theme: **PART 1: OCEAN RENEWABLE ENERGY**
Chair of Session: **ANDREW WANT**

DR ANDREW WANT

Research Associate/Lecturer
Herriot-Watt University

Dr Andrew Want is a marine ecologist with expertise in biofouling in high-energy habitats targeted by the Offshore Renewable Energy (ORE) sector. His research background includes leading the international Biofouling in Renewable Energy Environments (BioFREE) project and the Forensic Decommissioning of Tidal Energy Converters study. Dr Want is leading the ORE subgroup of the UNESCO GESAMP 44 Working Group on Biofouling Management and provides expertise to the Marine Alliance for Science and Technology for Scotland forum on Marine Renewable Energy, and the US Bureau of Ocean Energy Management. Peer-reviewed papers have recently appeared in: Biofouling; Ocean and Coastal Management; Renewable and Sustainable Energy Reviews; and Global Change Biology.

Theme: **PART 2: AQUACULTURE**
Chair of Session: **HENRIK OKSFELDT ENEVOLDSEN**

HENRIK ENEVOLDSEN

Head a.i. Ocean Science Section, IOC UNESCO / Head, IOC Science and Communication Centre on Harmful Algae
Intergovernmental Oceanographic Commission of UNESCO

Henrik Enevoldsen is the Head a.i. of the Ocean Science Section of the Secretariat of the IOC of UNESCO, He also serves as the Head of the IOC Science and Communication Centre on Harmful Algae which is hosted by the University of Copenhagen, Denmark. He has a background in aquatic ecology and has for more than 30 years worked with development and implementation of international research and capacity building in marine science. He has published on harmful algae ecology, international capacity building and programme development. He coordinates several international scientific working groups and regional networks in marine science, including the joint IOC-SCOR international research programme GlobalHAB and the IOC Intergovernmental Panel on Harmful Algal Blooms (IPHAB). He is IOC UNESCO Technical Secretary of GESAMP. He is a contributing author and part of the report Team for the Global Ocean Science Report, editor of the pilot of the State of the Ocean Report- StOR, (2022), and he has been and continues to be actively involved in the development of the UN Decade for Ocean Science for Sustainable Development 2021-2030. He is focal point in IOC UNESCO for the partnership with IMO on the GloFouling Partnerships project.

SIMONE DÜRR

Senior Lecturer in Marine Biology

Liverpool John Moores University

Dr Simone Dürr has worked since 1996 in the field of biofouling & antifouling with expertise in aquaculture & shipping having gained her PhD from Christian-Albrechts-University zu Kiel (Germany) in 2003. She predominantly designs & evaluates antifouling field & lab experiments. She led, managed, supervised & evaluated the antifouling field trials at 11 European sites in the EU project CRAB. SD won consultancies from Talga/Biomer and United Utilities. SD reviews grants (EU, MSCA; USDA; Canada Innovation Fund) & articles. She is both editor & contributor of the book Biofouling. She has worked in the Liverpool South Docks on Biofouling/Antifouling since 2008.

GUILLAUME DRILLET

Director of the board

World Aquaculture Society (WAS)

For Bio see p. 86

SESSION 4 – MONITORING BIOFOULING: HOW CAN INNOVATION HELP?

Chair of Session: **GEOFFREY SWAIN**

GEOFF SWAIN

Director, Center for Corrosion and Biofouling Control

Florida Institute of Technology, USA

Dr Geoff Swain is Professor of Oceanography and Ocean Engineering and the Director of the Center for Corrosion and Biofouling Control at the Florida Institute of Technology. He joined FIT in 1984 and established the Center, which is fully staffed, has a laboratory on campus, and static and dynamic seawater test facilities at Port Canaveral. They have active research grants with the Office of Naval Research, Bureau of Ocean Energy Management, and the shipping, offshore energy, coatings and cathodic protection Industries. He has authored over 100 publications on the subject.

SESSION 6 – PORT PERSPECTIVES OF BIOFOULING MANAGEMENT

Chair of Session: **CRAIG EASON**

PANELLISTS

NICOLA STOKES

Senior Environmental Advisor

North Queensland Bulk Ports (NQBP)

For Bio see p. 60

SIMON DORAN

Managing Director

HullWiper Ltd (GAC)

Simon has numerous professional qualifications from the subsea industry. He had 19 x years' decorated experience in the UK Military in 1998 Simon became General Manager for UMC, Middle East Division and oversaw the business expansion in the region and development of high-profile government contracts with Royal Navy, US Navy, Omani and Pakistan Navies to name a few. Simon was appointed Managing Director of HullWiper Ltd in October 2012 and oversaw the launch of HullWiper's Cleaning & Inspection ROV in 2013, now the largest single source ROV Hull Cleaning provider in the world. He is responsible for the continued roll-out of this cost-effective, eco-friendly, and diver-free hull cleaning solution to the shipping industry worldwide.

EVEN HUSBY

Head of Environment

Port of Bergen / CEO EPI

Even Husby (male), Head of Environment Port of Bergen and Director for Environmental Port Index. He holds a Master of Science from the University of Edinburgh. The reduction of air emissions from port- and maritime activities has been a focus area in his work at the port. He has also worked extensively with environmental accounting, project management, Geographical Information Systems and topographical mapping.

NIKHILESH BHATIA

Director, Fleet Analytics

Hapag-Lloyd

Nikhilesh Bhatia is former Master Mariner, now working ashore to improve fuel efficiency of ships in operational aspects of Liner shipping. He has experience in container stowage and port operations, both at sea and ashore. He uses his seafaring background to focus on reducing the carbon footprint of Hapag-Lloyd's fleet to make shipping sustainable.

Chair of Session: **GYORGYI GURBAN**

PANELLISTS

BEV MACKENZIE

Head of Intergovernmental Engagement

BIMCO

For Bio see p. 79

BIRGIT M. LIODDEN

Director of the board

World Aquaculture Society (WAS)

For Bio see p. 138

LILIA KHODJET EL KHIL

GloFouling Partnerships, IMO

IMO

For Bio see p. 133

LINA CEBALLOS-OSUNA

Senior Environmental Scientist

California State Lands Commission

For Bio see p. 74

SOLÈNE GUÉRÉ

Vice President

Notilo Plus

For Bio see p. 71

SHIREENE MOHAMED GALAL SALAH ELDIN

Permanent Director / Head, Administrative Monitoring Department

AWIMA General Secretariat - board executive member. Arab Women in Maritime Association (AWIMA) / Focal Point of IMO / MoU Office – IMO Compound - AASTMT / Arab Academy for Science & Technology & Maritime Transport

SHIREENE GALAL an Egyptian female leader with (26) years of experience in several branches in Maritime field. Her projects focus on encouraging women to study, work and lead in the MENA maritime sector through managing events, conferences, workshops, monitoring scholarships "Go to Sea! Campaign", training programs, and development initiatives. She Implemented and provided hosting facilities for the organization of selected ITCP activities, more over than 60 ITCP National & International programme from 2001 until now. She is currently the Head of Administrative Monitoring Department- IMO Compound - Arab Academy for Science, Technology & Maritime Transport AASTMT, besides being the Permanent Director of Arab WIMA Secretariat & a board member of Governing Council, also she was a Founding Member of the Alumni "AASTMT" also she holds many of armor of Honor in her career.

Shireene has previously held several roles including: Assistant Head of Information Technology Section in the Mediterranean MoU on Port State Control [PSC] Secretariat, and working in different company's departments at the international shipping and transport co. (ISTCO). In 1996 she was from the first batch to graduate from the College of Maritime Transport & Technology – AASTMT, in addition to being the Head of Students Council for two years. In 2012 she attained her Master's Degree in Maritime Transport technology (Marine Environment Protection).

SHIREENE GALAL has a passion for sea world, which can be traced back to her father. She is a daughter of a port captain and spent many happy childhood years living with her family in Alexandria. He inspires her and she continues to inspire the maritime industry.

Chair of Session: **AGNESE MARCHINI**

AGNESE MARCHINI

Senior researcher

University of Pavia, Italy

Agnese Marchini graduated in Biology in 2000 and obtained a PhD in Experimental Ecology in 2004 at the University of Pavia, Italy, with a study about fouling communities in the Lagoon of Venice.

She has been a visiting fellow at the University of Aveiro, Portugal, where she trained on taxonomy of marine amphipods, and a post-doc fellow at the Universities of Pavia and Ferrara, Italy, where she participated to several national and international projects. In particular, she has worked on benthos collected from man-modified habitats (ports, marinas, lagoons) of the Mediterranean Sea, Red Sea, Macaronesia and North-Eastern Atlantic, and has gained a vast experience on nonindigenous species occurring in the fouling communities. Since November 2016, Agnese Marchini is Senior Researcher in Ecology at the Department of Earth and Environmental Sciences, University of Pavia, where she supervises PhD and master theses and internships for incoming international students.

She has served as a reviewer for 40 international journals of ecology, marine biology, environmental monitoring, modelling and management, as well as for national and international funding programs. She is member of several scientific boards, including the Working Group on Invasive Alien Species (WGIAS) of the European Commission's Directorate General for Environment (DG Environment); the "Allochtonous species group" of the Italian Society of Marine Biology (SIBM), where she has been coordinator of the Horizon Scanning Exercise on marine alien species for Italy. Agnese Marchini has authored or co-authored 60 peer-reviewed articles and four book chapters; her researches have been presented at 70 scientific conferences. Her researches are covered by several national and international newspapers and she also writes educational articles for Italian magazines and blogs.

PANELLISTS

UDO KLEINITZ

Secretary General

ICOMIA

The International Council of Marine Industry Associations' (ICOMIA) Secretary General, Udo Kleinitz, holds the German master craftsman qualification in boatbuilding, which he obtained during 15 years working in yards at the lakes in the Munich area.

In 2008 Udo relocated to the UK after being appointed as Technical Manager at ICOMIA – a post he held for five years, before joining British Marine as Head of Technical Services. Udo returned to ICOMIA in June 2015 as Secretary General.

ICOMIA is the organization representing the marine industry globally. Its work covers provision of industry statistics, formulating policy on key industry topics, providing a forum of exchange amongst its members, industry advocacy at regional and international level, and seeking removal of barriers to trade by promoting harmonisation of requirements globally.

An avid outdoor enthusiast, Udo spends his free time bike touring and -packing, stargazing and on the water.

KATIE COSTELLO

Programme Support Associate - Invasive Species

International Union for Conservation of Nature (IUCN)

Dr Katie Costello is a member of the IUCN invasive species team, based in Cambridge UK. She is a marine ecologist with specialist knowledge of aquatic invasive species, specifically their methods of dispersal, impacts on biodiversity and interactions with parasites. Katie's work to date has focused heavily on the different pathways available in marine and freshwater environments, particularly those relating to vessel movements (commercial and recreational) and aquaculture. She is interested in working to develop the mechanisms to counteract the spread of invasive species and promote awareness of biosecurity.

ALEXANDRA RICKHAM

Head of Sustainability

World Sailing

Having joined World Sailing earlier this year as Head of Sustainability, double Paralympic medallist Alexandra Rickham has been working in sustainability in the sport sector as a consultant since retiring from full time competition in 2017. She combines her academic knowledge and insight with her practical experience in competitive sport and environmental operations to focus both on changing the sports industry and its practices, and on utilising sport's platform to inspire change. Alexandra is very passionate about diversity and inclusion and ensuring the athlete's voice is heard on sustainability and regularly participates on panels, podcasts and other speaking opportunities on these subjects.

SESSION 12 – POLICY ASPECTS – HOW CAN POLICY RESPOND TO BIOFOULING MANAGEMENT CHALLENGES?

Chair of Session: **SVEINUNG OFTEDAL**

SVEINUNG OFTEDAL

Specialist Director

Norwegian Ministry of Climate and Environment

Specialist Director in the Norwegian Ministry of Climate and Environment with focus on international negotiations on environmental requirements for the maritime sector.

He has been heavily involved in negotiations on the hot topics at the IMO such as Greenhouse Gas Emissions, Air Pollution and other issues addressed in MARPOL, Ship Recycling, Ballast Water Management, Antifouling Systems and other environmental issues for over two decades.

Chairman of the IMO BLG and PPR Sub-Committee (2010 – 2019) and is currently Chairman of the IMO Working Group on Greenhouse Gas emissions, and Coordinator of the IMO/PPR Correspondence group on biofouling.

PANELLISTS

LINA CEBALLOS-OSUNA

Senior Environmental Scientist

California State Lands Commission

For Bio see p. 74

TIM CAREW

Assistant Director

Marine Biosecurity Unit, Australian Department of Agriculture, Fisheries and Forestry

Timothy is an assistant Director in the Marine Biosecurity Unit working on the implementation of the Australian biofouling management requirements and the development of the Australian in-water cleaning standards. He has a background in marine biology and has been working for the department since 2017.

KATHERINE GIROUX-BOUGARD

Policy Advisor

Transport Canada

Katherine Giroux-Bougard is a policy advisor within Environmental Policy at Transport Canada, where she leads a team working on the development of Canada's policy framework on the control and management of vessel biofouling. She previously held various policy roles at National Defence, including in Cabinet affairs, strategic analysis, and international relations, and worked at Canada's Permanent Mission to the United Nations in New York. Katherine holds a M.A. in international relations from the Barcelona Institute of International Relations and a M.A. in development studies from the Erasmus University of Rotterdam.

DICK BRUS

Senior policy maker

Ministry of Infrastructure and Water Management of the Netherlands

Dick Brus is senior policy maker of the Ministry of Infrastructure and Water Management of the Netherlands. He worked for the United Nations for several years in Nicaragua, Thailand, and Indonesia, before joining the Dutch Ministry in 1998. Since 2007 he joins IMO meetings, and he is the Coordinator for the Netherlands for IMO environment. He is head of delegation of the Netherlands to the IMO LEGAL committee, the IMO PPR technical committee, the International Oil Pollution Fund and is alternate head of delegation of the Netherlands to the IMO Maritime Environment Protection Committee.

SPECIAL PRESENTATION

Proteus, the International Space Station of the Sea.

MARK PATTERSON & GARY ROSEWELL, PROTEUS OCEAN GROUP.

MARK PATTERSON

Lead Scientist

Proteus Ocean Group

Mark is a Lead Scientist at Proteus Ocean Group, while doubling as a Professor of Marine and Environmental Sciences as well as Civil and Environmental Engineering at Northeastern University. He brings a wealth of knowledge to PROTEUS, particularly in the robotics domain.

GARY ROSEWELL

Partnerships Director

Proteus Ocean Group

Gary serves as Partnerships Director at Proteus Ocean Group, working in an interdisciplinary team to realise PROTEUS - the world's first International Space Station of the Ocean.

POSTERS


CHALLENGES IN MANAGING
AQUATIC INVASIVE SPECIES (AIS) RISK
IN THE MARITIME INDUSTRY IN THE PHILIPPINES

Biofouling observation in tropical waters of Indonesia for marine renewable energy sector

Agung Iswadi[1], Joanne S. Porter[1], Michael C. Bell[1], Leuserina Garniati[1,2], Gadang Priyotomo[3]

[1] International Centre for Island Technology, Heriot-Watt University, Orkney Campus
[2] Aquatera, Ltd.
[3] National Research and Innovation Agency, Indonesia

ABSTRACT

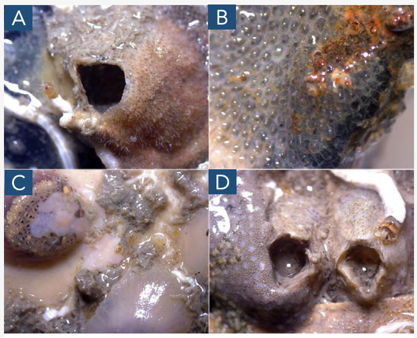
Biofouling, as a major concern in the maritime industry, has become an issue for the marine renewable energy sector since around 2 decades ago when the industry entered commercialisation stage. However, investigation on biofouling impacts on marine energy devices in tropical waters of Indonesia is very limited. This limited knowledge of technical aspects could challenge the promotion of local technologies to develop further into the next stage of development. This study aims to provide baseline knowledge on biofouling community characteristics in tropical waters of Indonesia. Biofouling panel settlements are deployed at Madura Strait, East Java, with varying duration of observation, different sea depths, and different types of material substrates. Preliminary results show that barnacles mostly dominated the panel settlement after the first month. The abundance of biofouling organisms in the first 1-month observation (April 2022) was higher compared to the second and third 1-month observations, deployed in May and June, respectively. Moreover, the 2-month observation data collected from April to May 2022 showed more diverse organisms compared to the 1-month observation with the discovery of calcareous tubeworm, Bryozoa, molluscs, sea cucumber, and sponge. Less biofouling accumulation was observed at 5m depth compared with 4m. In terms of material substrates, PVC, bamboo, and anticorrosion paint-coated steel experienced the same pattern of biofouling abundance, while antifouling paint-coated steel experienced little biofouling accumulation. This ongoing project will provide a knowledge base of biofouling community characteristics in Indonesia, that could help inform the design and development of marine energy technologies.

BIOFOULING OBSERVATION IN TROPICAL WATERS OF INDONESIA FOR MARINE RENEWABLE ENERGY SECTOR

Agung Iswadi*, Joanne S. Porter, Michael C. Bell
International Centre for Island Technology, Heriot-Watt University, Orkney

INTRODUCTION

Biofouling, as a major concern in the maritime industry, has become an issue for the marine renewable energy sector since around 2 decades ago when the industry entered commercialisation stage. However, investigation on biofouling impacts on marine energy devices in tropical waters of Indonesia is very limited. This limited knowledge of technical aspects could challenge the promotion of local technologies to develop further into the next stage of development. This study aims to provide baseline knowledge on biofouling community characteristics in tropical waters of Indonesia.



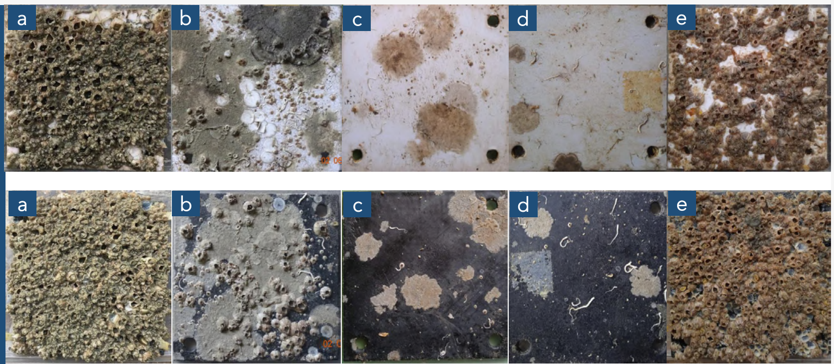
Competitive interaction of fouling organisms observed on anticorrosion-coated steel (A), uncoated steel (B), PVC (C), and bamboo (D) panels

METHOD

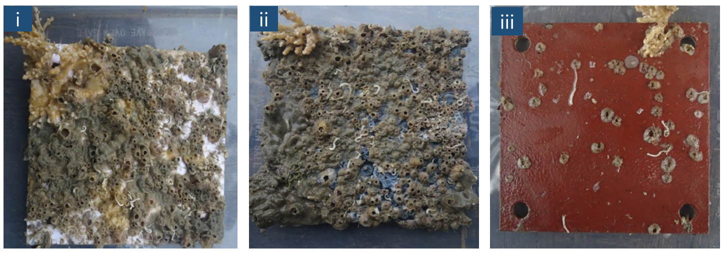
Biofouling settlement panels are deployed at Madura Strait, East Java, with varying duration of observation, different sea depths, and different types of the material substrate.

KEY FINDINGS

- *Barnacles mostly dominated the settlement panels after the first month.*
- *Biofouling settlement was abundant in the first 1-month observation panel (April 2022), decreased in May, June, and July, and became abundant again in August.*
- *Calcareous tubeworm, Bryozoa, molluscs, sea cucumber, sponge, and soft coral were found in the 2-month and 3-month observation panels.*
- *Competitive interaction of biofouling organisms with more diverse species is more clearly observed with the longer duration of submersion.*



Monthly observation of biofouling attachment: April (a), May (b), June (c), July (d), and August (e) for PVC (above) and anticorrosion-coated steel panels (below). Note that each panel has been immersed for one month's duration



2-month observation panels (above) for PVC (i), anticorrosion-coated steel (ii), and antifouling-coated steel (iii).

3-month observation panels for PVC (I) and anticorrosion-coated steel (II)

CONCLUSION

This ongoing project will provide a knowledge base of biofouling community characteristics in tropical waters of Indonesia, that could help inform the design and development of marine energy technologies.

