Biofouling and Non-Indigenous Species:
International Organization for Standardization (ISO) and Related Efforts

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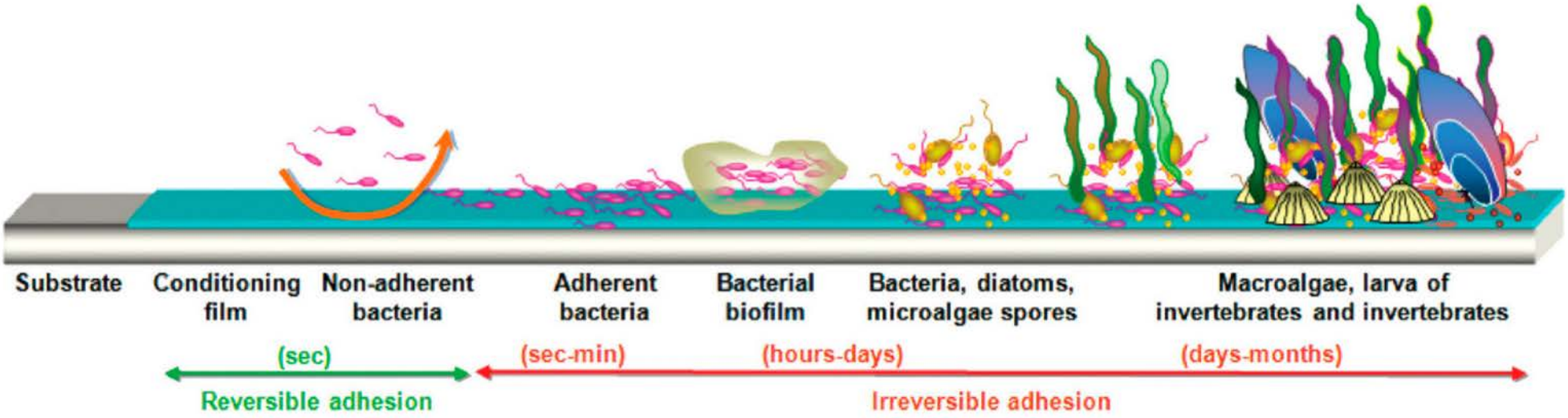
100 YEARS OF SCIENCE

Biofouling and Non-Indigenous Species:
International Organization for Standardization (ISO) and Related Efforts

- **Ship Biofouling**
- **In-Water Cleaning (IWC)**
- **ISO 20679 Testing of Ship Biofouling IWC Systems**
- **GESAMP WG44 Biofouling and Non-Indigenous Species**
- **GloFouling and ACT-Biofouling**
- **International Council for Exploration of the Sea (ICES)**

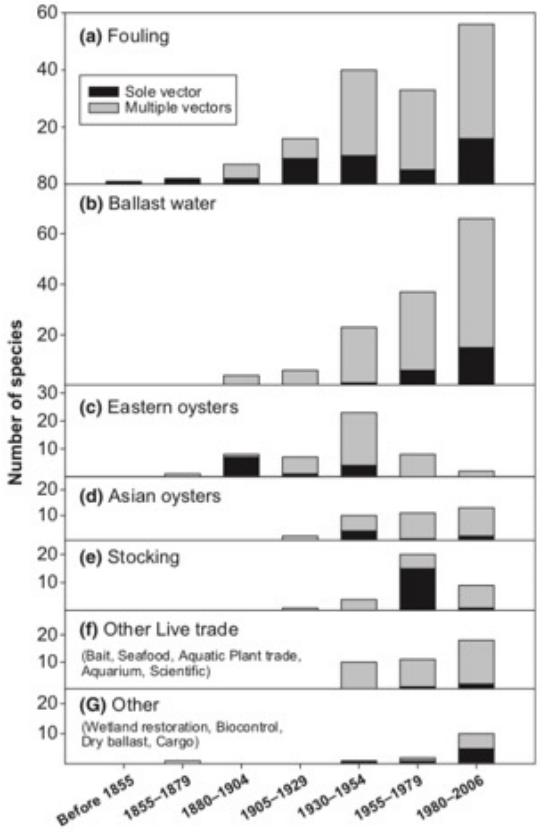
Biofouling



Hayek et al., 2021

Ship Biofouling

- **Vessel Operations:**
  - **Biofouling resulting in increased roughness, drag, fuel consumption, and exhaust emissions**
  - **Biofouling can interfere with water systems**
- **Biosecurity Concerns:**
  - **Significant vector for the movement and introduction of non-indigenous species (NIS)**
  - **NIS have a range of impacts on economic, ecological, societal, and cultural resources**
  - **Evolving regulations - IMO, VIDA, New Zealand, Australia, Canada, etc.**



Ruiz et al., 2015

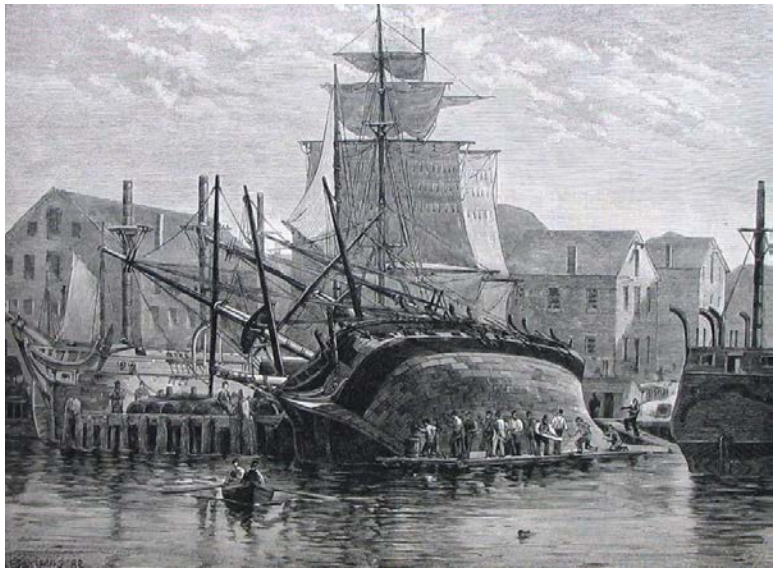
Ship Biofouling

- **Antifouling Coatings**
  - **Various coatings designed to either prevent macrofouling attachment (using biocidal coatings, e.g., copper and/or zinc) or reduce adhesion (foul-release or non-ablative hard coatings).**
  - **Typically a 5-years service life and do not consistently prevent biofouling accumulation on all ship surfaces over time.**

  - **Biofouling tends to increase as coatings age and when ships have extended stationary periods.**
  - **Substantial areas of ships' are more prone to biofouling because they:**
    - **cannot be painted (e.g., anodes)**
    - **are prone to damage (e.g., bulbous bow, tug and fender points, area below anchor chain)**
    - **are challenging to coat (e.g., dry-dock blocking areas)**
    - **are sub-optimal for coating performance (e.g., gratings, rudders, and sea chests).**