Acknowledgement

Directorate General of Higher Education, Research and Technology, the Ministry of Education, Culture, Research, and Technology, Indonesia

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An elastomeric model system for assessing the contribution of physico-mechanical properties of marine biofilms to drag

Alexandra Jackson[1], Shi-Qi An[2], Alistair Finnie[3], Marie Dale[3], Simon Dennington[1], Jennifer Longyear[3], Julian Wharton[1] and Paul Stoodley

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[3] AkzoNobel/International Paint Ltd., Gateshead, United Kingdom
[4] Departments of Microbial Infection and Immunity and Orthopaedics, The Ohio State University, OH, Columbus, USA

ABSTRACT

It is hypothesized that the physico-mechanical properties of biofilms are significant in contributing to ship drag yet the relative contribution of viscoelasticity, heterogeneity and roughness is not known. Rigid and homogenous structures are often used as references for studying biofilm-associated drag, yet do not account for material compliance. The main objective of this study was to design a synthetic model biofilm, with well-characterized mechanical and surface properties, for studying the effect of compliance and roughness on drag. A compliant elastomer and a rigid material were used to generate surfaces replicating different grades of sandpaper roughness. Drag coefficients (Cf) were calculated from pressure drop velocity measurements in flow cell experiments. Physico-mechanical properties of the materials were calculated from in-situ Optical Coherence Tomography (OCT) imaging of roughness features deforming under flow. The shear modulus of the compliant elastomeric model biofilm ranged from 79 - 279 Pa, within an order of magnitude of that for marine biofilms cultivated in-field. Further the compliant replicas induced up to a 52 % increasing in Cf when compared to the rigid counter-parts of the same surface roughness. The relative contributions of biofilm geometry and mechanics to frictional drag can be studied in isolation by utilising a synthetic biofilm system, such as is presented in this study, and a tailored surface design. A better understanding of biofilm fluid-structure interactions and the contribution of biofilm compliance to drag could improve predictions of biofilm-associated drag at ship scale, as well as inform of the development of future fouling control coatings.

AN ELASTOMERIC MODEL SYSTEM FOR ASSESSING THE CONTRIBUTION OF PHYSICO-MECHANICAL PROPERTIES OF MARINE BIOFILMS ON DRAG

ALEXANDRA SNOWDON, SHI-QI AN, ALISTAIR FINNIE, MARIE DALE, SIMON DENNINGTON, JENNIFER LONGYEAR, JULIAN WHARTON, PAUL STOODLEY

AkzoNobel National Biofilms Innovation Centre University of Southampton

On ships biofilms induce hydrodynamic drag, which has costly economic and environmental consequences (1). As a result, it is important that we understand which biofilm characteristics contribute to drag so that their presence can be managed or prevented. Due to biofilm heterogeneity, it is difficult to link properties to drag, therefore rigid structures are often adopted as they can successfully simulate roughness; however, rigid systems fail to capture mechanical properties, such as elasticity, which are thought to be important in influencing drag (2). We aim to build on rigid conventional models by proposing a fully synthetic and deformable model marine biofilm system (3).

AIMS

- To create a novel marine biofilm model using a reproducible casting and moulding method
- To quantify surface deformation using OCT images
- To determine the significance of elasticity and roughness on drag
- To rheologically characterize marine biofilms

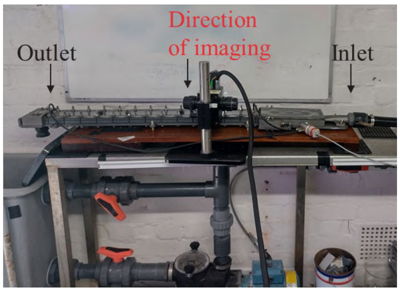

Fig. 1. Flow cell and OCT set up for simultaneous measurements of drag and deformation of the material sandpaper replicas.

METHODOLOGY

Synthetic system
- Mechanical characterisation of materials
- Casting and moulding of material sandpaper replicas

Flow experiments and imaging (Fig.1)
- Meso-scale flow cell (0.85m x 0.5m x 0.1m)
  - Drag measurements using friction factor
- Optical Coherence Tomography (OCT)
  - Shear modulus measurements using angles of deformation, Fiji

Validation of materials
- Marine biofilms grown in-house from in-field inoculate
- Rheometer testing (amplitude sweep, 1Hz)

ELASTICITY AND ROUGHNESS SIG. AFFECT DRAG

- On average, the elastomeric replicas caused a **52 % increase** in drag when compared to the rigid alternatives
- If the rigid line of best fit was used to predict drag associated with an elastic, or viscoelastic material then drag would be likely underestimated (Fig. 2).

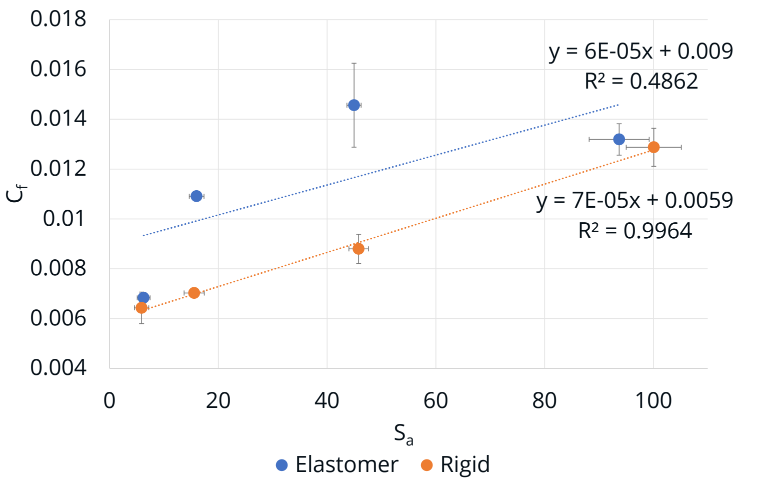

Fig. 2. Average drag (C_f) plotted against average surface roughness (S_a) for the elastomeric and rigid sandpaper replicas. A linear line of best fit has been applied.

REFERENCES:

1)SCHULTZ ET AL., 2011, DOI: 10.1080/08927014.2010.542809
2)HARTENBERGER ET AL., 2020, DOI: 10.1080/08927014.2020.1806250.
3)SNOWDON ET AL., 2022 (ACCEPTED)
4)PERKINS ET AL., 2012, DOI: 10.7158/M12-087.2014.12.1

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Funding Sources:
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AN ELASTOMERIC MODEL SYSTEM FOR ASSESSING THE CONTRIBUTION OF PHYSICO-MECHANICAL PROPERTIES OF MARINE BIOFILMS ON DRAG

ALEXANDRA SNOWDON, SHI-QI AN, ALISTAIR FINNIE, MARIE DALE, SIMON DENNINGTON, JENNIFER LONGYEAR, JULIAN WHARTON, PAUL STOODLEY

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AN ELASTOMERIC MATERIAL IS A BETTER SUBSTITUE THAN A RIGID MATERIAL FOR STUDYING DRAG

- The drag curves for the elastomer and rigid sandpaper replicas showed different behaviour with increasing *Re* (Fig. 3)
- The elastomer showed a plateau up to ~ 30,000 *Re* where it dropped; similar behaviour has been found for biofilms in the literature (4).

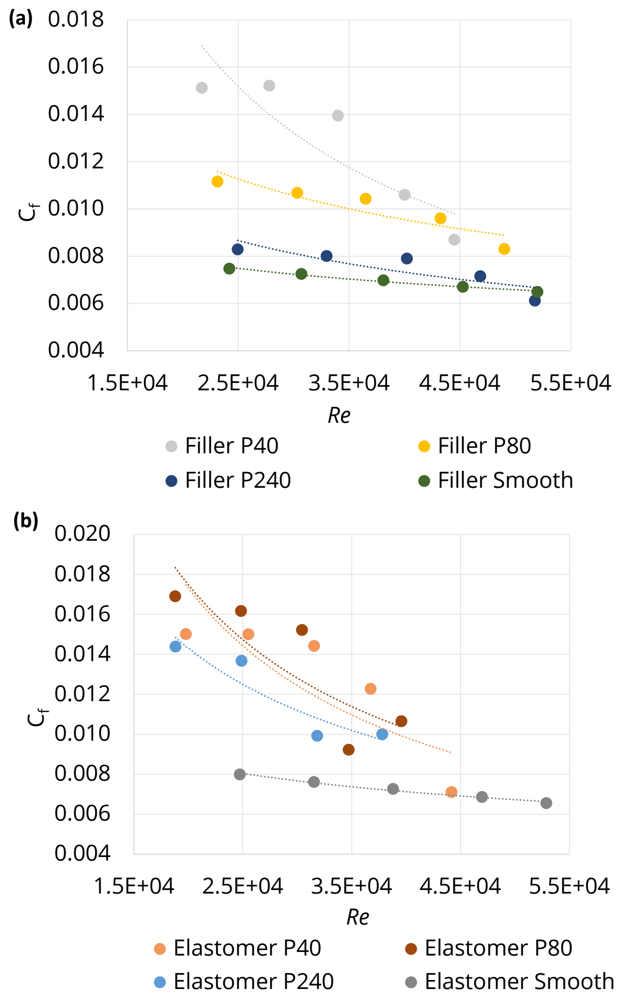

Fig. 3. C_f plotted against *Re* for the (a) rigid filler and (b) elastomeric sandpaper replicas

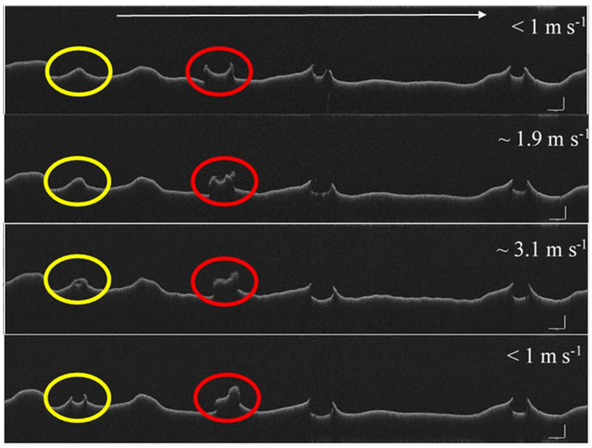

Fig. 4. Consecutive OCT 2D-scans of an elastomer P80 sandpaper replica, the red and yellow circles indicate areas of deformation under changing flow velocity (m s -1)

- OCT scans showed evidence of permanent deformation in the surface topography of the elastomeric sandpaper replicas (Fig. 4)
- The elastomeric material possessed a shear modulus within an order of magnitude of that for a marine biofilm
  - **Marine biofilm = 1 – 57 Pa (amplitude sweep, rheometer)**
  - **Elastomer = 79 – 279 Pa (angles of deformation, Fiji)**
  - **Rigid filler = 555 – 1763 Pa (angles of deformation, Fiji)**

CONCLUSIONS

- A successful, repeatable and novel method for studying the effect of physico-mechanics on marine drag has been proposed.
- An elastomeric material is more suitable for modeling and predicting marine biofilm behaviour than a rigid material
- **Mechanical behaviour**, such as elasticity**, cannot be neglected** when studying the drag of a deformable materials, such as a biofilm

REFERENCES:

1)SCHULTZ ET AL., 2011, DOI: 10.1080/08927014.2010.542809
2)HARTENBERGER ET AL., 2020, DOI: 10.1080/08927014.2020.1806250.
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Funding Sources:
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AkzoNobel

Comparative study of biofouling settlements on the boats and on the quay of the Port of Toliara (Southwestern Region of Madagascar)

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SUMMARY

Biofouling problems continue to be a global issue, hence this study conducted from February to June 2020. The main objective is to compare biofouling populations on the quay of the Port of Toliara Madagascar and on the hulls of ships on this quay.

To this end, three boats in the Port and two sites on the quay were studied, using a typical method for characterising benthic species populations. This method consists of inventorying and counting species on the boat hulls and on the wharf using a quadrat to extract abundance, dominance, bionomic classification, specific richness and diversity.

This study shows the great capacity of organisms to foul any type of submerged support, whether living (except for a few species of ascidians and sponges) or inert, covered with antifouling or not. Thus, out of 67 species recorded, some of which are potentially invasive such as the lower crustacean *Balanus amphritite*, only 11 were common to the dock and boats (e.g. the bivalve *Modiolus auriculatus).* The boat hulls, with 50 species, are richer and more diverse than the quay (29 species). Each stage of the phytosystem of the wharf is populated, dominated and characterised by different species; the most dominant species being *Chthamalus antennatus* (lower crustacean) and *Crassostrea cucullata* (bivalve). For the boats, the dominant species is the worm *Pomatoceros triqueter,* but the most characteristic species are all others *(Nereis diversicolor, Trididemnum cyclops, ...).*

Keywords: Comparison; biofouling; boats; quay; Port of Toliara

INTRODUCTION

The invasion of alien (or invasive) species is known to be the fourth greatest cause of environmental degradation after overexploitation of resources through fishing, chemical pollution and eutrophication and physical degradation of habitats, even ahead of climate change (Amara, 2010).

Among the vectors for the introduction and spread of alien species (species that have become naturalized in an ecosystem where they have never been recorded before (Rejmánek et al. 2002)), biofouling of ships' hulls plays a key role. This biofouling corresponds to the colonisation of any immersed surface in an aquatic environment (Watnick & Kolter, 2000; Kolter & Greenberg, 2006; Hamadouche N., 2003; Brading *et al.* 1995), whether it is a living being or not. It is a phenomenon known to all sailors since the existence of navigation (Anon, 1952) and it can be observed on any type of boat some time after it has been put to sea (Munk *et al*., 2009), whether it is a trawler, a sailing boat, a speedboat, an ocean liner or others (source: IUCN booklet).

One of the major obstacles in combating this problem, involving more than 4000 marine organisms (Yebra *et al.,* 2004), is that information on the dangers of transfer-mediated biofouling is poor or non-existent in many countries such as Madagascar, which is one of the twelve pilot countries selected by the International Maritime Organisation (IMO) to carry out the work of the GloFouling project aimed at strengthening the control and management of ship biofouling. The main objective of this study is to "compare the biofouling population on the hulls of ships and on the quay of the port of Toliara". The aim of the study is not to directly combat the problems linked to biofouling but to enrich the existing data in this field.

MATERIALS AND METHODS

The Port of Toliara was chosen as the site for this study. This port, located at Mahavatse with latitude -23°23′ and longitude 43°40′, is the second largest port in Madagascar and the most important of the ports along the coast of the Atsimo Andrefana Region. The port of Toliara can receive a large number of national and international ships and all types of cargo for import and export activities (source: APMF Toliara).

After a preliminary visit to the site, some bibliographies, webographies and semi-directive surveys of the personnel of organizations and/or companies working in the Port of Toliara, notably APMF, SEMS, SMOI and COMATO, were carried out. The method chosen for this study is the characterization of the populations of the quay and the boats by benthic species. This was done by inventorying and counting species on the boat hulls and on the quay using a 25cm x 25cm quadrat in order to extract abundance (Dajoz, 1971; Guille, 1971), dominance (Guille, 1971), richness and specific diversity (Shannon and Weaver, 1949; Ramade, 2008), and the bionomic classification of species in the different zones (Dajoz, 1971; Gentil, 1976).

At the level of this port, two parts of the quay (the first part or first site in calm mode accommodating national boats, and the second part or second site in semi-battered mode accommodating international boats) and three national boats in the first part of the quay (a SMOI launch, an APMF launch and a SEMS tug, the latter not yet having been repainted with antifouling after its last washing) were studied. These three boats have not moved from the port since their last wash 12 months ago, 3 months ago and 9 months ago respectively, apart from the SMOI boat which was in Anakao and Mangily before the study.

The sampling adopted was random sampling stratified vertically according to the tiering of the plant system (subdivision according to Olivier, 2018) and horizontally according to mode for the wharf; and random sampling stratified vertically according to the live-work and dead-work, and horizontally according to the four sides for the boats. The sampling effort depends mainly on the size of the wharf and the boats, as well as their accessibility. Thus, for the wharf, sixteen (16) samples were taken on each level of the plant system using a 25cm x 25cm quadrat, except for the infralittoral level of the second site which was inaccessible: eight samples in calm mode and eight in semi-battered mode. For the first two boats (launches), the first 12m long and 4m wide with a draught of 0.80m and the second 10.45m long and 3.65m wide with a draught of 1.20m, 24 samples were taken using the previous quadrat: 12 samples on the emerged part and 12 on the submerged part. For the second boat, six samples were taken randomly from each of the four sides of the boats: three from the surfaced area and three from the submerged area. For the first boat, however, the port side was inaccessible due to its position in relation to the port. In order to have the same number of samples on the first two boats, which are approximately the same size, the number of samples on the three accessible sides of the boat was increased. For the latter, eight samples were taken on each accessible side: four on the emerged part and four on the submerged part. The port side of the third boat was also inaccessible; for this boat, with its large size (29.18m long and 8.24m wide with a draught of 3.65m), 32 samples were taken: six samples for the bow, three of which were immersed and three emerged, and the same for the stern, and 20 samples for the starboard side of the boat: 10 on the immersed part and 10 on the emerged part.

The identification and counting of species were done directly on site for the wharf populations (except for the infralittoral stage), with samples taken (sampling by trial) to define the maximum and minimum size of each species, while for the boats the samples were taken and then identified, measured and counted in the laboratory of the Institut Halieutique et des Sciences Marines (IH.SM) of the University of Toliara Madagascar. This identification was done by observing the morphology of the species.

RESULTS

Overall presentation of the wharf and vessel populations

A total of 67 species have been recorded on the quay and the boats. These species are animals and plants of various phyla (molluscs, sponges, plathelminths, arthropods, annelids, echinoderms, bryozoans, chordates, algae and phanerogams) ranging in size from 0.1cm (*Chthamalus antennatus* Darwin, 1854) to 11cm (*Hyotissa hyotis* (Linnaeus, 1758)) for the wharf and from 0.1cm (*Siphorbis siphorbis*) to 10cm (*Hyotissa hyotis*) for the boats.

Of these species, 11 are common to the wharf and boats, considering juvenile crabs (a crab species not identified because of its small size) as a separate species. These species are *Crassostrea cuculata* (Born, 1778), *Modiolus auriculatus* Krauss, 1848, *Brachyodontes variabilis* (Krauss, 1848), *Hyotissa hyotis, Mytilus edulis* Linnaeus, 1758, *Pinctada margaritifera* (Linnaeus, 1758), *Balanus amphritite* Darwin, 1854, *Tetraclita porosa* (Gmelin, 1790), *Crapsus tenuicrustatus* (Herbst, 1783) and *Acanthophora spicifera* Borgesen, 1910. Thus, the remaining species are present on the quay but absent on the boats (17 species) and vice-versa (38 species) as shown in Table 1.

Table 1: List of species exclusive to docks and boats

Description	List of species
Species exclusive to the wharf	*Littorina scabra* (Linnaeus, 1758), *L. glabrata* Philippi, 1846, *L. pintado* (W.Wood, 1828), *L. lutea* (Philippi, 1847), *L. ziczac* (Gmelin, 1791), *Littorina sp, Nodilittorina pyramidalis* (Quoy & Gaimard, 1833), *Patella capensis* Gmelin, 1791, *Siphonaria normalis* Gould, 1846, *Nerita plicata* Linnaeus, 1758, *Morula granulata* (Duclos, 1832), *Thais sp, Gibbula umbilicalis* (da Costa, 1778), *Pedalion nucleus* (Lamarck, 1819), *Nereis sp,* *Chthamalus antennatus* and *Ulva lactuca* Linnaeus, 1753
Species exclusive to boats	*Trididemnum solidum* (Van Name, 1902), *Trididemnum cyclops* Michaelsen, 1921, *Ascidia sp, Ascidia virginea* Müller, 1776, *Mycale microsigmatosa* Arndt, 1927, *Didemnum maculosum* (Milne Edwars, 1841), *Didemnum sp1, Didemnum sp2, Ostrea edulis* Linnaeus, 1758, *Isognomon ephippium* (Linnaeus, 1758), *Pinctada radiata* (Leach, 1814), *Natica sp, Hinia sp, Nerita albicila* Linnaeus, 1758, *Phrikoceros mopsus* (Marcus, 1952), *Spongia sp, Myxilla austini* Ott, Reiswig, McDaniel & Harbo, 2019, *Striatobalanus sp, Plagusa squamosa* (Herbst, 1790), *Grammarus sp, Dikerogammarus villosus* (Sowinsky, 1884), *Lepas anatifera* Linnaeus, 1758, *Pomatoceros triqueter* (Linnaeus, 1758), *Spirorbis spirorbis, Nereis diversicolor* (O.F. Müller, 1776), *Nereis pelagica* Linnaeus, 1758, *Nereis sp1, Nereis sp2, Nereis sp3, Phascolosoma granulatum* Leuckart, 1828, *Phascolosoma sp, Holothuria scabra* Jaeger, 1833, *Bohadschia vitiensis* Semper, 1868, *Stichopus chloronotus* Barndt, 1835, *Hypnea rosea* Papenfuss, 1947, *Chlorodesmis sp* Harvey & Bailey, 1841, *Amphiroa fragilissima* (Linnaeus) J.V.Lamouroux, 1816, and *Syringodium isoetifolium* (Ascherson) Dandy, 1939.

Wharf populations

Divergences are also observed when comparing the two modes (calm and semi-battered) of the quay of the Port which are populated, characterized and dominated by different species despite some remarkable similarities. In fact, several species present in one mode are absent in the other and/or vice versa, and species present in the two modes generally have different bionomic classifications and different abundances, dominances, constancies and fidelities. The most noticeable variations are correlated with the change in the stages of the plant system, although other factors such as the nature of the substrate should also be taken into account as will be seen later.

The following tables show respectively the divergence between the species of the two sites on the quay, the list of the most characteristic and dominant species of the first site (with a quiet mode) and that of the second site (with a semi-battered mode) according to the levels of the plant system.