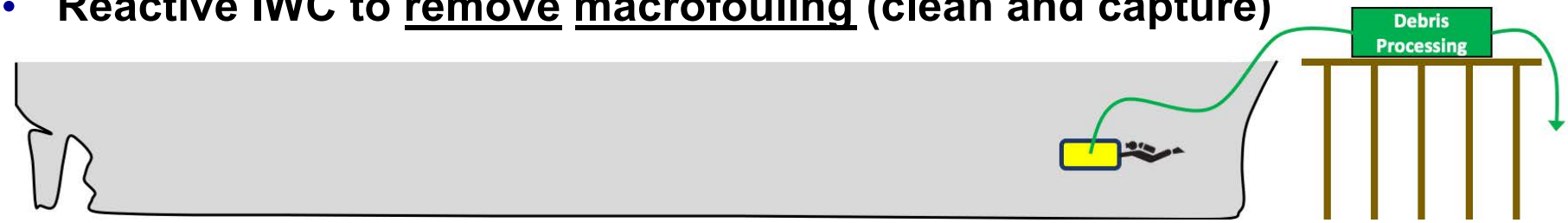
In-Water Cleaning of Ship Biofouling

- **Long history**



In-Water Cleaning Systems

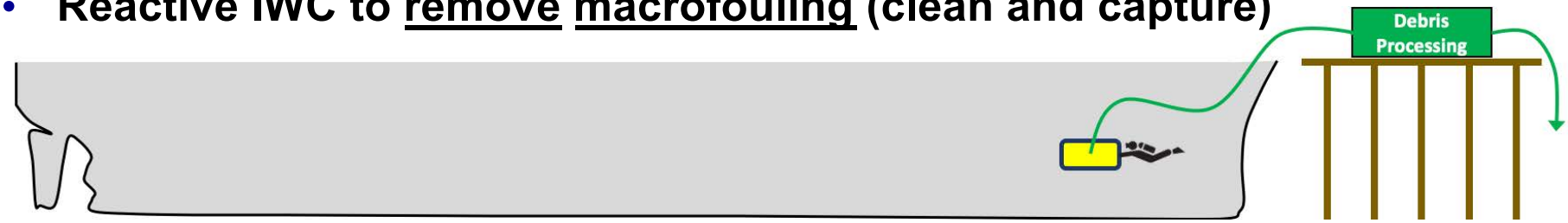
- New generation of in-water cleaning (IWC) technologies and systems
- Reactive IWC to <u>remove</u> <u>macrofouling</u> (clean and capture)



- Proactive IWC to <u>prevent</u> <u>macrofouling</u> (periodic removal of biofilms)

In-Water Cleaning Systems

- New generation of in-water cleaning (IWC) technologies and systems
- Reactive IWC to remove macrofouling (clean and capture)



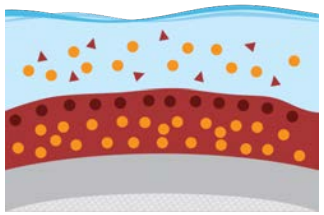
  - Effective removal of macrofouling
  - Effective capture and disposal of debris removed
  - Measurable environmental impacts
  - Measurable coating impacts

- Proactive IWC to prevent macrofouling (periodic removal of biofilms)

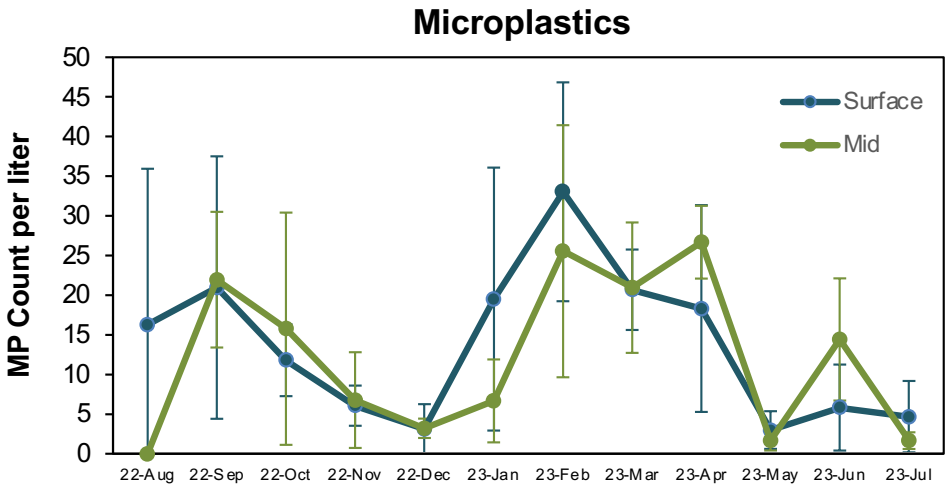
  - Effective removal of biofilms
  - Effective prevent of macrofouling
  - Measurable environmental impacts
  - Measurable coating impacts

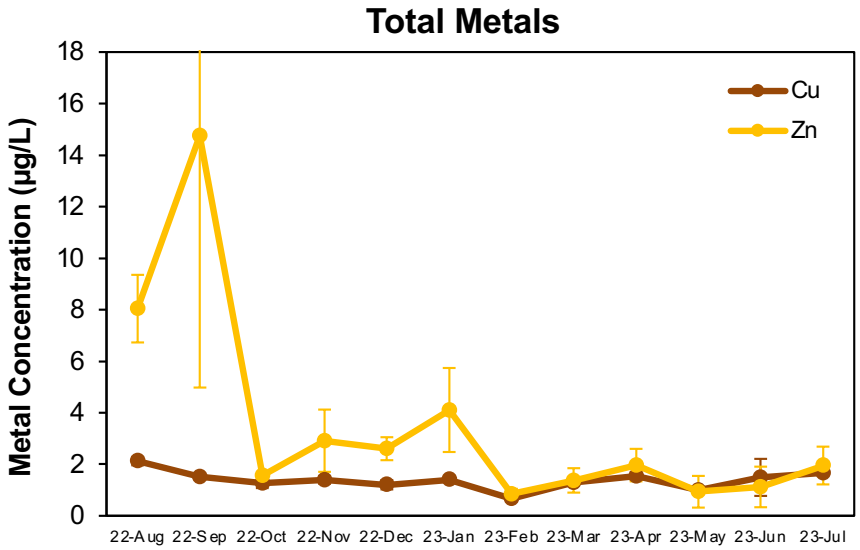
In-Water Cleaning in Ports

- **Ship biofouling is an open system, material is released from surfaces independent of IWC.**