Table 2: Divergence between species at the two wharf sites

Characterisation	List of species
Wharf species present in quiet mode and absent in semi-battered mode	*Pinctada margaritifera, Littorina sp, Balanus amphritite, Nerita plicata, Mytilus edulis, Hyotissa hyotis*
Wharf species present in semi-battered and absent in quiet mode	*Littorina pintado, Nodilittorina pyramidalis, Littorina lutea, Siphonaria normalis, Brachyodontes variablilis, Gibbula umbilicalis, Thais sp, Nereis sp, Ulva lactuca*

Table 3: List of the most characteristic and dominant species of the first site of the quay according to the tiering of the plant system

Stations	Most characteristic species	Most dominant species
Supralittoral stage		*Littorina scabra*
Upper mediolittoral stage	*Littorina glabrata*	*Chthamalus antennatus*
Middle mediolittoral stage	*Mytilus edulis*	*Crassostrea cuculata, Chthamalus antennatus*
Lower mediolittoral stage	*Modiolus auriculatus*	*Crassostrea cuculata*
Infralittoral stage		*Acanthophora spicifera*

Table 4: List of the most characteristic and dominant species of the second site of the quay according to the tiering of the plant system

Stations	Most characteristic species	Most dominant species
Supralittoral stage		*Littorina scabra, Nodititorina pyramidalis*
Upper mediolittoral stage	*Littorina lutea, Siphonaria normalis*	*Chthamalus antennatus*
Middle mediolittoral stage		*Crassostrea cuculata*
Lower mediolittoral stage		*Tetraclita porosa*
Infralittoral stage	NA	NA

For the first site, the most characteristic species are observed in the different subdivisions of the mediolittoral stage. For the second site, however, the only two characteristic species were recorded on the upper mediolittoral stage. With a total of 28 species recorded for the quay, the mediolittoral stage is also the stage with the greatest species richness: 11 species for the lower mediolittoral, nine species each for the upper and middle mediolittoral, four species for the supralittoral, and three species for the infralittoral stage.

Of these species, in relation to the tiering of the plant system, the most dominant are *Littorina scabra, Nodititorina pyramidalis, Chthamalus antennatus, Crassostrea cuculata, Acanthophora spicifera* and *Tetraclita porosa*. If tiering of the plant system is not considered, however, the total dominance of species in the two modes of the wharf can be summarized in Figure 1.

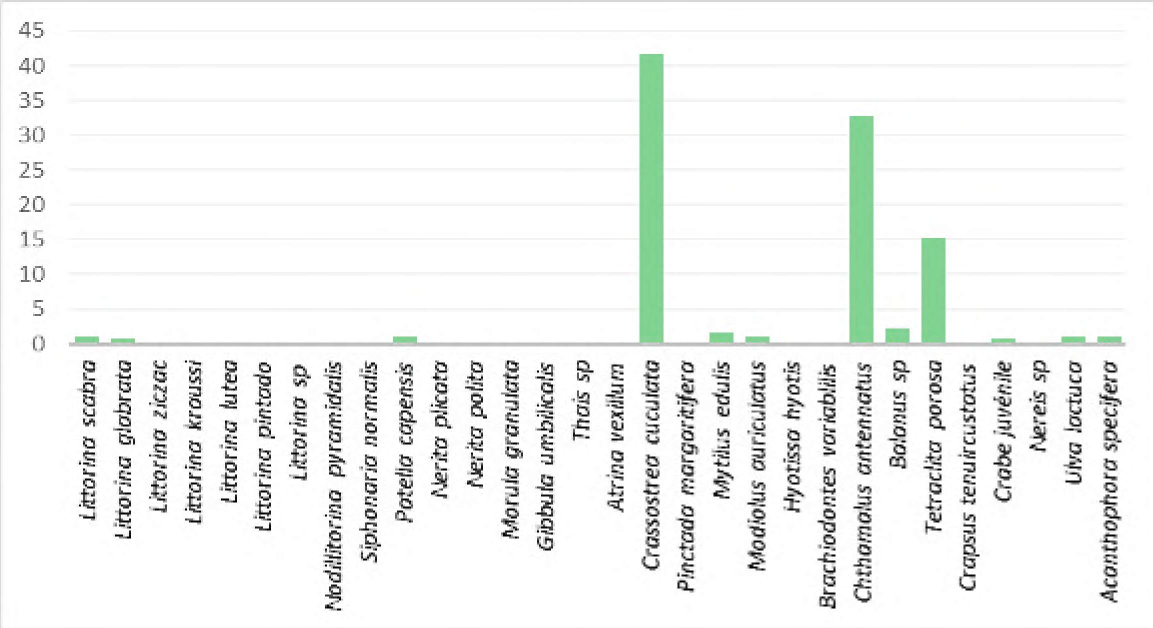

Figure 1: Dominance of species at the quay of the Port of Toliara.

It is seen that the most dominant species for both modes of the wharf are *Crassostrea cuculata* with a dominance of 42% and forming a belt-like biofacies along the mid-littoral stage, *Chthamalus antennatus* with a dominance of 33% and *Tetraclita porosa* with a dominance of 15%.

Vessel populations

For the boats, in general, it is seen that the emerged part of the boats is poor in species. Indeed, no species was observed on the SEMS boat and for the SMOI and APMF boats, only the species *Lepas anatifera* was inventoried on their bow. On the other hand, for the submerged part, several species were recorded, including those presented in table 1, of which the most characteristic and dominant are listed in table 5.

Table 5 List of the most characteristic and dominant species of boats in the Port of Toliara.

Stations	Most characteristic species	Most dominant species
SMOI boat	*Phrikoceros mopsus, Didemnum sp1, Ascidia sp, Myxilla austini, Crabe juvénile (non identifié), Nereis diversicolor, Nereis sp 3,*	*Pomatoceros triqueter, Tetraclita porosa*
APMF boat	*Trididemnum solidum*	*Pomatoceros triqueter, Tetraclita porosa*
SEMS boat	*Trididemnum cyclops*	*Pomatoceros triqueter*

This table shows the difference between the most characteristic species of the three boats. Seven characteristic species for the first boat, and one for the other two. The boat with the highest species richness (the greatest number of species) is the third with 36 species, followed by the first with 28 species, and the second with 25 species.

In relation to the sides of the boats, it is seen that those facing the sea and/or outside are more populated than the others and had a much higher abundance. The APMF boat had the highest number of individuals (3,003), followed by the SEMS boat (1,915). The SMOI boat had the lowest total abundance (1,624). In terms of most dominant species, however, the same species dominate all three boats. These are *Pomatoceros triqueter* and *Tetraclita porosa.* This dominance is shown in Figure 2.

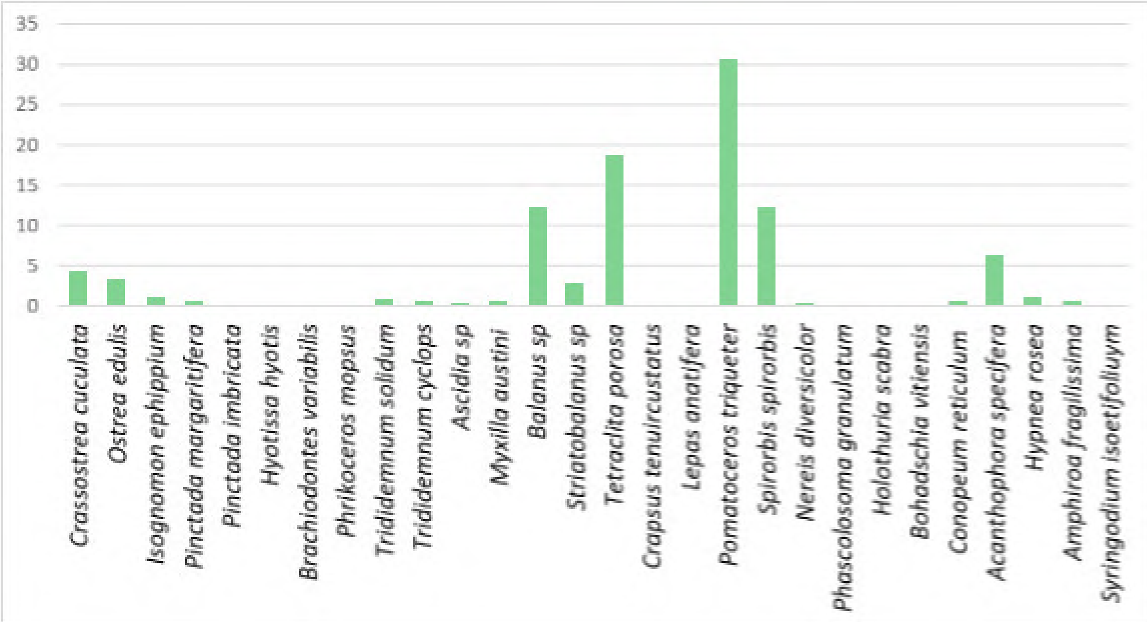

Figure 2: Dominance of species at the level of boats in the Port of Toliara.

It is seen that the most dominant species for the three boats are Pomatoceros triqueter with a dominance of 31% and *Tetraclita porosa* with a dominance of 18%, followed by *Balanus amphritite* and *Spirorbis spirorbis* each with a dominance of 12%.

Brief summary of the comparison of the wharf and boat populations

The diversity and equitability indices for the boats and the wharf have a low value, which may correspond to a stand in strong disequilibrium. These indices show the greater stability and equitability of the stands at the boat level compared to those at the wharf. Indeed, the diversity and equitability index of each boat is higher than the highest diversity index of the wharf (1.030 for the infralittoral stage of the calm mode); and the same is true for the equitability index, if the supralittoral of the second site is not taken into account.

In short, the populations of the boats are much richer and more diversified than those of the quay in general, except for the emerged part of the boats, which has only one species: *Lepas anatifera.* In fact, despite a greater number of samples taken at the quay, the boats have a higher species richness: 49 species on the boats and 27 species on the quay. The abundance of species on the boats is also much higher than on the quay. For the quiet mode, for example, with 40 samples, this site has 3,855 individuals, whereas 3,003 individuals were counted on the APMF boat with only 12 samples from the same quadrat. For the boats, the high abundance of organisms per quadrat is mainly associated with organisms growing on top of each other. The only species on which other organisms did not grow are ascidians *(Ascidia virginea, Ascidia sp, Trididemnum solidum, Trididemnum cyclops Didemnum maculosum, Didemnum sp1*, etc.) and sponges *(Spongia sp.).*) and sponges *(Spongia sp and Myxilla austini).* This overlap is also observed in the species of the mediolittoral and infralittoral stages of the wharf. Thus, above Crassostrea, Balanus, Tetraclita, Mytilus, Modiolus, etc., other organisms can be found (e.g. Pomatoceros, other Balanus and tetraclita, etc.).

In general, the parts that are constantly submerged and not coated with antifouling are covered with mud, both for the boats and the harbour quay, which briefly explains the presence of some characteristic soft substrate species on these parts. For the third boat, for example, this mud seems to have favoured the installation of plant and animal species of soft substrate such as *Acanthophora spicifera, Hypnea rosea, Syringodium isoetifolium, Dentalium sp, Holothuria scabra, Bohadschia vitiensis, Stichopus chloronotus, Nereis diversicolor, Nereis pelagica, Phascolosoma granulatum* etc. The metal parts that are constantly emerged are very low in species. This is the case of the boats, but also of the supralittoral stage of the second site of the quay.

DISCUSSION

The discrepancies observed between the wharf and boat stands, the wharf stands among themselves, and the boat stands among themselves are due to the variations in environmental conditions within the Port. When the ecological conditions at each station change, the composition of the settlement changes in parallel. Species such as Littorina will, for example, never be seen in environments that are constantly flooded, as these species thrive in non-drenched wetting or spray zones (Bellan-Santini *et al.*, 1994; Peres, 1961; Peres and Picard, 1958) such as the supralittoral and mediolittoral zone. Sponges and ascidians from the living works of boats will also, for example, never be observed in non-submerged areas as they cannot withstand dehydration and heating due to direct sunlight (Olivier, 2018), etc. It is also for this reason that the species common to the dock and the boats are those that live in the same conditions: middle and lower mediolittoral populations and the live work of the boats, species that can withstand long immersions and/or permanent immersions, etc. The settlement of an individual in a given environment always depends on several parameters, known as environmental parameters (Warwick, 1993). The same is true for variations according to mode (calm and semi-battered). Moreover, studies such as those by Annie *et al.* (1973) and Olivier (2018) show that the hydrodynamic capacity of the "mode" can vary the distribution of species, etc.

This diversity of ecological factors (abiotic and biotic) shows that different species are found at different locations in the Port despite the relatively low diversity and equitability index values. It is known that ecosystems with low diversity and/or richness are more vulnerable to natural and anthropogenic pressures (Worm *et al.* 2006). This is even seen at the microbial level: diversity guarantees the sustainability of microbial colonization (Walters *et al.* 2003). If the populations on the boats are richer, more stable and more balanced than those on the harbour quay, this must be due to the fact that the conditions are more stable (favourable) on the boats. This stability is also found in the infralittoral zone of the quay. The imbalance in the populations of the quay must be due to the strong dominance of certain species and the virtual absence of others.

The fact that species such as *Crassostrea cuculata, Chthamalus antennatus* and *Tetraclita porosa* can dominate a population is not unique to the Port wharf. Indeed, the fact that the oyster *Crassostrea cuculata* forms a belt-shaped biofacies is typical of the mediolittoral (Peres and Picard, 1964). Ostreidae beds, mainly consisting of the genus Crassostrea, are even among the remarkable features of warm seas (Peres, 1961). The barnacle *Tetraclita porosa* is also described in some books as being able to have a large cover in rocky substrate environments (Trang, 1962) such as the Port wharf. In terms of boat-dominating species, the polychaete worm *Pomatoceros triqueter* has long been considered the primary species responsible for biofouling (Crisp, 1965; OECD, 1967) and the barnacle *Balanus amphritite* is known to be the main fouling species in tropical waters (Shahdadi et al., 2014) in addition to being considered a ubiquitous species composing fouling in general (Rittschof, 2001). It is therefore not so surprising to see them dominating the boat population.

The high abundance of species in boats through the development of organisms on top of each other is not really something new, and in the evolution of communities, processes of succession (replacement of species over time) play a large, sometimes major role (Grigg, 1983). This is generally manifested by the installation and disappearance of certain organisms (Connell and Slatyer, 1977; Grigg, 1983) to achieve a certain stability. Moreover, over the course of succession, the composition of fouling species changes continuously in response to variation in biotic and abiotic factors (Greene and Schoener, 1982; Lin and Shao, 2002). Khosravi *et al,* (2019) confirms this by admitting the existence of changes in biofouling communities throughout the year. Nevertheless, the development of biofouling on a surface is always the net result of several physical, chemical and biological factors (Delauney *et al.*, 2010): temperature, conductivity, pH, dissolved oxygen content, organic matter content, hydrodynamic conditions, location, season, light and therefore depth, etc. The fact that no species grows on sponges and ascidians may suggest that these organisms possess a means of combating biological fouling. This possession of certain organisms is known and has been the subject of some studies for the purpose of manufacturing antifouling (Briand, 2009; Dobretsov and *al.*, 2013).

By analysing various works, it can be concluded that the mud on the constantly immersed parts corresponds to the bacterial biofilm that occurs in most cases of fouling (Delauney *et al.,* 2010; Rittschof, 2001; Dobretsov, 2010; Wahl *et al.,* 2012). Indeed, the constantly submerged parts are favourable to the installation of biofilm (Thibaut, 2014; Ahlem, 2014; Boles, 2011): this is the case for the three boats and the infralittoral stage of the Port. However, in the first two boats, the antifouling paint seems to have inhibited the formation of this film. This is normal since antifouling paints generally target specific organisms (e.g. inhibition of the growth of marine bacteria and fungi by the use of Flexiline as an antifouling according to Paul & Fenical, 1986) which in most cases are the biofilms or microfouling considered by several researchers to influence macrofouling in general.

In short, despite everything, since the boats did not move after being washed, apart from the SMOI boat, it is important to stress that the species not found on the wharf but found on the boats are still Port species. Furthermore, most of the species not found on the wharf but present on the boats are seen in the study by Plante (1963). Indeed, ascidians *(Didemnum sp)*, sponges (unspecified), oysters *(Pinctada radiata)* and even organisms such as bryozoans, are all cited in his study as species of the infralittoral stage of the quay in the Port of Toliara. Although it is difficult to determine exactly which of the species recorded in this study are invasive within the Port, some known invasives outside Madagascar can be cited: *Didemnum sp* (IUCN, 2019), *Lepas anatifera* (Jensen and Kathe, 2010), *Balanus amphritite* (Reise *et al.*, 1999), *Pinctada imbricata radiata* (Jamila, 2015), *Mytilus edulis,* etc.

CONCLUSION

The problems generated by biofouling are far from being solved. Nevertheless, studies such as this one have been started in biofouling management and control pilot sites such as Madagascar. This study, carried out from February to June 2020, has as its main objective to compare the biofouling populations on the hulls of ships with those on the quay of the Port of Toliara. It allows a better understanding of biofouling and highlights the disparity and similarity of benthic species populating the quay and the boats within the Port of Toliara.

All substrates are affected by biofouling whether they are covered with antifouling or not, whether they are made of metal or other materials. The diversity of the ecological conditions and/or parameters of the port influence the structure, the specific richness, the specific diversity as well as the equitability of the biocenosis of the port, both on the port structures and on the hulls of the ships. Thus, of the 67 species recorded, some of which are potentially invasive *(Pinctada radiata, Balanus amphritite, Didemnum sp,* etc.), 11 are common to the quay and the boats, 17 are exclusive to the quay and 38 are exclusive to the boats,

In general, the boat stands are richer, more stable and more balanced than the wharf stands, and have more characteristic species. This is generally manifested by the highest number of species in the boats (50 species for the boats, compared to 29 species for the wharf), the highest diversity indices (between 2.67 and 3.03 for the boats, and 0.25 and 1.03 for the wharf) and the highest equitability indices (between 0.23 and 0.28 for the boats; and 0.02 and 1 for the wharf). The populations of the wharf vary mainly according to the level of the plant system (supralittoral, upper mediolittoral, middle mediolittoral, lower mediolittoral and infralittoral); each level being populated, dominated and characterised by different species, the most dominant of which in the wharf are *Chthamalus antennatus* and *Crassostrea cuculata,* while the most characteristic species are: *Littorina glabrata* for the upper mediolittoral, *Mytilus edulis* for the middle mediolittoral and *Modiolus auriculatus* for the lower mediolittoral. For the boats, the greatest distinction observed is the poverty of the dead or emerged part (only one species: Lepas anatifera) and the great specific richness of the living or immersed part, where this richness amounts to forty-nine species (49 species). The most dominant species in the three boats is the *Pomatoceros triqueter.* As for the most characteristic species in each boat, *Phrikoceros mopsus, Didemnum sp1, Ascidia sp, Myxilla austini, Nereis sp 3, Nereis diversicolor* and juvenile crabs were observed in the first boat, *Trididemnum solidum* in the second, and *Trididemnum cyclops* in the third.

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ANNEXES

Annex 1: Bionomic classification table for each species present in the calm mode site of the quay of the Port.

Bionomic classification	Species more characteristic of the stand	Characteristic but rare species of the stand	Tolerant species with wide distribution and no stand characteristics	Species too rare to be considered characteristic of the stand	Species with no apparent characteristics
Supralittoral			*Littorina scabra*	*Littorina sp*	
Upper mediolittora	*Littorina glabrata*	*Littorina ziczac, Atrina vexillum*	*Patella capensis, Chtamalus antennatus*		*Littorina scabra*
Mid-littoral	*Mytilus edulis*	*Morula granulata,*	*Chtamalus antennatus, Balanus sp, Crassostrea cuculata*	*Nerita plicata,*	*Juvenile crab, Modiolus auriculatus*
Lower mediolittoral	*Modiolus auriculatus*		*Tetraclita porosa, Crassostrea cuculata,*		*Hyotissa hyotis, Acanthophora spicifera*
Infralittoral			*Hyotissa hyotis*		*Pinctada margaritifera, Acanthophora spicifera*

Annex 2: Bionomic classification table for each species present in the semi-battered site of the quay of the Port.

Bionomic classification	Species more characteristic of the stand	Characteristic but rare species of the stand	Tolerant species with wide distribution and no stand characteristics	Species too rare to be considered characteristic of the stand	Species with no apparent characteristics
Supralittoral				*Nodillitorina pyramidalis*	*Littorina scabra*
Upper mediolittora		*Littorina lutea, Siphonaria normalis*	*Littorina scabra, Chthamalus antennatus*	*Littorina pintado*	*Littorina pintado Littorina glabrata, L. ziczac, Patella capensis, Pedalion nucleus, Atrina vexillum*
Mid-littoral			*Tetraclita porosa, Patella capensis, Crassostrea cuculata*	*Brachyodontes variabilis, Gibbula umbilicalis, Thais sp, Nereis sp, Ulva lactuca*	*Chtamalus antennatus, Juvenile crab, Morula granulata, Modiolus auriculatus*
Lower mediolittoral			*Tetraclita porosa, Crassostrea cuculata*		*Modiolus auriculatus, Morula granulata, Acanthophora spicifera*

Annex 3: Bionomic classification table for each species present on the three vessels in the Port of Toliara

Bionomic classification	Species more characteristic of the stand	Characteristic but rare species of the stand	Tolerant species with wide distribution and no stand characteristics	Species too rare to be considered characteristic of the stand	Species with no apparent characteristics
SMOI boat	*Phrikoceros mopsus, Didemnum sp1, Ascidia sp, Myxilla austini, Juvenile crab, Nereis diversicolor, Nereis sp 3*	*Grammarus sp, Dikerogammarus villosus*	*Crassostrea cuculata, Ostrea edulis, Pinctada margaritifera, Balanus sp, Tetraclita porosa, Pomatoceros triquer, Acanthophora specifrea*	*Ascidia virginea, Mycale microsigmatosa, Lepas anatifera, Nereis sp 2, Hypnea rosea*	*Isognomon ephibium, Hyotissa hyotis, Trididemnum solidum, Siphorbis siphorbis, Nereis sp 1, Hypnea rosea, Conopeum reticulum*
APMF boat	*Tridídemnum solidum*	*Pinctada imbricata, Striatobalanus sp, Syringodium isoetifolium*	*Crassostrea cuculata, Ostrea edulis, Isognomon ephibium, Balanus sp, Tetraclita porosa, Pomatoceros triquer, Siphoribs siphorbis*	*Natica sp, Dentalium sp, Spongia sp, Plagusa squamosa*	*Pinctada margaritifera, Hyotissa hyotis Myxilla austini, Trididemnum cyclops, Grammarus sp, Juvenile crab, Acanthophora spicifera, Amphiroa fragilissima, Conopeum reticulatum, Didemnum sp1*
SEMS boat	*Tridídemnum cyclops*	*Striatobalanus sp, Phascolosoma granulatum*	*Crassostrea cuculata, Ostrea edulis, Pinctada margaritifera, Balanus sp, tetraclita porosa, Siphorbis siphorbis*	*Brachyodontes variabilis, Hinia sp, Nerita albicila, Didemnum maculosum, Didemnum sp 2, Nereis sp1, Nereis pelagica, Holothuria scabra, Bohadschia vitiensis, Stichopus chloronotus, Hypnea rosea, Clorodesmis sp*	*Isognomon ephibium, Pinctada imbricata, Hyotissa hyotis, Dentalium sp, Trididemnum solidum, Myxilla austini, Grammarus sp, Nereis diversicolor, Phascolosoma sp, Acanthophora spicifera, Amphiroa fragilissima, Conopeum reticulatum, Syringodium isoetifolium, Juvenile Crab, Pomatoceros triquer*

COMPARATIVE STUDY OF BIOFOULING SETTLEMENTS ON THE BOATS AND QUAY OF THE PORT OF TOLIARA

Ramamonjisoa Andriamirado Andy * (1), Ravelo Vololonavalona (1), Manera Jean Yves (1) and Raheriniaina Christian Edmond (1)

(*) Principal author
(1) Institut Halieutique et des Sciences Marines (IH.SM), Université de Toliara

INTRODUCTION

Biofouling continues to be a global problem. Indeed, despite advances in biofouling management, it remains one of the four impactful sources of marine degradation. This is due to its ability to introduce new species into an environment through the hull of ships.

One of the major bottlenecks in the fight against biofouling is currently the lack of information on the subject in many countries.

In this sense, this study, carried out from February to June 2020, aims to provide additional information on biofouling, particularly for Madagascar which is one of the pilot sites for this control.

The main objective here is to compare biofouling populations on ships and on the quay of the Port of Toliara.

METHODS

For this study, the port of Toliara was chosen because it is the second biggest port in Madagascar and the most important in the south of the country. This port can receive a large number of national and international vessels and all types of cargo for import and export activities. Its proximity to the laboratory of the Institut Halieutique et des Sciences Marines (IH.SM) is also one of its assets.

For this study, two quay sites and three boats were chosen. For the quay, the sites chosen are those hosting the Port's boats : one has a calm mode (site 1) and the other a semi-beaten mode (site 2). For the boats, those permanently parked in the Port were chosen in order to be able to carry out the study without constraints. These are two launches (boats 1 and 2) and a tugboat (boat 3).

The method chosen in this study is a typical method for characterising benthic species populations. This method consists of inventorying and counting species on the hulls of boats and on the quay using a quadrat (50cmX50cm in our case), to extract abundance, dominance, bionomic classification, specific richness and diversity.

In general, the inventory and enumeration at wharf level was carried out directly during the fieldwork if samples were taken from the boats due to the constant immersion of their live-work. Sampling was done in a stratified random fashion: stratified vertically according to the plant system's tiering and horizontally according to the mode for the wharf, and vertically according to the life opening and horizontally according to the sides for the boats. The sampling effort takes into account the size of the wharf and the boats but also their accessibility.

RESULTS AND DISCUSSION

A total of 67 species were recorded during this study. Of these species, 11 are common to the wharf and the boat: *Crassostrea cuculata, Modiolus auriculatus, Brachyodontes variabilis, Hyotissa hyotis, Mytilus edulis, Pinctada margaritifera, Balanus amphritite, Tetraclita porosa, Crapsus tenuicrustatus and Acanthophora spicifera.*

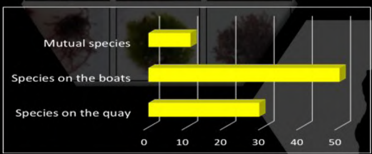

Fig. 1 : Number of species on the boats and on the quay of the Port of Toliara

Among all these species, some are known to be invasive outside Madagascar, such as *Didemnum sp, Lepas anatifera, Balanus amphritite, Pinctada imbricata radiata* and *Mytilus edulis.*

It is also observed that the majority of species responsible for biofouling are themselves subject to biofouling, except for ascidians and sponges such as *Trididemnum solidium, Trididemnum cyclops, Ascidia sp, Spongia sp, Myxilla austini*, etc.

Table 1: list of he most characteristic and dominant species on the first site of the quay (according to the plant system)

Stations	Most characteristic species	Most dominant species
Supralittoral stage		*Littorina scabra*
Upper mediolittoral stage	*Littorina glabrata*	*Chthamalus antennatus*
Middle mediolittoral stage	*Mytilus edulis*	*Crassostrea cuculata, Chthamalus antennatus*
Lower mediolittoral stage	*Modiolus auriculatus*	*Crassostrea cuculata*
Infralittoral stage		*Acanthophora spicifera*

Table 2: list of he most characteristic and dominant species on the second site of the quay (according to the plant system)

Stations	Most characteristic species	Most dominant species
Supralittoral stage		*Littorina scabra, Nodittorina pyramidalis*
Upper mediolittoral stage	*Littorina lutea, Siphonaria normalis*	*Chthamalus antennatus*
Middle mediolittoral stage		*Crassostrea cuculata*
Lower mediolittoral stage		*Tetraclita porosa*
Infralittoral stage	NA	NA

Table 3: List of the most characteristic and dominant species on the boats of the Port of Toliara

Stations	Most characteristic species	Most dominant species
Boat 1	*Phrikoceros mopsus, Didemnum sp1, Ascidia sp, Myxilla austini, Crabe juvénile, Nereis diversicolor, Nereis sp 3*	*Pomatoceros triqueter, Tetraclita porosa*
Boat 2	*Tridídemnum solidum*	*Pomatoceros triqueter, Tetraclita porosa*
Boat 3	*Tridídemnum cyclops*	*Pomatoceros triqueter*

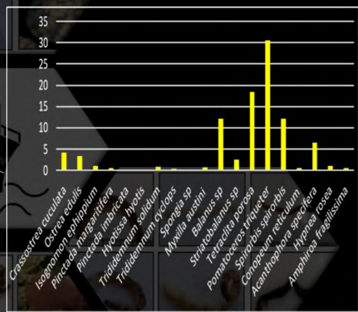

Fig. 2 : Species dominance on the boats of the Port of Toliara

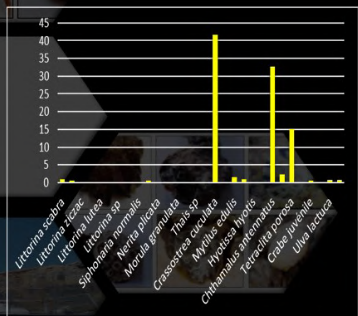

Fig. 3 : Species dominance on the quay of the Port of Toliara

CONCLUSION

The problems related to biofouling are far from being completely solved. Nevertheless, studies on the subject are beginning to be carried out on the large island and the results are providing a better understanding of the subject.

This study shows the disparity and similarity of benthic species inhabiting the quay and the boats.

Both substrates are affected by biofouling whether or not they are protected by antifouling, whether they are made of metal, concrete or other materials. Ecological factors such as the nature of the substrate, wetting, temperature, light, mode, etc. seem to be the main factors responsible for the structure of the populations both on the harbour structures of Toliara and on the hulls of the boats.

ACKNOLEDGEMENT

First of all, I would like to cordially thank my parents for financing and supporting this work and my studies in general. Secondly, I would like to thank each of my teachers, with a special mention for my supervisor, because if I am here, it is largely thanks to them. I do not forget my classmates who have always been there for me and helped me in the fieldwork.

Thanks to all of them.

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Challenges in managing aquatic invasive species risk in the maritime industry in the Philippines

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University of the Philippines Diliman, Quezon City, Philippines

ABSTRACT

The Philippines acceded to the Ballast Water Management Convention and the Anti Fouling Conventions in 2018. This obliges the country to implement protocols in reducing the risks in the translocation of aquatic invasive species (AIS) via maritime transport and industry. At present, at least 13 species of AIS have been recorded likely through ballast water release, with the tropical American charru mussel, *Mytella striata* documented to have significant ecological and economic impacts. Given the likelihood of further AIS introduction since the charru mussel was introduced in 2013, it is imperative that a risk management program be implemented soon. The SAILS Ballast Water and Biofouling Management Research Program has identified at least 10 possible AIS in five international ports. The recommended management approach is pathways management especially on domestic shipping routes. This will require efficient identification of AIS through eDNA technologies, rapid taxonomic identification through image recognition and analysis and continuing ecological monitoring of ports and harbors. The challenges the Philippines have is in developing the necessary technical capacity for port state authority in the Philippine Coast Guard, development of information systems for AIS ID and detection, ballast water and antifouling technology research and development. These will have to be given the necessary legal and policy instruments. In this paper, I outline the initiatives that been taken and the ways forward.

GLOFOULING RESEARCH & DEVELOPMENT FORUM AND EXHIBITION ON BIOFOULING PREVENTION AND MANAGEMENT FOR MARITIME INDUSTRIES
10-14 OCT 2022, LONDON, UK

CHALLENGES IN MANAGING AQUATIC INVASIVE SPECIES (AIS) RISK IN THE MARITIME INDUSTRY IN THE PHILIPPINES

BENJAMIN M VALLEJO JR, PHD
Institute of Environmental Science and Meteorology
University of the Philippines, Diliman

THE PHILIPPINE MARITIME INDUSTRY

One of the most active in the maritime industry thus, the introduction of species is high

29th maritime country among the top 35 flags of registration

183 accredited overseas maritime-related companies (total paid-up of PHP 3.3 billion)

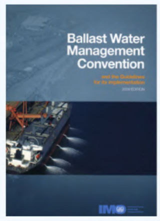
Vessel's average age Passenger: 18 years Cargo: 12 years

World's 5th largest shipbuilding country after China, Japan, Korea and Brazil

Vessels built before 2017 have no ballast water management system

LEGAL INITIATIVES

- Maritime Industry Authority (MARINA) advised the PH-flagged vessels to comply with the Ballast Water Management Convention of 2004. BWMC entered into force in 2017 and was ratified in 2018
- Compliance is necessary for long-term competitiveness. Non-compliance may remove PH from the IMO Whitelist.
- Policy recommendations have been sent to MARINA for implementation.



CHALLENGES IN MANAGING AIS

Development of information systems for AIS ID and detection

Failure to realize the potential ecological damage

Lack of extensive and comprehensive technical information

Unwillingness to interfere in the commerce and trade of exotic species

Mytella strigata

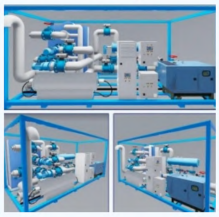
Failure of implementation of laws

Unregulated ballast water

CURRENT INIATIVES & PROGRAMS

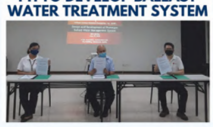
Implementation of the SAILS Ballast Water and Biofouling Management Research Program

1. Port and Ballast Water Baselines using Ecological, Microbiological and eDNA Approaches (PORTEC) Project



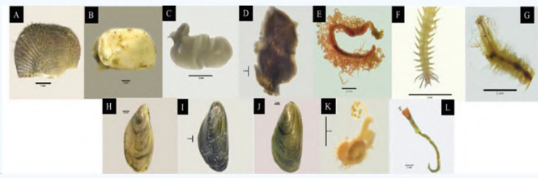
2. Developing a Prototype Ballast Water Management System (BWMS), a technology designed and currently being developed by local scientists and engineers

PH TO DEVELOP BALLAST WATER TREATMENT SYSTEM



Major Findings:

- 27 species of AIS have been recorded, with the tropical American charru mussel, *Mytella strigata*, documented to have significant ecological and economic impacts
- PORTEC has identified at least 10 possible AIS in five PH international ports



LONG-TERM STRATEGIC SOLUTIONS

Capacitating stakeholders through a multi-sectoral partnership

- Philippine Coast Guard
- Maritime Industry Authority
- DENR Biodiversity Management Bureau
- Academic institutions
- Corporate partners

The Importance of Latitude and Longitude in Developing a Ship Hull Grooming Management Plan

Geoffrey Swain and Melissa Tribou. Ocean Engineering, Florida Institute of Technology. Melbourne, Florida.

Jarema M. Didoszak and Sam Royster. Mechanical & Aerospace Engineering, Naval Postgraduate School, Monterey, California.

ABSTRACT

The proactive in-water grooming of fouling control coatings is now being considered as a management strategy to maintain ship hull coatings in a smooth and fouling free condition. This will reduce fuel consumption, exhaust gas emissions, the spread of invasive species and the discharge and damage to coatings associated with reactive underwater cleaning. The choice and frequency of grooming method will be determined by many factors including fouling control coating type, age, and condition; ship operational schedule; ship location and time of year. This study investigated the differences in grooming frequency required to maintain copper ablative, fouling release and toughened fouling release coatings free of fouling at a warm water location in Port Canaveral, Florida and a cold-water location in Monterey, California. The results demonstrated that a higher grooming frequency was required to maintain surfaces free of fouling at the warm water site for all coatings. It was also found that the copper ablation rate was less at the cold-water site. The successful implementation of a well-managed ship hull grooming program will require knowledge of the coating type and condition, the fouling pressure, the operational schedule of the ship and the selection of the appropriate grooming tool.

The Importance of Latitude and Longitude in Developing a Ship Hull Grooming Management Plan

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Dr. Jarema M. Didoszak and Lt. Sam Royster. Mechanical & Aerospace Engineering, Naval Postgraduate School, Monterey, California

FLORIDA TECH

Center for Corrosion and Biofouling Control

NAVAL POSTGRADUATE SCHOOL

INTRODUCTION

The proactive in-water grooming of fouling control coatings is now being considered as a management strategy to maintain ship hull coatings in a smooth and fouling free condition. This will reduce fuel consumption, exhaust gas emissions, the spread of invasive species and the discharge from and damage to coatings associated with reactive underwater cleaning. The choice and frequency of grooming method will be determined by many factors including; fouling control coating type, age and condition; ship operational schedule; ship location and time of year.

The influence of ship position in terms of latitude and longitude on the presence and recruitment of fouling to surfaces will influence how a grooming program is managed.

OBJECTIVES

This study investigated the differences in grooming frequency required to maintain copper ablative, fouling release and toughened experimental coatings free of fouling at a warm water subtropical location in Port Canaveral, Florida and a cold-water temperate location in Monterey, California.

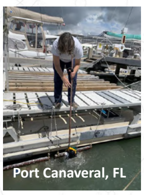
METHODS

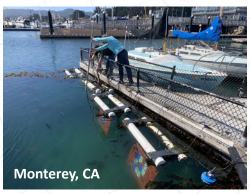
A total of forty-eight 10.2 cm x 20.3 cm (4"x8") panels were mounted on four frames and statically submerged at each test site. The 12 panels on each frame include three replicates of a copper ablative antifouling (Interspeed BRA 640), a fouling release coating (Intersleek 1100 SR) and two toughened experimental coatings. Each grooming frame was subjected to the following grooming frequencies using the Florida Tech patented suction brush design:

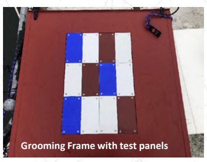
- once/week
- once/2 weeks
- once/4weeks
- ungroomed control.

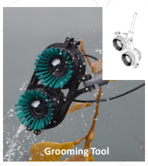
The panels were inspected once every 4 weeks to identify fouling recruitment, coating condition, and measure dry film thickness of the BRA 640. The test frames were deployed on 3 June 2021 in Port Canaveral and on 8 July 2021 in Monterey.

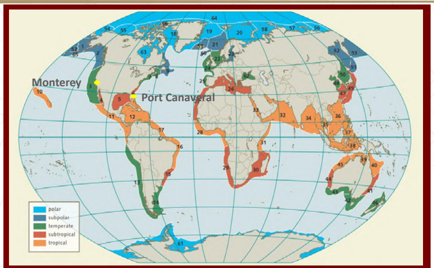
Test Sites and Methods


Port Canaveral, FL

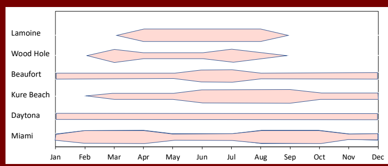

Monterey, CA


Grooming Frame with test panels


Grooming Tool



The coastal areas of the world's oceans have been classed into 66 large transnational marine ecosystems. Taken from World Ocean Review Living with the Oceans. 5 Coasts – 2017



Barnacle Recruitment at 6 sites on the East Coast USA
Redfield and Deevy, The Seasonal Sequence, Marine Fouling and Its Prevention 1952

RESULTS

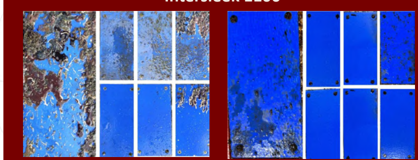
Biofouling Pictures

Left Ungroomed Control Panel
Top: Pre-grooming, once/week, once/2weeks, once/4weeks
Bottom: After Grooming, once/week, once/2weeks, once/4weeks

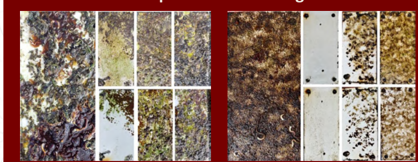
Port Canaveral, FL. August 2022 **Monterey, CA** April 2022

BRA 640

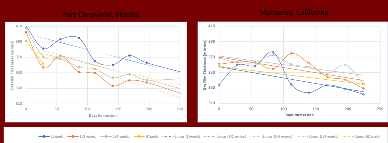
Intersleek 1100



Experimental Coating



Dry Film Thickness Changes for BRA 640



Treatment	Regression		DFT decrease/12 months (microns)		R^2	
	FIT	NPS	FIT	NPS		
once / week	0.20	0.15	75	53	0.75	0.35
once / 2 weeks	0.25	0.13	92	49	0.76	0.53
once / 4 week	0.22	0.11	80	40	0.73	0.60
Ungroomed	0.18	0.10	66	38	0.81	1.00

RESULTS

The results demonstrated that a higher grooming frequency was required to maintain surfaces free of fouling at the warm water site for all coatings. The copper ablative coatings required a grooming frequency of once a week in Florida to prevent recruitment by the copper tolerant barnacle *Amphibalanus amphitrite*. The same coating in northern California was kept free of macrofouling with a grooming frequency of once/4 weeks. A similar pattern was seen for the fouling release coating where grooming was required every 2 weeks to maintain the surfaces in Port Canaveral whilst once every 4 weeks was sufficient at Monterey. Grooming of the experimental coatings was more effective at the Monterey test site.

The change in dry film thickness was monitored for the copper ablative coatings. These readings are not precise; however, the data suggests that copper ablation rate was less at the cold-water site. These observations agree with prior research that has shown similar coatings to ablate faster in warm saline waters.

CONCLUSIONS

The successful implementation of a well-managed ship hull grooming program will require knowledge of the coating type and condition, the fouling type and pressure, the operational schedule and location of the ship and the selection of the appropriate grooming tool. The results from this study confirms that the grooming frequency required to maintain coatings free of fouling will be determined by the latitude and longitude and the fouling species present.

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Dynamics of Marine Bacterial Biofouling Communities after Initial Alteromonas genovensis Biofilm Attachment to Anti-fouling Paint Substrates

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[1]Library of Marine Samples, Korea Institute of Ocean Science & Technology, Geoje, 53201, Republic of Korea, [2]Risk Assessment Research Centre, Korea Institute of Ocean Science & Technology, Geoje 53201, Republic of Korea, and [3]Ballast Water Research Center, Korea Institute of Ocean Science & Technology, Geoje 53201, Republic of Korea.

ABSTRACT

To determine how bacterial communities succeed after the initial attachment of the bacterial biofilm adhesion using 16S rDNA meta-barcoding in plates coated with copper-based anti-fouling (AF) and non-AF (control) coatings as well as ambient seawater, coated plates were submerged in a marine environment in situ. Alteromonas genovensis (Gammaproteobacteria) in AF coating and Pacificibacter sp. (Alphaproteobacteria) in the control plate were initially abundant. In the AF coating, the abundance of A. genovensis decreased rapidly, whereas that of genus Phaeobacter (Alphaproteobacteria), Serratia (Gammaproteobacteria) and Cupriavidus (Betaproteobacteria) increased. Bacterial community in the control plate had a strong connection to pathogenic Vibrio spp. associated with the growth of invertebrates. Therefore, in the in-situ AF coating experiment, A. genovensis accumulation was initially and intensively increased, and the bacteria responded to chemical antagonism, induced the proliferation of specific biofilm bacteria, and influenced the interactions and recruitment of additional bacterial communities.

Dynamics of marine bacterial biofouling communities after initial *Alteromonas genovensis* biofilm attachment to anti-fouling paint substrates

Hyun-Jung Kim[1], Jung-Hoon kang[2], Kyoungsoon Shin[3], Seung Won Jung[1,*]
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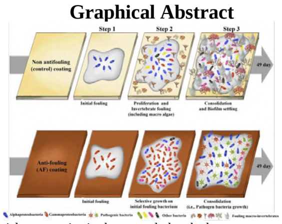
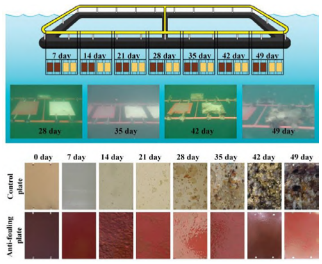
[2] Risk Assessment Research Centre, Korea Institute of Ocean Science & Technology, Geoje 53201, Republic of Korea
[3] Ballast Water Research Center, Korea Institute of Ocean Science & Technology, Geoje 53201, Republic of Korea.

Graphical Abstract



To determine how bacterial communities succeed after the initial attachment of the bacterial biofilm adhesion using 16S rDNA meta-barcoding in plates coated with copper-based anti-fouling (AF) and non-AF (control) coatings as well as ambient seawater, coated plates were submerged in a marine environment in situ. *Alteromonas genovensis* (Gammaproteobacteria) in AF coating and *Pacificibacter* sp. (Alphaproteobacteria) in the control plate were initially abundant. In the AF coating, the abundance of *A. genovensis* decreased rapidly, whereas that of genus *Phaeobacter* (Alphaproteobacteria), *Serratia* (Gammaproteobacteria) and *Cupriavidus* (Betaproteobacteria) increased.
Bacterial community in the control plate had a strong connection to pathogenic *Vibrio* spp. associated with the growth of invertebrates. Therefore, in the in situ AF coating experiment, *A. genovensis* accumulation was initially and intensively increased, and the bacteria responded to chemical antagonism, induced the proliferation of specific biofilm bacteria and influenced the interactions and recruitment of additional bacterial communities.

Material and methods



Schematic diagram of the in situ experiment of the vertical deployment settlement anti-fouling (AF, brown colour) and non-AF (control, yellow colour) coatings in seawater located at the Jangmok Bay Time-series Monitoring Site. Photographs indicate the time-series changes at weekly intervals in the biofouling communities between AF and control plates.

- The in situ experiment involving AF hull coatings was performed at the Jangmok Bay Time-series Monitoring Site (JBTMS, 34◦ 59′ 37′′ N and 128◦ 40′ 27′′) on the southern coast of South Korea for 49 days from 8 May to 26 June 2018.
- The iron plate (200 x 300 mm) that mimicked the ship's hull surface. The first group comprised the non-antifouling (control) plate coated with commercially available paint (Tie-Coat Primer, Permanent Painted Coatings Ltd., USA). The second group comprised the plate coated with AF components (Intersmooth 7475Si SPC, International Paint Ltd., Gateshead, United Kingdom). As per the manufacturer's safety datasheet, the active ingredient of Intersmooth 7475Si SPC was 3.43% w/w copper pyrithione and 37.45% w/w cuprous oxide.
- 16S rDNA meta-barcoding analysis of bacterial communities: The samples were subjected to a pre-filtering (3.0 μm) step to remove the organic and harvested using a 0.2 μm membrane. Genomic DNA was extracted using DNeasy Powersoil Kit (Qiagen, Valencia, CA, USA). The V3–V4 hypervariable region of bacterial 16S rDNA genes was amplified using universal Illumina-tagged primers.

Result

[Changes in the bacterial communities]

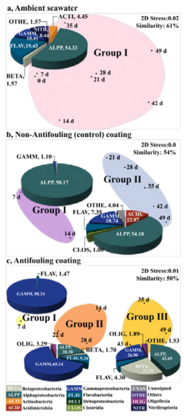
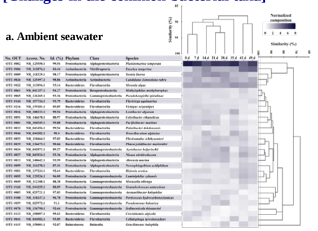


Fig 1. Non-metric multidimensional scaling (nMDS) plot and Venn diagram in the ambient seawater (a), the control plate (b) and the anti-fouling coating (c). nMDS plot was analysed using the Bray–Curtis similarity method. The pie charts indicate the high-ranking taxonomic distribution at the class level of the bacterial community.

- Fig. 1a) In the ambient seawater (similarity 61%), a single group comprised the communities of Alphaproteobacteria (54%), Flavobacteriia (20%), Gammaproteobacteria (10%) and other groups.
- Fig. 1b) In the control plate (similarity 54%), Group I was in the 'initial settlement stage (start–14 days)'; in this group, Alphaproteobacteria (98%) were dominant. Group II was in the 'irreversible adhesion stage (21–49 days)'. In this stage, the bacterial groups were more diverse than those in Group I; the diversities of Gammaproteobacteria, Acidimicrobiia, Flavobacteriia and Deltaproteobacteria were increased.
- Fig. 1c) In AF coating (similarity 50%), Group I was in the stage of 'biofouling formation by Gammaproteobacteria (start–7 days)'; in this group, Gammaproteobacteria were highly dominant (98%). Group II was in the 'early bacterial succession stage after biofilm formation (14–28 days)'. In this stage, the diversities of Alphaproteobacteria, Flavobacteriia, Oligoflexia and Betaproteobacteria were increased. Group III was in the stage of 'formation of a stable bacterial community', comprising Alphaproteobacteria (44%), Gammaproteobacteria (28%) and other groups. In particular, the predominant taxa were changed from Gammaproteobacteria to Alphaproteobacteria in this group.

[Changes in the common bacterial taxa]



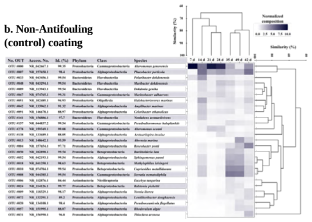
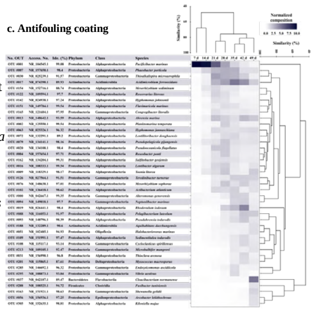


Fig 2. Heatmap showing the most abundant bacterial operational taxonomic units (OTUs) Each OTU displayed a relative abundance of >1% in at least one sample in the ambient seawater (a), the control plate (b) and the anti-fouling coating (c). Heatmap displayed the fourth-root-normalised data. Hierarchical agglomerative clustering using the group average of the most abundant bacterial OTUs using the Bray–Curtis similarity method.



- Fig. 2a) In the ambient seawater, the most dominant bacterium was *Planktomarina temperata*, with a mean abundance of 35%; the abundance of this taxon initially increased rapidly and then gradually decreased. *Euzebya tangerina* was the second most common taxon, with a mean of 8%; the abundance of this taxon was initially low and then continued to increase.
- Fig. 2b) In the control plate, *Pacificibacter marinus* in Group I was the most common taxon, with a mean relative abundance of 94%. In Group II, the abundances of a bacterium in *Acidimicrobium ferrooxidans*, *Rhodovulum iodosum* and *Ahrensia marina* were observed to increase continuously, with mean abundances of 12%, 6% and 3%, respectively.
- Fig. 2c) In AF coating, Group 1 was independently classified on the 7th day, *Alteromonas genovensis* was dominant, with a mean relative abundance of 97%. In Group II, the abundance of *A. genovensis* gradually decreased to 59%, whereas that of *Phaeobacter porticola* suddenly and rapidly increased to 16%. In Group III, the abundance of *A. genovensis* decreased to 8%, whereas that of *Serratia nematodiphila*, *Cupriavidus metallidurans* and *Roseobacter ponti* suddenly and rapidly increased. The abundance of *Phaeobacter porticola* persisted at 16%.

[Changes in the emergence of potential pathogenic bacteria]

- A total of 41 OTUs belonging to the pathogenic bacteria were identified, including Actinobacteria (2 OTUs), Chlamydiae (1 OTU), Firmicutes (1 OTU), Proteobacteria (36 OTUs) and Tenericutes (1 OTU) . Among the Proteobacteria, Gammaproteobacteria accounted for the majority.
- In the ambient seawater and the control plate, 24 and 29 bacteria, respectively, were identified. In AF coating, 19 bacteria were identified and among them, *Burkholderia lata*, *Cupriavidus metallidurans*, *Ralstonia pickettii* and *Serratia nematodiphila* accounted for >1%. In particular, *Burkholderia lata*, *S. nematodiphila* and *C. metallidurans* were present continuously from the beginning of the experiment, increased rapidly to 16%, 4% and 23%, respectively, on the 35th day and remained high until the end of the experiment.

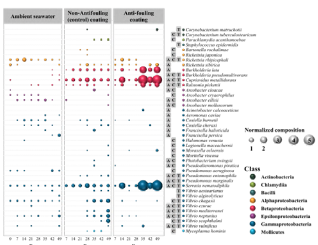
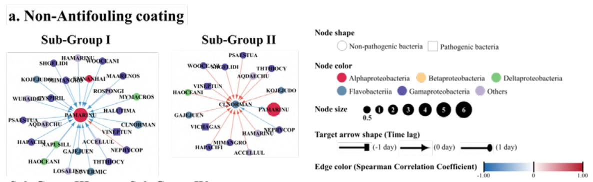


Fig 3. Time-series circle plot showing the potential pathogenic bacterial OTUs. The colours in circle plots and dimension corresponded to the bacterial classification groups and relative abundances (displayed the fourth-root-normalised data), respectively.



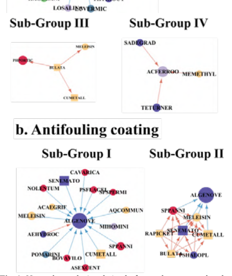


Fig 4. Network analysis derived from the most abundant bacterial operational taxonomic units (OTUs). Zoomed images are the sub-networks associated with the control plate (a) and the anti-fouling coating (b). Total network figures are presented in Supplementary Figure 3a, b and c. All nodes and edges were significantly correlated (P < 0.01, Q < 0.05).

[Co-occurrence of bacterial communities]

- Fig. 4a) When the control plate is divided into four sub-networks, the core-node of the first sub-network was *Pacificibacter marinus*, (PAMARINU) and was strongly associated with the other 26 OTUs. In particular, *P. marinus* co-occurred with *Neptunomonas* sp. (NEPHYCOP) and *Vibrio neptunius* (VINEPTUN). In the second sub-network, *Cloacibacterium normanense* (CLNORMAN) was significantly associated with 16 nodes, of which 9 were in Gammaproteobacteria. The third and fourth sub-networks were relatively simple compared with the first and second sub-networks.
- Fig. 4b) In AF coating, mainly comprised two sub-networks. In the first sub-network, *Alteromonas genovensis* (ALGENOVE) co-occurred with 15 nodes. In particular, *A. genovensis* co-occurred with four Betaproteobacteria and two Gammaproteobacteria. In the second sub-network, *Serratia nematodiphila* (SENEMATA) was connected to seven nodes (four Beta-, two Gamma- and one Alphaproteobacteria). In addition, *S. nematodiphila* was negatively correlated with *A. genovensis*, and it strongly co-occurred with *Burkholderia lata* (BULATA), *Cupriavidus metallidurans* (CUMETALL) and *Ralstonia pickettii* (RAPICKET).

[Bacterial putative function annotations]

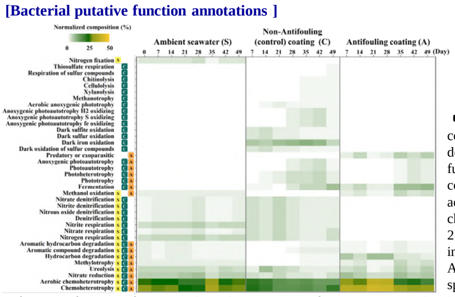


Fig 5. Time-series heatmap showing the metabolic functions during the changes in bacterial community composition through the functional annotation analysis of the prokaryotic taxa (FAPROTAX). Heatmap displays the fourth-root-normalised data of the bacterial read counts.

- The ambient seawater as well as control and AF coatings were defined in 17, 37 and 15 metabolic functions, respectively. The common metabolic functions were aerobic chemoheterotrophy and chemoheterotrophy, with a mean of 27% in the ambient seawater, 18% in the control plate and 32% in the AF coating. Each group had its specific metabolic characteristics: function of nitrogen fixation in the ambient seawater; functions associated with lysis, including chitinolysis, cellulolysis and xylanolysis and functions associated with oxidation, including H2, S, Fe, dark sulphur, thiosulphate and sulphur compounds in the control plate and predatory or exoparasitic functions in the AF plate. In particular, in the control plate, 'lysis'-related functions appeared on the 28th day and increased continuously until the end of the experiment.

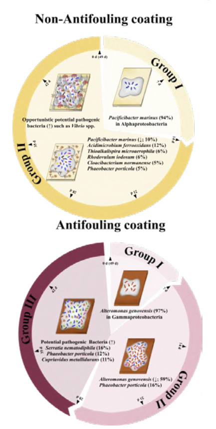


Fig 6. Conceptual schematic diagram of the changes in common bacterial OTUs between non-antifouling and antifouling coatings.

Discussion

(i) in early-stage adhesion, *A. genovensis* (Gammaproteobacteria) in AF coating and *Pacificibacter* sp. (Alphaproteobacteria) in the control plate were abundant. The intensive attachment of some Gammaproteobacteria (herein *A. genovensis*) on AF coating in the early stage may be associated with substrate-specific chemical responses on the coating. These specific bacteria associated with particular substrates exhibited specific stimulation and inhibition in response the released extracellular polymeric substances. This habitat may provide other bacteria an opportunity to promote or inhibit each other's growth. (ii) The abundance of *A. genovensis* decreased rapidly during the later stages in the AF coating, whereas that of Phaeobacter, *Serratia* and *Cupriavidus* sp. increased. This surge may provide a selective habitat in the biofilm formed by *A. genovensis* and may inhibit the growth of other bacteria. These selective organisms are not only potential human pathogens but are also known to be resistant to metals. On the control plate, the community was changed to *Cloacibacterium* sp., which had a strong connection with *Vibrio* spp. These *Vibrio* spp. appear to have emerged because of the increased attachment and growth of invertebrates, including scallops and bivalves. Therefore, in the in situ AF coating experiment, *A. genovensis* attachment was intensively increased on AF coating in the early stage and the bacterium responded to chemical antagonism, induced the proliferation of specific biofilm bacteria and influenced the interactions and recruitment of additional bacterial communities.

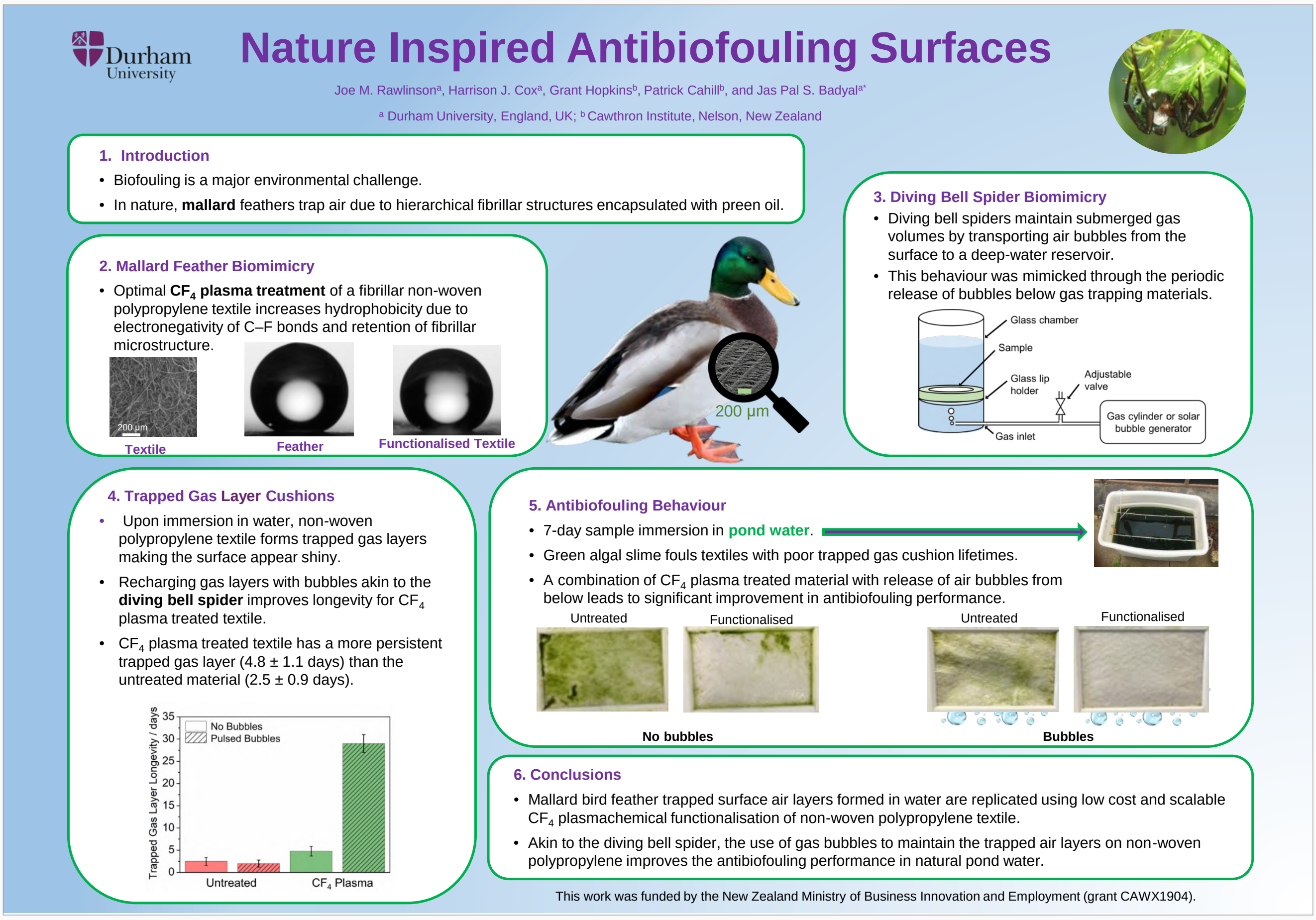
Nature-Inspired Antibiofouling Surfaces

Joe M. Rawlinson; Harrison J.Cox; Grant Hopkins; Patrick Cahill; Jas Pal S. Badyal

Durham University (UK) and Cawthron Institute (New Zealand)”

ABSTRACT

Biofouling (the settlement and growth of microscopic and macroscopic organisms on submerged surfaces) causes a range of problems for the maritime industries, including hydrodynamic penalties which increase fuel consumption of vessels, accelerated deterioration of surfaces through microbially-induced corrosion, increased drag and loading on static structures, and facilitating spread of invasive species across the globe. Developing eco-friendly methods to prevent such biofouling is a long-standing challenge that necessitates broad-spectrum activity against the large taxonomic diversity of biofouling organisms (of which over 4,000 species have been recorded to date). Achieving such broad-spectrum activity without causing collateral harm to the environment has proven elusive. In contrast, there are many well-documented examples of the absence of biofouling for natural world water systems. A range of innovative nature-inspired eco-friendly concepts will be described for antifouling applications. The developed methodologies also offer potential for use to increase the speed of high-performance watercraft and improve flow rates within pipework.



Low salinity water as biosecurity tool for the prevention of bioinvasion mediated by ships

Mauricio Peixoto Scapolatempore (Head of the Ballast Water and Biofouling Division at the Directorate of Ports and Coasts – Brazilian Navy);
Maria Cecilia Trindade de Castro (Chief of the Department of Environment for the Coast Zone at the Directorate of Ports and Coast – Brazilian Navy);
Fábio Bettini Pitombo (Departamento de Biologia Marinha - Universidade Federal Fluminense-UFF); and
Bernardo Antonio Perez da Gama (Programa de Pós Graduação em Biotecnologia Marinha - Instituto de Estudos do Mar Almirante Paulo Moreira-IEAPM/UFF).

ABSTRACT

In order to test the mortality and antifouling effect of low salinity water on ship's biofouling, we submitted previously fouled polyethylene panels, in replicates of five, to different salinity treatments (0, 7, 15 and 35) for two hours. After treatments, panels were photographed in high resolution and immediately hanged back at 1.5m depth, under a deck with low hydronamics and limited sunlight, at Guanabara Bay, Rio de Janeiro state, Brazil. Other sessions of photos were carried out one day, one week and one month after treatment. In each one of the eighty pictures, a hundred points were identified as close to the species level as possible, using the software PhotoQuad. The Shannon Diversity Index and the Bray-Curtis similarity analysis were performed on the softwares PAST and PRIMER 6, respectively. Results indicated a similar increase pattern in diversity over time for all treatments, and the same index between treatments, with higher variations towards lower salinities. Resemblance analysis showed two groups: salinities 0 and 7 (74% similar), and 15 and 35 (78% similar). The separation is mainly explained by lower abundances of the established ascidian Didemnum sp., the invasive Styela plicata, Hydrozoa sp., the established briozoan Bugula neritina and Bugula sp. in the low salinities' group. Although barnacle recruitment and polychaetes (mainly the invasive Hydroides elegans) increased in low salinities, so did mortality and blank spots. Results suggest the use of low salinity water could help preventing the spread of aquatic invasive species, acting as an environmentally friendly tool and improving biosecurity.

INTRODUCTION

It is estimated that more than 80% of the world's goods are transported by ship (UNCTAD, 2021). The increasing frequency and ease of operations of this type of transport has exacerbated the problem known as bioinvasion, allowing more and more species to cross naturally impassable biogeographic boundaries.

To tackle bioinvasion mediated by ships' biofouling, the International Maritime Organization (IMO) published the "Guidelines for the Control and Management of Biofouling on Ships to Minimize the Transfer of Aquatic Invasive Species", in 2011 (IMO, 2011), and GEF-UNDP-IMO lunched the GloFouling Partnerships project. As a member of the project, Brazil is acting towords the revision of the Guidelines, and the elaboration of its national standard.

In this context, the present work aims to understand whether low sanility water can be used in ship's niche areas as a feaseble biosecurity tool in the high productive waters of Guanabara Bay, Rio de Janeiro, Brazil.

MATERIAL AND METHOD

To test the mortality and antifouling effect of low salinity water on ships' biofouling, we submitted fouled panels to different salinity treatments (0, 7, 15 and 35) for two hours. Salinities were defined based on Castro et al. (2018).

To do so, a total of 20 polyethylene panels of 12 x 12 x 0.5 cm each were hanged on the Charitas

Naval Club's deck, in Niteroi city, Rio de Janeiro state (figure 1) on October 28, 2020. It was fixed at a 1.5 m depth, in a low light and hidrodynamic environment, simulating a vessel's niche area such as a sea cheast.

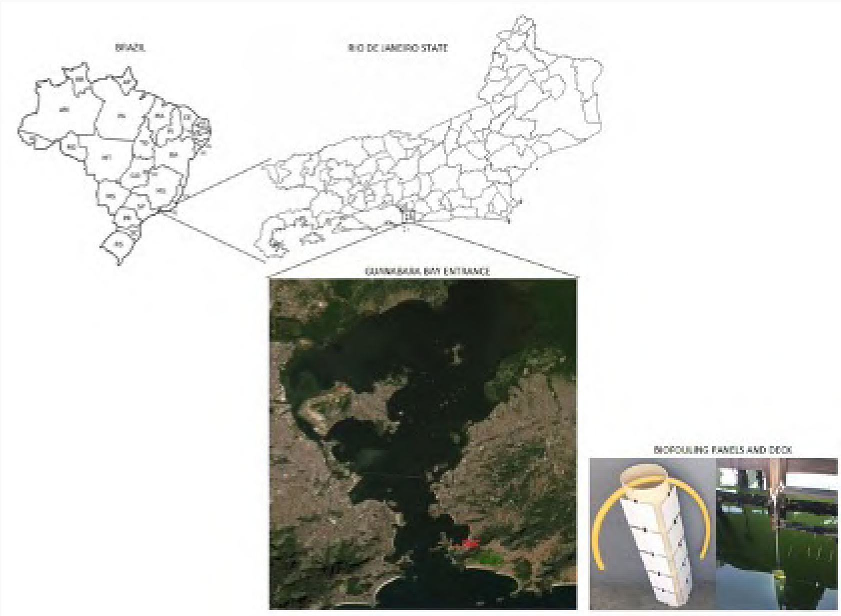


Figure 1 – Maps of Brazil, Rio de Janeiro State and Guanabara Bay, indicating the Charitas' Naval Club (CNC) (22°56'02.1"S 43°06'24.8"W) where panels were fixed for biofouling develpment and experiment was performed.

Four buckets containing local seawater mixed with fresh water, to achieve the disered salinities, were placed in a larger recepient with constant influx of the local seawater to maintain environmental temperature through water bath, as shown in figure 2.

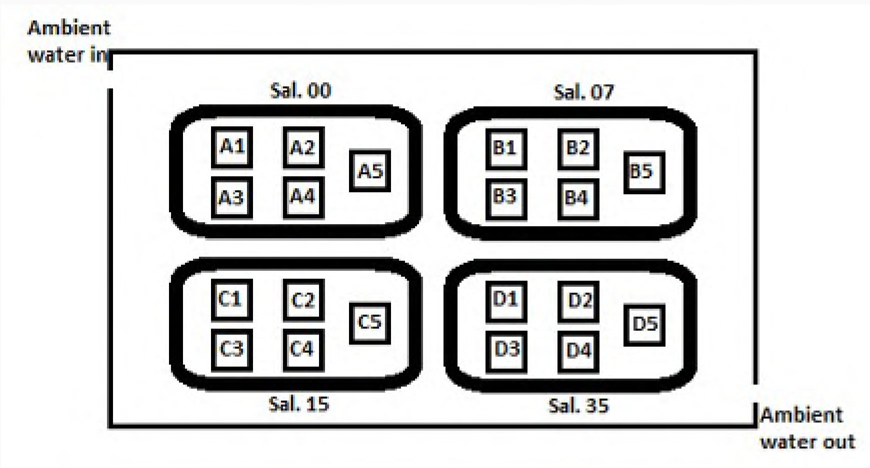


Figure 2 – Schematic draw of the experiment design.

Two hours after treatment, panels were photographed with a NIKON D7100, in a 4,000 x 6,000 pixels resolution, and fixed under the deck again. Other sessions of photos were carried out one day, one week and one month after treatment.

All 80 pictures were analyzed using the software PhotoQuad version 1.4, where each one had one hundred segmented dots identified as close to the species level as possible, for abundance quantification.

For diversity it was calculated the Shannon Diversity Index of each panel and treatment, and for resemblace it was performed the Bray-Curtis similarity analysis of square root transformed data from samples photographed one month after treatment. The aforemention routines were performed using the softwares PAST and PRIMER 6, respectively.

RESULTS AND DISCUSSION

The experiment started on February 14th, 2021, and after treatment, some panels already lost larger and less fixed organisms, such as the invasive ascidian Styella plicata, clearing visualization for more diverse 'hidden' assemblages, and, in some cases, clean surface patches, that were filled by polychaetas and barnacle recruits on the following weeks, thus also creating a more diverse sample. Hence, the observed increase in diversity over time pattern in figure 4.c can be explained by the release of larger organisms. This is more evident in lower salinities, such as zero and seven (figure 4.a). In general, results show similar index between treatments, yet, it is possible to notice lower diversity variation as salinity increases toward the control (salinity of 35) (figure 4.b).

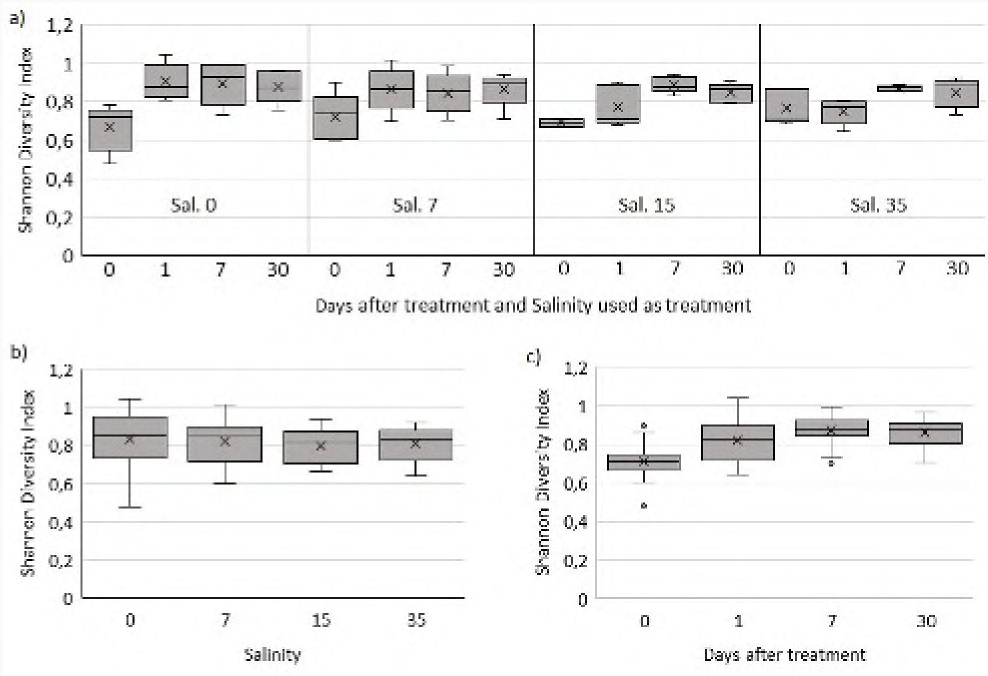


Figure 4 – Boxplot graphs of the Shannon Diversity Index for each treatment through time (days after treatment) (a); and against salinity treatment (b) and time (days after treatment) (c) alone.

The Multi-Dimensional Scaling - MDS (figure 5) shows the formation of two distinct groups with a threshold set to 70% of similarity: the 00-07 salinity group (low salinities' group); and the 15-35 salinity group (high salinities' group).

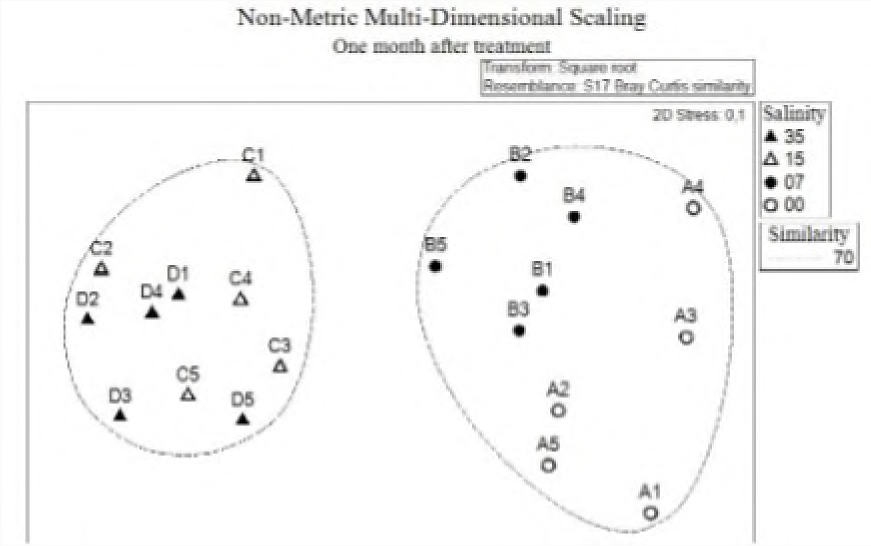


Figure 6 – Multi-Dimensinal Scaling of samples photographed one month after treatments. Data was square root transformed before performing the Bray Curtis Similarity Resemblance analysis. Doted line specifies groups with at least 70% similarity.

Simper analysis demonstrate the dissimilarity between these groups (41.94%) is mainly explained by lower abundances of the established colonial ascidian Didemnum perlucidum., the established bryozoan Bugula neritina, Hydrozoa sp., the invasive solitary ascidian Styela plicata, the detected bryozoan Bugula stolonifera, and the invasive anemone Diadumene lineata; and higher occurance of clean patches, polychaetes (mainly the invasive Hydroides elegans), dead organisms (Bugula neritina, B. stolonifera, D. lineata, Polydora sp., and barnacles), as well as barnacle recruits in the low salinities' group. This means sanilities under seven not only killed biofouling but also delayed fouling development one month after treatment. Data also matches field observations concerning lower abundance, rotten odor and appearance in lower salinities.

CONCLUSION

Results show high mortality of biofouling, including non-native especies, in salinities below 7, one month after a two hour treatment, suggesting the feasability of the use of low salinity water as an environmentally friendly tool to improve biosecurity in Guanabara Bay.

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United Nations Conference on Trade and Development (UNCTAD). 2021. *Review of Maritime Transport.* United Nations publication, 177p.

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MARINHA DO BRASIL

IEAPM

Universidade Federal Fluminense

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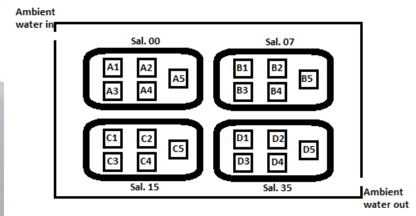

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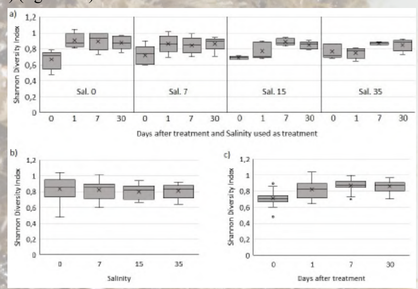

Figure 4 – Boxplot graphs of the Shannon Diversity Index for each treatment through time (days after treatment) (a); and against salinity treatment (b) and time (days after treatment) (c) alone.

The Multi-Dimensional Scaling - MDS (figure 5) shows the formation of two distinct groups with a threshold set to 70% of similarity: the 00-07 salinity group (low salinities' group); and the 15-35 salinity group (high salinities' group).

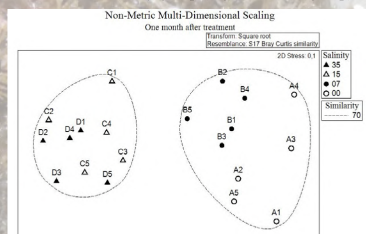

Figure 6 – Multi-Dimensinal Scaling of samples photographed one month after treatments. Data was square root transformed before performing the Bray Curtis Similarity Resemblance analysis. Doted line specifies groups with at least 70% similarity.

Simper analysis demonstrate the dissimilarity between these groups (41.94%) is mainly explained by lower abundances of the established colonial ascidian *Didemnum perlucidum.,* the established bryozoan *Bugula neritina*, *Hydrozoa sp.,* the invasive solitary ascidian *Styela plicata*, the detected bryozoan *Bugula stolonifera*, and the invasive anemone *Diadumene lineata*; and higher occurance of clean patches, polychaetes (mainly the invasive *Hydroides elegans*), dead organisms (*Bugula neritina*, *B. stolonifera, D. lineata, Polydora* sp., and barnacles), as well as barnacle recruits in the low salinities' group. This means sanilities under seven not only killed biofouling but also delayed fouling development one month after treatment. Data also matches field observations concerning lower abundance, rotten odor and appearance in lower salinities.

CONCLUSION

Results show high mortality of biofouling, including non-native especies, in salinities below 7, one month after a two hour treatment, suggesting the feasability of the use of low salinity water as an environmentally friendly tool to improve biosecurity in Guanabara Bay.

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Establishing Philippine port baselines using ecological, microbiological and molecular approaches

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ABSTRACT

The Philippines acceded to the International Maritime Organization Ballast Water Management and Anti-Fouling Conventions in June 2018. This obliges the Philippines to ensure that its ports and maritime transport industry will take measures to lessen the risk of biological invasion, public health threats and the transport and translocation of harmful marine organisms and pathogens. Creating a port baseline in the country is the first step to enact policies in compliance to the conventions. The PORTEC project is the Philippines' initiative for this which started in 2020 and will end in 2023. The study aims to establish port baselines using ecological, microbiological and molecular approaches. The ecological approach employs the use of PICES collectors, and foulers are classified using morphological investigation. The identity and quantity of collected biofoulers will be the basis for classification of invasive species. Unidentifiable organisms (cryptic species) are classified by DNA sequencing and barcoding (single-species eDNA). Metagenomic DNA from port waters are analyzed using next generation sequencing (multiple species eDNA for eukaryotes and shotgun sequencing for prokaryotes). All collected data will be deposited in a Port Ecology (PORTEC) database. Initial results have shown the presence of invasive species Mytella charruana and potentially invasive ones such as Hydroides elegans, Brachidontes pharaonis, Mytilopsis sallei and Arcuatula senhousia, among others. The species of indicator bacteria in the D-2 standards are above acceptable counts. As the study progresses, more species are expected to be identified and the database to be generated will play a significant role in policy creation and implementation.

GLOFOULING RESEARCH & DEVELOPMENT FORUM AND EXHIBITION ON
BIOFOULING PREVENTION AND MANAGEMENT FOR MARITIME INDUSTRIES
10-14 OCT 2022, LONDON, UK

ESTABLISHING PHILIPPINE PORT BASELINES USING ECOLOGICAL, MICROBIOLOGICAL AND MOLECULAR APPROACHES

SAILS
Philippines Ballast Water and Biofouling Management Research

OCAMPO, MELODY ANNE B.
FACULTY, DEPARTMENT OF BIOLOGY, COLLEGE OF ARTS AND SCIENCES, UNIVERSITY OF THE PHILIPPINES MANILA, ERMITA, MANILA, PHILIPPINES
PROJECT LEADER, PORTEC PROJECT, DOST-PCIEERD

BACKGROUND

The Philippines acceded to the International Maritime Organization Ballast Water Management and Anti-Fouling Conventions in ***June 2018.***

- obliges the Philippines to ensure that its ports and maritime transport industry will take measures to lessen the risk of biological invasion, public health threats, and the transport of harmful marine organisms

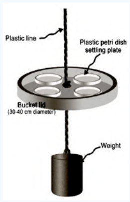
Creating a port baseline is the first step to comply to the conventions:

- the ***PORTEC Project is the Philippines' initiative*** for this which started in 2020 and will end in 2023

The research aims to establish port baselines using three approaches.

METHODOLOGY

Three approaches are utilized:

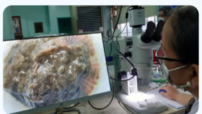


PICES collector

ECOLOGICAL APPROACH

- employs PICES collectors, foulers are classified using morphological investigation
- identity, quantity and distribution of non-indigenous biofoulers used as basis for classification of invasive species

MICROBIOLOGICAL APPROACH



- metagenomic DNA from port waters are analyzed using next generation sequencing (shotgun sequencing for prokaryotes)

MOLECULAR APPROACH

- used for unidentifiable organisms (cryptic species)
- classified by DNA sequencing and barcoding (single-species eDNA)
- also uses next generation sequencing

All collected data are deposited in a Port Ecology (PORTEC) database.

RESULTS

Initial results have shown the presence of invasive species *Mytella charruana* and potentially invasive ones such as *Hydroides elegans, Brachidontes pharaonis, Mytilopsis sallei* and *Arcuatula senhousia*.


Mytella charruana


Hydroides elegans


Brachidontes pharaonis


Arcuatula senhousia


Mytilopsis sallei

The species of indicator bacteria toxicogenic *Vibrio cholerae*, *Escherichia coli* and intestinal enterococci, in the D-2 standards are above acceptable counts.

As the study progresses, more non-indigenous species are expected to be identified and their modes of invasion can be modelled.

The database to be generated will be used by:

- Philippine Coast Guard (PCG)
- Maritime Industry Authority (MARINA)

as lead agencies in enacting IMO Conventions.

CONCLUSION

Port baselines are key in monitoring introduction and spread of nonindigenous species via maritime transport and performing risk assessments.

As more ports are studied by the PORTEC Project and analyses are being conducted for the data of each approach, a bigger picture of the port baselines in the Philippines is being drawn. This will be significant in policy creation in relation to IMO Conventions and their implementation in the country.

IMO INTERNATIONAL MARITIME ORGANIZATION · MARINA · UC university of cebu · ICTSI Foundation, Inc. · DOST-PCIEERD · REPUBLIC OF THE PHILIPPINES DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES BIODIVERSITY MANAGEMENT BUREAU

Remotely operated Hull-cleaning technologies: Reducing GHG emissions and damages to marine biodiversity, an asessment of impacts.

P. Berutti, M. Carneiro da Cunha, F. Maienza, M. Minnella

Faculty of Economics - University of Genoa,

ABSTRACT

The paper aims to describe the positive effects derived from the adoption of the latest hull cleaning solutions (remotely operated vehicles) on an environmental and economical level. Particularly, the employment of several new technologies already available and not yet exploited by the shipping sector. Indeed, major sustainability problems and economic inefficiencies are connected to poor antifouling and biofouling management, in particular, high levels of hull roughness cause:

- The spread of alien invasive species disrupting marine ecosystems.

- Increased GHG emissions of marine engines.

- Increased transport costs.

- Overall lower performances.

The study shows that a great amount of these effects can be reduced by ensuring the development of antifouling and biofouling management systems. For the shipping sector, we see the major advantages in the remotely operated in-water hull cleaning technologies, which can ensure that the hull cleaning is conducted in a fast, safe, and sustainable way, as well as in a less capital and time-consuming manner with respect to traditional techniques.

However, the complex legal framework and the highly specialized labour required are topics that still need to be addressed and clarified. Namely, the norms regulating hull cleaning activities inside port areas and the technical knowledge required to operate the machinery may threaten their adoption.

In conclusion, the paper shows that in-water hull cleaning is a ready, fast, easy, and reliable way of reducing GHG emissions while waiting for future and more comprehensive solutions that are in phase of development but not already employable

Remotely operated Hull-cleaning technologies:

Università di Genova

Reducing GHG emissions and damages to marine biodiversity, an asessment of impacts.

About the project and identifying the problem

This paper will guide the reader on a journey in search of sustainability in the Shipping sector with the description of the new disruptive technologies in Hull Cleaning. Biofouling is an "invisible" enemy that damages everyone:

- Shipowners that expend a large amount of money for Antifouling paints,
- Ship operators that pay an increased bill for the bunker and increased GHG emissions,
- Local Communities that have to deal with the negative externalities (e.g. maritime pollution)

Both academic literature and industry reports confirm that an increased level of Hull Roughness leads to a more than 10% increase in bunker consumption and GHG emissions.

With these assumptions, we think that the implementation of a Biofouling Management Plan is of paramount priority both for the shipping companies to control costs and to be compliant with coming regulations and for the Public Authorities to preserve their local communities.

Solution - Remotely operated Hull-Cleaning services

We consider Remotely Operated In-Water Cleaning as the best available solution to implement and exploit the benefits of future Biofouling Management Plans. The cleaning is delivered via a Remotely Operated Vehicle (ROV) that is launched by a land crew. With the help of vacuum pumps and magnetics, the ROV is attached to the vessel hull, and it is then piloted to remove biofouling and clean the ship. The main features of the service are:

- Highly specialized (Value Added Service)
- Mobile and flexible, easily transferable
- Fast, service delivered during vessel's port stay
- Safe and remotely operated
- Ensures biofouling capture
- Via soft jets, not distruptive

Did you know...

Inrcreasing BUNKER PRICE and volatility

Incoming REGULATION for GHG emissions

ALIEN INVASIVE SPECIES causes 12B/yrs damage in Europe

Bio State of California, New Zealand and Australia passed BIOFOULING CERTIFICATE laws

Ensuring Biofouling BIOMASS CAPTURE for circular economy

EMMP – Economia e Management Marittimo e Portuale

DIPARTIMENTO DI ECONOMIA – UNIVERSITÀ DEGLI STUDI DI GENOVA

UNIVERSITÀ DEGLI STUDI DI GENOVA

ecosubsea

Supervisor:
Prof. Roberto Garelli

Fellow researchers:
Pietro Berutti
Martim Carneiro da Cunha
Federico Maienza
Mirko Minnella

Remotely operated Hull-cleaning technologies:

Università di Genova

Reducing GHG emissions and damages to marine biodiversity, an asessment of impacts.

An implementation strategy

Nowadays, these innovative solutions are available only in some areas.
To exploit the benefits of extended use of hull cleaning services across the world fleet, the service network HAS to be expanded and SCALED-UP
Thanks to an implementation strategy we developed, we hope we can help the spread of new service centers, and show that the expansion of the service network is not only possible but also very profitable.
The PRIMARY TARGET of this service are vessels with high schedule reliability (mainly cruise ships, ferries, and RO-RO), to ensure a high utilization rate of the ROV, then it's important to start operations in a strategic area with high volumes of vessel calls (especially targeted sector) to take advantage of economies of scale.
Another crucial topic to assess concerns the legal aspects. Strong knowledge and understanding of local and international regulations is essential for a correct business set-up. Indeed, most ports already have a specific procedure for garbage or ballast water treatment as well as areas where emissions are closely monitored (SECA and NECA). Specific norms regarding hull cleaning are common and further developments are "underway".

S

EASILY ACCESSIBLE AND GREAT VALUE FOR MONEY
LOWER BUNKER CONSUMPTION AND GHG EMISSIONS
HIGHER COMMERCIAL SPEED

W

YOUNG MARKET
COMPLEX AND EVOLVING REGULATIONS
SPECIALIZED LABOUR REQUIRED
LOCAL REGULATIONS

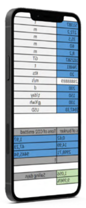
O

ADDED VALUE FOR PORTS
ECONOMIES OF SCALES
EXPLORING NEW MARKETS (NAVY)
FIRST MOVER ADVANTAGE
CIRCULAR ECONOMY OF BIO-WASTE
PARTNERSHIP AND JOINT VENTURES WITH PORT FACILITIES

T

HEAVY MACHINE RELIANCE
TECHNOLOGY LEAKS
TECHNICAL OBSOLESCENCE
WASTE MANAGEMENT
CULTURAL CHANGE REQUIRED

A software calculating payback



We think that showing customers full **collaboration and visibility is paramount**, in order to transition from a transactional market to a relationship one. To do so, we developed a **software** that with the help of shipowners inserting their vessel data (LOA, Displacement, and usual trading) is able to compute the **potential savings** they could obtain with the implementation of a biofouling management plan and the implied payback period.

The results were incredible, for a medium-sized cruise ship we observed:

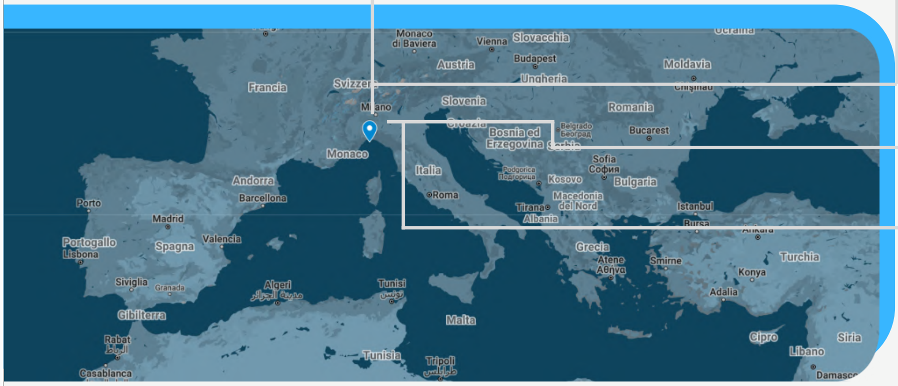
- 10% reduction in bunker consumption
- > 10% reduction in GHG emissions
- PBP in less than a sailing week

"If you can't measure it, you can't manage it"

Case study - Port of Genoa

High volumes .

"The Ports of Genoa" Authoriry has the largest volume of traffic among Italian ports
Liner and Passenger vessels (primary target customers) make up to 70% of the traffic.



. Strategic position

Genoa is in a strategic position both to offer and to request the service. It is a crucial point for TEN-T and MOS networks.

. Interconnected

Transport infrastructures make ROV easily transportable via road and rail, ensuring the potential to scale the business into land and service-connected ports

. Positive externalities

This service could improve the competitiveness of the port of Genoa and its terminals in the Mediterranean Sea and in the world, leading to a win-win situation for all actors in the maritime industry and for the community

GloFouling PARTNERSHIPS

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Mr. Gian Enzo Duci (ESA GROUP)
Direzione Marittima di Genova

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Detection of Fouling Organisms using Environmental DNA in Cebu International Port, Philippines

Casiguran, Richard[1], Fontanilla, Ian Kendrich[2], Pascua, Lester Arvin[2], Ocampo, Melody Anne[1], Vallejo, Benjamin[3]

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[3] Institute of Environmental Science and Meteorology, University of the Philippines Diliman, Quezon City, Philippines

ABSTRACT

Environmental DNA (eDNA) is increasingly being utilized in conservation and even in aquatic invasive species surveillance, especially in detecting the transfer of indigenous species through maritime transport. eDNA can essentially be used as proxy for early detection of non-indigenous species being transported from one port to another through ballast water and hull fouling. The objectives of the study are to establish an inventory of fouling organisms and non-indigenous species (NIS) in Cebu International Port (CIP), Philippines and detect potentially invasive species thorough eDNA. The study collected and filtered 2.5 L each of four water samples for each site for a total of five sites in CIP in parallel with the retrieval of biofouling organisms in collectors designed by North Pacific Marine Sciences Organization (PICES). The fouling organisms were detected using universal COI minibarcode primers, with about 99,800 COI sequences obtained. BLAST analysis revealed that most sequences belonged to the metazoans (93.3%), of which arthropods (82.9% of total) make up the majority. The NIS detected using eDNA metabarcoding are different from the NIS that were morpho-taxonomically characterized. The NIS detected via eDNA include the copepods Parvocalanus crassirostris, Oithona attenuata, the gastropods Norrisia norrisii and Ceraesignum maximum, the polychaete worm Artacama valparaisiensis, and the brown alga Chordariopsis capensis. eDNA approach can be an alternative or complement to the traditional methods because of its sensitive detection mechanism to rapidly monitor NIS. Such information provided by eDNA techniques coupled with morpho-taxonomic identification can be used for biofouling monitoring and bioinvasion management programs in ports.

Detection of Fouling Organisms using Environmental DNA in Cebu International Port, Philippines

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INTRODUCTION

Environmental DNA has become prevalent in conservation and has become rapidly developed for aquatic invasive species surveillance. This non-invasive method promotes a reliable and cost-effective method for monitoring various organisms in an aquatic environment, particularly when the populations are low in abundance (Maussiveau, et al, 2019).This has become really powerful and cost-effective because the DNA could be sourced from mucus, feces, sloughed-off cells, and decomposing organisms can introduce eDNA in a system and this can be identified through the use of the Polymerase Chain Reaction (PCR).Therefore, environmental samples can be obtained anywhere, anytime, and the presence of target specimens from trace DNA can be detected.

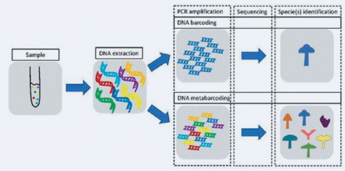

Figure 1. Process of species identification for the DNA barcoding (species-specific approach) and DNA metabarcoding (multispecific approach)

As an alternative or complement to some traditional methods, eDNA technologies provide a cost effective and sensitive detection tool to quickly and accurately monitor species' distribution over large geographic areas (Gingera, et al, 2017). Environmental DNA can be done using two approaches – a species specific approach and the approach that deals with a large number of species (Herder et al., 2014).

METHODOLOGY

Study Site. The samples were collected last July 2021 from the Cebu International Port which is located in Cebu City, Cebu, Philippines.

Figure 2. Actual photo and map where the samples were collected in CIP.

Protocol:

- Sampling of Port Water. A volume of 2.5 liters will be needed.
- Filtration of samples
- DNA Extraction and Amplification.
- Multiple Species eDNA Approach . The water sample will be sent to the Philippine Genome Center .
- Phylogenetic Analysis.
- Comparison with the species collected using PICES collector

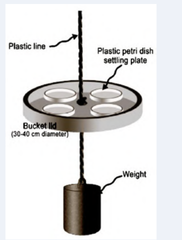

Figure 3. Diagram of the PICES collector used in this study (Vallejo, et al., 2017)

RESULTS

DNA Extraction Optimization

Before processing of samples, parameters involved in DNA kit extraction (using Thermo-Fisher GeneJet Extraction Kit) are: 1) filter paper cutting, 2) digestion and incubation time, 3) amount of reagents to be added, 4) addition of RNase A, 5) pooling in purification columns, and 6) amount of elution buffer. By checking the DNA concentration and using Nanodrop machine and DNA integrity using Agarose Gel ElectrphoMoreover, multiple characterization steps were checked which include the use of Nanodrop machine for checking of concentration and purity, a Qubit fluorometer to determine accurate double stranded DNA concentration. The optimized protocol resulted in consistently high concentration and purity of extracted DNA from the CIP samples and are sufficient for downstream analysis.

Table 1. Nucleic acid concentrations (ng/ul) and absorbance values of eDNA extracted from water samples of Cebu International Port (CIP)

Cebu International Port							
Site	Elution	Tube	Nucliec Acid Concentration (ng/µl)	A260	A280	A260/280	A260/230
CIP SP1A	1st	1	117.4	2.35	1.51	1.57	1.36
		2	81.7	1.63	1.05	1.60	2.42
	2nd	1	124.0	2.48	1.68	1.53	1.09
		2	94.3	1.88	1.26	1.58	1.23
CIP SP1B	1st	1	52.5	1.05	0.58	1.82	1.93
		2	67.1	1.34	0.78	1.72	1.30
	2nd	1	1897.3	37.35	26.14	1.43	0.76
		2	28.1	0.56	0.33	1.70	2.53
CIP SP2A	1st	1	69.2	1.38	0.69	2.02	2.59
		2	38.0	0.76	0.34	2.23	3.33
	2nd	1	612.2	12.25	8.44	1.46	0.70
		2	580.3	11.61	7.97	1.46	0.74
CIP SP2B	1st	1	182.2	3.64	2.28	1.59	0.92
		2	71.2	1.43	0.72	1.98	2.36
	2nd	1	7.8	0.16	0.03	-9.65	-0.24
		2	5.7	0.11	0.04	2.67	-0.43
CIP SP3A	1st	1	166.5	3.33	1.50	2.22	3.23
		2	122.6	2.45	1.20	2.04	2.63
	2nd	1	94.4	1.89	0.87	2.17	3.50
		2	57.6	1.15	0.51	2.28	4.67
CIP SP3B	1st	1	252.4	0.76	0.34	2.23	3.33
		2	530.2	10.60	5.81	1.83	1.20
	2nd	1	104.3	2.09	0.95	2.19	3.73
		2	90.3	1.81	0.83	2.17	4.06
CIP SP4A	1st	1	509.6	9.30	4.30	2.16	2.57
		2	510.1	10.20	4.73	2.16	2.53
	2nd	1	295.1	5.90	2.70	2.19	2.84
		2	42.5	0.85	0.37	2.32	10.68
CIP SP4B	1st	1	408.1	8.16	3.77	2.17	2.66
		2	302.6	6.05	2.77	2.19	2.85
	2nd	1	293.3	5.87	2.73	2.15	2.66
		2	269.1	5.38	2.50	2.16	2.71
CIP SP5A	1st	1	126.4	2.53	1.14	2.21	3.33
		2	267.8	5.36	2.56	2.09	2.16
	2nd	1	74.3	1.49	0.69	2.16	3.94
		2	73.5	1.47	0.66	2.21	4.29
CIP SP5B	1st	1	215.5	4.28	1.97	2.19	2.57
		2	219.7	4.39	2.01	2.19	2.59
	2nd	1	73.8	1.48	0.67	2.22	5.11
		2	30.4	0.61	0.26	2.36	-9.43

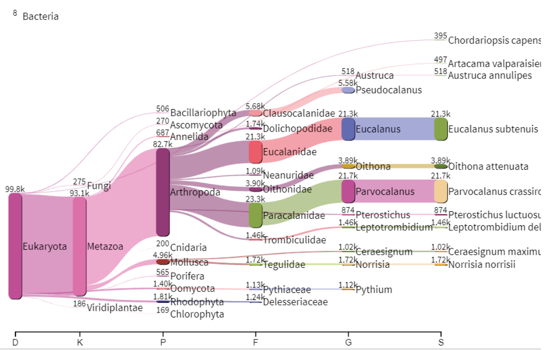

Figure 4. breakdown of sequences obtained from Cebu International Port (CIP)

The top 10 most abundant species in terms of sequence reads found from Metabarcoding of CIP samples were ran against databases World Register of Marine Species (WoRMS) and The Catalogue of Life (CoL) . Note that the distribution indicated here was not tagged either as native or introduced, but merely reported.

Table 2. Distribution of Top 10 most abundance species from Metabarcoding samples

Your List			Match Against WoRMS				Match against CoL with Distribution
Top	Genus	Species	Marine	Brackish	Fresh	Terrestrial	Region
1	Eucalanus	subtenuis	1	0	0	0	
2	Parvocalanus	crassirostris	1	0	0	0	Mediterranean Sea - Eastern Basin
2	Parvocalanus	crassirostris	1	0	0	0	North Atlantic Ocean
2	Parvocalanus	crassirostris	1	0	0	0	Lebanese Exclusive Economic Zone
2	Parvocalanus	crassirostris	1	0	0	0	Mediterranean Sea
3	Oithona	attenuata	1	1	1	0	Kenya
4	Norrisia	norrisii	1				
5	Leptotrombidium	deliense					
6	Ceraesignum	maximum	1	0	0	0	
7	Pterostichus	luctuosus					
8	Austruca	annulipes	1				
9	Artacama	valparaisiensis	1	0	0	0	Valparaiso Bay
10	Chordariopsis	capensis	1				

Initial Metabarcoding Results

Environmental DNA metabarcoding is done using MiSeq (Illumina) sequencing using the universal metazoan cytochrome oxidase I (COI) uni-Minibar forward and reverse primers (Meusnier et al., 2008). After trimming, about 99,800 COI sequences were obtained. These are composed mostly of Metazoans, of which Arthropods make up the bulk of the sequences.

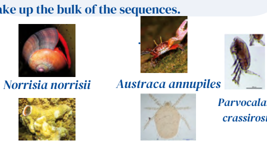

Figure 5. Downloaded images of some of the identified species from initial results of metabarcoding in Cebu International Port (Photos are not owned by the project)

Species collected using PICES Collector

During the July 2021 retrieval, a total of 813 organisms were counted and 69% of this is *Notaulax* sp. It was followed by *Spirorbis* sp. and *Amphibalanus* sp.

Table 3. Summary of species and taxonomic groups identified in the samples collected using PICES in Cebu International Port for the second retrieval, July 2021

Phylum	Class	Order	Family	Genus/Species	No. of individuals recorded
Annelida	Polychaeta	Eunicida	Dorvilleidae	-	2
Annelida	Polychaeta	Sabellida	Serpulidae	*Notaulax* sp.	561
Annelida	Polychaeta	Sabellida	Serpulidae	*Spirorbis* sp.	126
Annelida	Polychaeta	Sabellida	Serpulidae	*Hydroides elegans*	21
Arthropoda	Malacostraca	Decapoda	Brachyura	-	1
Arthropoda	Thecostraca	Balanomorpha	Balanidae	*Amphibalanus* sp.	57
Bryozoa	Gymnolaemata	Ctenostomatida	-	-	-
Bryozoa	Gymnolaemata	Cheilostomatida	Candidae	-	-
Chordata	Ascidiacea	Enterogona	Ascidiidae	*Phallusia arabica*	33
Mollusca	Bivalvia	Mytilida	Mytilidae	*Modiolus* sp.	4
Mollusca	Bivalvia	Ostreida	Ostreidae	-	3
Mollusca	Bivalvia	Ostreida	Placunidae	-	2
Mollusca	Bivalvia	Ostreida	Pteriidae	*Pinctada imbricata*	3
TOTAL					813

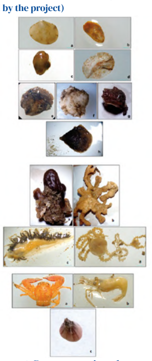

Figure 6. Representative photos of some fouling organisms collected in PICES collectors

KEY FINDINGS AND RECOMMENDATIONS

- The inital metabarcoding result did not identify any similar organism from what was collected using the PICES collector
- eDNA approach can be an alternative or complement to the traditional methods because of its sensitive detection mechanism to rapidly monitor NIS.
- Cryptic species and unidentified species collected using PICES collectors should be processed for DNA Barcoding

REFERENCES

Please use the qr code to see list of literatures cited

IMPLEMENTING AGENCIES AND PARTNERS

A new fouling Olifantiella (Bacillariophyceae) species from the northwest temperate Pacific coast

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ABSTRACT

Two naviculoid diatoms with an internal tubular process that opens externally through a pore or process on the valve face, were observed on the hull of R/V Onnuri of the Korea Institute of Ocean Science & Technology in South Korea. Owing to the presence of special morphological features, namely the buciniportula and an internal marginal canal, these diatoms were assigned to the genus Olifantiella, which was recently described from tropical regions. Of the two Olifantiella species, one (Olifantiella onnuria sp. nov.) is new to science. It can be distinguished from other Olifantiella species by two internally closed, bean-like buciniportulae, and an external T-shaped groove near the terminal raphe endings. These morphological characteristics of O. onnuria resemble those of the genus Labellicula. However, the presence of an internal marginal canal does not match Labellicula. The other Olifantiella species is identical to O. muscatinei, which possesses occluded fenestrulae on the valve face. The occurrences of these two Olifantiella species are the first records for the temperate Pacific region and their presence on a ship's hull indicates that Olifantiella spp. may be dispersed widely along shipping routes.

A new fouling *Olifantiella* (Bacillariophyceae) species from the northwest temperate Pacific coast

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Two elusive naviculoid diatoms with stigma-like structures on their valve face were observed on the hull of the R/V Onnuri from the Korea Institute of Ocean Science & Technology (KIOST) in South Korea. Under a scanning electron microscope, the morphological features, namely the buciniportula and the internal marginal chamber, were matched to the genus *Olifantiella*, which was recently described in tropical regions. Of these two Korean *Olifantiella* species, one is new to science and named as *Olifantiella onnuria* sp. nov., which can be distinguished from other *Olifantiella* species by an internally raised bean-like double processes and external T-shaped terminal raphe endings. These morphological features of *O. onnuria* resemble those of the genus *Labellicula*, however, the presence of an internal marginal chamber does not match the genus concept of *Labellicula*. The other Korean *Olifantiella* species is identical to *O. muscatinei* by the occluded macroareola on the valve face. These occurrences of two *Olifantiella* species are the first records from a temperate Pacific region and their presence on a ship's surface indicate that *Olifantiella* spp. may be widely distributed globally despite their periphytic habit.

INTRODUCTION

- **Morpholgical characteristics of *Olifantiella***

1) presence of a remarkable internal tubular process (buciniportula); 2) small valve dimension; 3) design of the external raphe endings; 4) presence of more or less elevated marginal ridge.

- **Number of *Olifantiella* species and its distribution**

- Eleven *Olifantiella* species have been described to date.
- Most species have been recorded in tropical regions of the Indian and Central Pacific Ocean.
- There are no other reports of *Olifantiella* species from Pacific temperate regions.
- Due to their small size and delicate valves, the species are regarded as elusive (Riaux-Gobin 2015).

- **Confusion with similar genus *Labellicula***

- Stigma-like structure and macroareolalae make a confusion between *Labellicula* and Olifantiella.

- **Purpose**

- Recently, we observed two abundant, small, naviculoid fouling diatoms growing at the surface of Onnuri R/V from the Korea Institute of Ocean Science & Technology (KIOST) in South Korea.
- **One is a new to science and named as *Olifantiella onnuria* S.W. Jung & J.S. Park**, and the other one is a *O. mustcatinei* (Reimer & J.J. Lee) Van de Vijver, Ector & C.E. Wetzel.
- With studying on the fine structure of two *Olifantiella*, **the genus concept for *Olifantiella* is re-considered with clarifying the definition of buciniportula, and the occurrences of *Olifantiella* and *Labellicula* species in the world are considered.**

MATERIALS AND METHODS

- **Fouling diatom sampling**

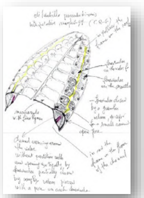
- Fouling diatom assemblages were collected from the hull of the ship R/V Onnuri of KIOST while the ship was being repaired on a floating dock.
- Five quadrates of 30 x 30 cm were placed on the surface of the ship, which were scraped using a brush and washed with filtered seawater for GF/F filter.

- **Morphological observations**

- The organic matters in the cells were removed following Simonsen's method described in Halse & Syvertsen (1996).
- The acid-treated materials were mounted using a diluted Pleurax (Mountmedia, Wako, Osaka, Japan) by equal amount of 100% ethanol.
- The permeant slides were observed using a LM.
- SEM observation was conducted following Jung et al. (2010).

Onnuri R/V of KIOST on a floating dock and collecting the fouling diatoms on the vessel hull of the ship.

Holotype of *Olifantiella onnuria* sp. nov. S.W. Jung & J.S. Park.



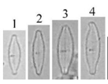
First description of *Olifantiella onnuria* sp. nov. S.W. Jung & J.S. Park

Holotype: Slide no. B-S-PP-00008266, deposited at the Library of Marine Samples, Korea Institute of Ocean Science & Technology, South Korea
Isotype: Slide no. NIBRDI0000138932 deposited at the National Institute of Biological Resources Herbarium, South Korea
Type locality: Hull of Onnuri R/V of KIOST, Jangmok coastal waters, South Korea in 20 March, 2017.

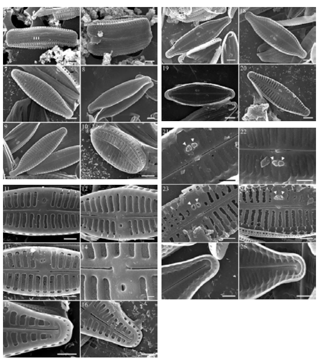
RESULT

***Olifantiella onnuria* sp. nov. S.W. Jung & J.S. Park (Figs 1–26)**

- **Description:** Frustules rectangular in the girdle view. Cingulum comprised of many bands with two rows of poroids. Valves elliptic with subrostrate apices, 4.8–12.6 μm long and 1.7–2.7 μm wide. Transapical striae slightly radial, equidistant, 35–50 in 10 μm. One to two shortened striae vestigial remains or very short macroareola near the external opening of buciniportula. Apice slits denser than the striae. Each stria composed of macroareola and fenestrula. Macroareolae occluded by finely perforated hymen. Fenestrula opened near marginal elevated ridge. Marginal ridge elevated in a junction of valve face– mantle. Raphe straight. Central raphe endings slightly expanded and deflect outwards external opening of buciniportula. Terminal raphe endings simple and deflect to same direction of central raphe endings. T-shaped grooves present to each apice near terminal raphe endings. Central nodule between central raphe endings internally present. Buciniportula internally double and raised with paired tubular processes and covered by a finely perforated bean-like thickening.
- **Etymology:** This new species was named after the Onnuri R/V of the Korean Institute of Ocean Science and Technology (KIOST), South Korea, as the material was collected from the hull of this ship.
- **Ecological characteristics:** *Olifantiella onnuria* is firstly observed in the temperate northeast Pacific region as a fouling species. Although *O. onnuria* only observed from the ship hull and there are no data currently, this species could be more widespread via ship transportation.

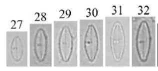


Figs 1–4. Light microscope images of *Olifantiella onnuria* S.W. Jung & J.S. Park sp. nov. **Figs 1, 3, 4.** Isotype. **Fig. 2.** Holotype. Scale bar = 10 μm.

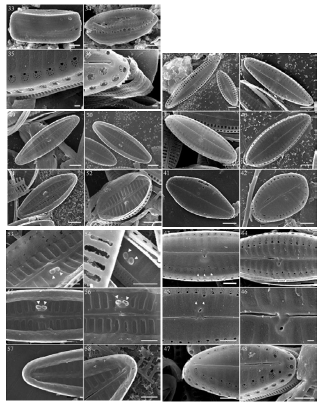


Figs 5–10. *Olifantiella onnuria* S.W. Jung & J.S. Park sp. nov. **Figs 5 and 6.** Girdle view. **Fig. 7.** Naviculoid valve with slightly elongated apices. **Fig. 8.** Linear-lanceolate valve with subrostrate apices. **Fig. 9.** Naviculoid valve with abnormal apices. **Fig. 10.** Abnormal elliptical valve. Scale bars = 1 μm.
Figs 11–16. *Olifantiella onnuria* S.W. Jung & J.S. Park sp. nov. **Figs 11–13**. Macroareolae with a naked finely perforated hymen on the valve face and small semi-circular fenestulae near the valve margin. **Fig. 14.** External opening of buciniportula and the central raphe endings. **Figs 15 and 16.** Terminal T-shaped groove perpendicular to the simple terminal raphe endings and apical areolae in the valve mantle. Scale bars = 0.5 μm (Figs 11–13, 15, 16), 0.1 μm (Fig. 14).
Figs 17–20. *Olifantiella onnuria* S.W. Jung & J.S. Park sp. nov. **Figs 17–20.** Internal valve view. Scale bars = 1 μm.
Figs 21–26. *Olifantiella onnuria* S.W. Jung & J.S. Park sp. nov. **Figs 21 and 22.** Internally paired bean-like buciniportula (arrowheads) and the central nodules between the raphe endings. **Figs 23 and 24.** Corroded external covers of buciniportula (arrowheads). **Figs 25 and 26.** Helictoglosae of internal terminal raphe endings and marginal canal along the valve margin. Scale bars = 0.5 μm.

***Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Van de Vijver, Ector & C.E. Wetzel (Figs 27–58)**
Basionym: *Navicula muscatinei* C.W. Reimer & J.J. Lee 1988, p. 345, figs 19–25.
Synonym: *Olifantiella pseudobiremis* C. Riaux-Gobin in Riaux-Gobin & Al Handal 2012.
Description: Valves small and elliptic to lanceolate with subrostrate apices (Figs 27–32), 3.6–11.7 μm long and 1.3–3.4 μm wide. Striae invisible but a buciniportula visible near the central area as an isolated dot (Figs 33–58).



Figs 27–32. Light microscope images of *Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Vand de Vijver, Ector & C.E. Wetzel. Scale bar = 10 μm.



Figs 33–36. *Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Vand de Vijver, Ector & C.E. Wetzel. **Fig 33.** Girdle view. **Fig. 34.** Girdle bands in the tilted valve view. **Fig. 35.** Valvocopula with transapically elongated pores. **Fig. 36.** Five bands with transapically elongated pores in the valve apices. Scale bars = 1 μm.
Figs 37–42. *Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Vand de Vijver, Ector & C.E. Wetzel. **Figs 37 and 38**. Lanceolate valve. **Fig. 39.** Elliptical valve. **Figs 40 and 41.** Apically asymmetric abnormal valve. **Fig. 42**. Elliptical abnormal valve. Scale bars = 1 μm.
Figs 43–48. *Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Vand de Vijver, Ector & C.E. Wetzel. **Figs 43 and 44.** Striae composed of macroareola and marginal areola. **Figs 45.** Macroareolae occluded by finely perforated hymen and marginal areola occluded by coarse perforated hymen with a circular foramen towards the valve center. **Fig. 46.** External opening of buciniportula near the central raphe endings. **Figs 47 and 48.** Terminal raphe endings and apical areolae in the valve mantle. Scale bars = 0.5 μm (Figs 43–45, 47, 48), 0.1 μm (Fig. 46).
Figs 49–52. *Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Vand de Vijver, Ector & C.E. Wetzel. **Figs 49–52.** Internal valve view. Scale bars = 1 μm.
Figs 53–58. *Olifantiella muscatinei* (C.W. Reimer & J.J. Lee) Vand de Vijver, Ector & C.E. Wetzel. **Figs 53–56.** Internally paired buciniportula covered by a finely perforated rounded domed thickening and the central nodules between the raphe endings. **Figs 57 and 58.** Helictoglossa of internal terminal raphe endings and marginal canal along the valve margin. Scale bars = 0.5 μm.

DISCUSSION

- **Taxonomic identification of new taxon based on the morphological characters**
  - **Buciniportula**

  - We divided the buciniportula into five types (Fig. 59): (1) single raised tubular structure; (2) single, short, raised, flat, dish-like structure; (3) double, short, raised, tubular structure; (4) double or multiple and flattened tubular structures; (5) double, short, raised, finely perforated, bean-like structure.
  - Buciniportula supported the taxonomic position of new species is correspond to *Olifantiella*.

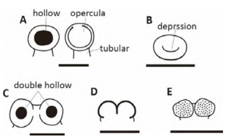


Fig. 59. Diagrams of five types of buciniportula. A. *Olifantiella mascarenica*. B. *Olifantiella elisabethiana*. C. *Olifantiella rodriguensis*. D. *Olifantiella gorandiana*. E. *Olifantiella onnuria*. Sclae bars = 0.5 μm.

  - **Marginal canal**

  - *Olifantiella* the hymeous velum is extended from the valve mantle to the valve face and connected onto the stria and opened by fenestrula (Fig. 60).
  - The presence of marginal canal of new species is correspond to *Olifantiella*, and an character to distinguish *Olifantiella* from the other genera such as *Biremis* as well as *Labellicula*.

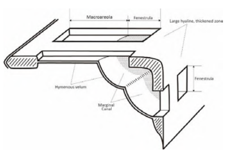


Fig. 60. Diagram of transapical cross-sections of *Olifantiella*.

  - **Terminal groove**

  - The grooves near the terminal raphe endings of new species is similar to that of *Labellicula* species.
  - However, It is difficult to designate the presence of groove near the terminal raphe endings as a generic

- **Distribution**

- Eight species were reported from the tropical regions of the Indian and Pacific oceans, and one species from the temperate region of the Atlantic Ocean.
- *Olifantiella muscatinei* is the most frequently reported species (Van de Vijver et al. 2018), it has been reported from temperate northern Atlantic and Pacific, tropical Indo-pacific and eastern Pacific.

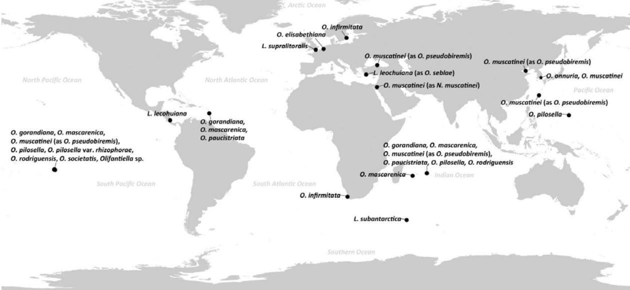


Fig. 61. Biogeography of *Olifantiella* and *Labellicula*.

Safeguarding Biosecurity by Effective Biofouling Regulations

Dr. Wei Chen, Consultant

EN Decision Ltd, UK

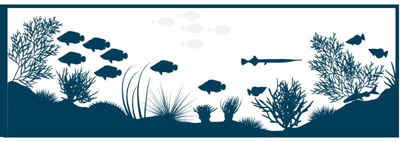
ABSTRACT

This presentation compares the biosecurity rules on land and at sea, their regulatory frameworks and effectiveness, and the pitfalls to be avoided by the evolving biofouling rules for international shipping.

Biosecurity regulations have been well developed and implemented ashore for many decades, such as in our agricultural and wastewater industries. Biosecurity can take priority over environmental initiatives to secure the livelihood of our communities, national agricultural interest, global food security, and biodiversity. Despite the sophisticated challenges of diseases and invasive species, biosecurity rules on land have well established based on extensive research and experiences over the years. They are introduced with relatively simple and consistent requirements, and well-defined the minimum treatment criteria that include good safety margins to safeguard the biosecurity goals. They are strictly implemented and enforced under the so-called Hazard Analysis Critical Control Points (HACCP) plan that is originated from food industry, as well as periodical performance verifications.

International shipping has been subject to several biosecurity rules. When it comes to ballast water, instead of having simple and consistent treatment criteria, each BWMS is granted its own birth right to define its criteria for meeting the IMO's biosecurity goal. This has profound implications, especially in the absence of mandatory performance verifications. When it comes to the biosecurity requirements on international food waste, international shipping has also served as a startling contrast with the aviation industry. There are lessons to be learnt when developing biofouling regulations for international shipping, so that they are evidence-based, practicable, and sustainable.

BIOFOULING **RESIDUE**



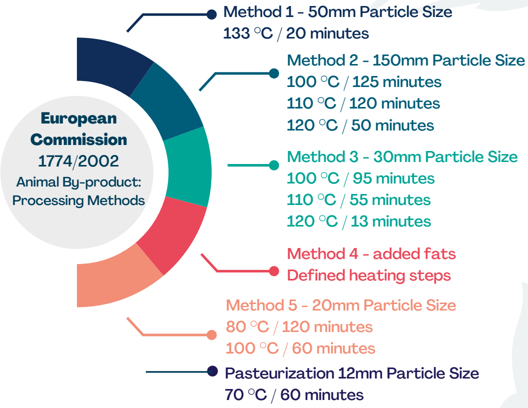
Strategic Elements: Defining the approach

Biofouling on vessels are cleaned as part of Biofouling Management. While this preserves the biosecurity of the destination port, we need to be mindful about residual from cleaning efforts that are left behind and the risk it poses to local waters. Precautions and best practices to follow up with residuals post-cleaning is essential for a complete biosecurity program.

Policy: Steering industrial practices

Good policies set the tone of the industrial practices. Policy development stage is critical. It is the starting point that shapes any industry. Implementing general objectives and directions allow flexibility for operators to utilize various resources and methods to achieve results and specific guidelines become necessary for areas where precise results are expected.

Policies such as those from European Commission 1774/2002 on Animal By-Product and similarly US EPA on Sewage Sludge Treatment provide very defined treatment specifications to be taken.



US EPA 40 CFR -503 (Sewage Sludge) Pathogen Treatment	Composting > 55°C , >3 days	Heat Drying > 80°C <10% moisture
Beta Radiation 1.0 Megarad	Thermophilic Aerobic Digestion Agitation- 10 days 55°C - 60°C	Heat Treatment > 180°C 30 minutes
Gamma Radiation Shortlisted Isotopes 1.0 Megarad	Pasteurization 70°C >30 minutes	PRECISE PRODUCT OUTCOME

Adoption: From other industrial regulations

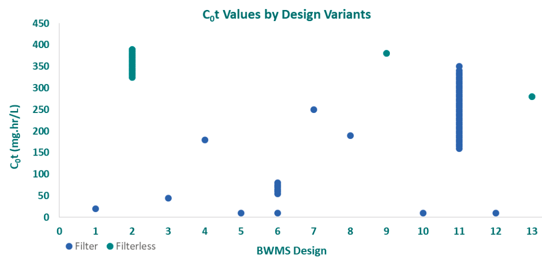
We can avoid reinventing the wheel by learning from other evidence-based and effective regulations that are utilized independent and focused research work as well as compliance monitoring. The pursuit for biosecurity has to be all inclusive involving all stakeholders less we risk threats falling through the cracks.

UnNoticed Problem: Legacy Practices

Traditionally accepted practices should constantly be reviewed and corrected where necessary. MEPC.295(71) provides guidelines for handling food waste on ships but the reality is that many ships are channeling international food waste and food waste derivatives to the sewage treatment plant and eventually released to water and land protected by national biosecurity laws. System designs that facilitate such practices have also been unknowingly approved by Class allowing this biosecurity threat to persist.

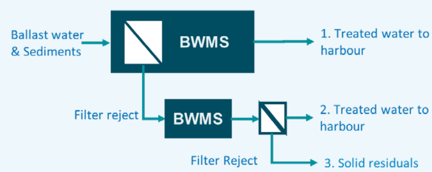
Solutions: Effective Regulation

Marine biosecurity rules need to be made effective by on-going compliance monitoring and enforcement. Recent biosecurity efforts include regulations requiring Ballast Water (BW) to be treated before discharge. Requirements for BWMS does not specify treatment requirements other than the end results which are not continuously monitored. Many makers of BWMS have ventured into chlorine based treatment techniques. Their methodology varies between each other and we can see that the outcome of Concentration Time (CT) is having huge variances across different makers.



Shore reception facilities receiving untreated BW are also venturing into new phases of experience building. Untreated water that bypassed ship BWMS will contain sediments and biological matter. Reception facilities should be prepared to deal with Ballast water as well as biological matter . Presently there is no detailed policies and guidelines for handling the reception residues which take the forms of sediments, crustacean and similar oceanic life forms

Illustration of ballast water reception in ports



Biosecurity wastes?
Existing biosecurity regulations applicable?
Existing environmental regulations applicable?
Performance standards?

Analysis methods available?
Responsible government agencies?
HACCP and compliance monitoring?
Disposal routes?

However, such initiative deserve praise and complement for being first movers that begin the journey to impact industry. Policies will improve over time as long as stakeholders collaborate and work together to bring improvement in policies, practices and governance.

Authors: Alvin Lee , Dr. Wei Chen

Impact of biofouling and invasive aquatic species on Shipping operations, Aquaculture and Ocean renewable energy industries.

Yousef Bilal Yousef Alkhalafat

Marine officer and Lecturer at Jordan Academy for Maritime Studies

ABSTRACT

Maintaining food chains and biodiversity are essential components of maritime environment preservation, and lowering pollution improves the standard of living. Therefore, the primary goal is to adopt the most efficient techniques for all parties involved in the marine sector to reduce and manage the effects of invasive species transfer from the ship's hull.

Beginning with recommendations relating to installing anti-fouling systems and the management of cleaning the hull, the IMO Guidelines present practical ways to assist the ship's submerged component in decreasing the accumulation of fouling. All of these reasonable steps aim to reduce the transport of marine species that harm the maritime ecosystem and reduce operational costs associated with ships' efficiency owing to the build-up of fouling on the hull (IMO, 2011).

In Short, the possibility of importing invasive aquatic organisms, which travel adherent to the biofouling of ships, is, in essence, the principal effect created by biofouling. These IAS have various effects, including reduced fisheries productivity, economic harm from tourist destinations closing because of algae, loss of local biodiversity, and potential health risks from diseases brought in by toxic species.

PHOTOS


GloFouling
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2nd GloFouling R&D Forum and Exhibition
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Greener Technologies for Biofouling Management
11-14 October 2022
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SESSIONS


CONCEPTUAL APPROACHES FOR RISK-BASED ASSESSMENT
Direct measurements:


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Guillaume Drillet
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GloFouling
2nd GloFouling R&D Forum and Exhibition
on Biofouling Prevention and Management
for Maritime Industries
11-14 October 2022 | IMO Headquarters, London, UK


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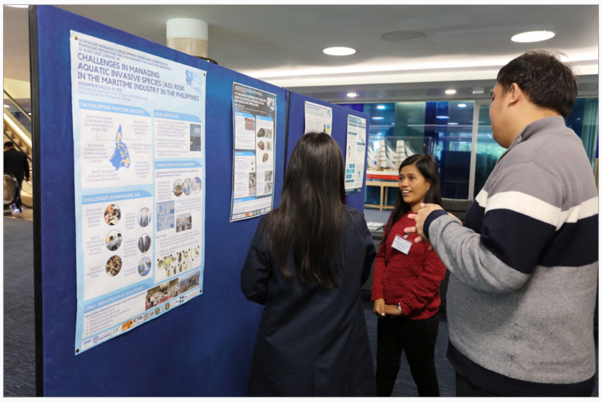
EXHIBITION


CHALLENGES IN MANAGING
AQUATIC INVASIVE SPECIES (AIS) RISK
IN THE MARITIME INDUSTRY IN THE PHILIPPINES


GloFouling
Biofouling
virtual reality
experience

RECEPTION

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