- **Ports commonly have measurable and variable background levels of contaminants.**
  - **Monthly samples at Dundalk Terminal, Port of Baltimore**

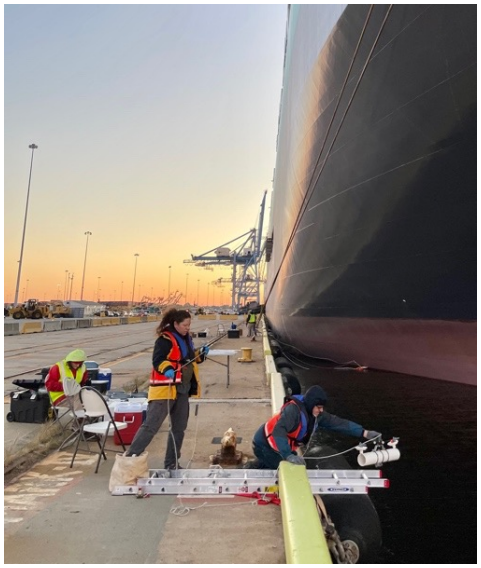


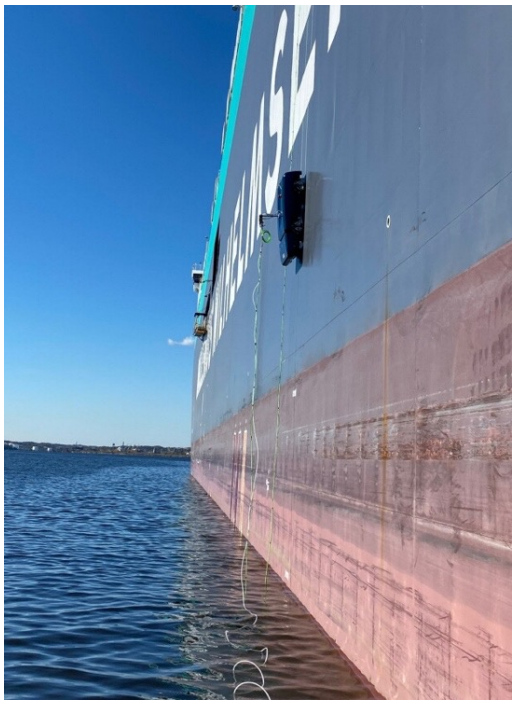


Initial IWC Testing Efforts Under ACT/MERC

- **Tested a reactive IWC with capture system in 2018**

- **Tested a proactive IWC system in 2020-2021**





- **Ongoing assessments of of several IWC systems**

ACT/MERC IWC System Testing Guidelines

- **2021**

frontiers in Marine Science

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

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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. Ship in-water cleaning (IWC) systems are now being incorporated into biofouling policy, and rigorous, transparent, and predictive verification testing is vital to regulatory success. 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 appropriately trained IWC operators.

Keywords: ship biofouling, in-water cleaning, non-indigenous species, environmental regulations, verification testing

INTRODUCTION

The colonization of submerged surfaces by sessile and sedentary organisms, including microbes, invertebrates, and macroalgae, has long been a significant challenge for coastal and ocean-going ships (Woods Hole Oceanographic Institute, 1952). Biofouling of the global shipping fleet, which is responsible for transporting approximately 80% of the world's goods and materials

- **2022**

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Guidelines for Testing Ship Biofouling In-Water Cleaning Systems

26 October 2022

ALLIANCE FOR COASTAL TECHNOLOGIES

Maritime Environmental Resource Center

ISO Standards Related to In-Water Cleaning of Ships' Biofouling

Ships and marine technology – Marine environment protection – In-water cleaning of ships' biofouling ISO/TC 8/SC 2/WG 13

ISO 6319 – Performing and documenting in-water cleaning of ships' biofouling (by 2026)

ISO 20679 – Testing ship biofouling in-water cleaning systems (January 2025)

- **In support of the IMO 2023 *Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species*, new IMO CG on IWC, and other related efforts.**
- **WG 13 is comprised of subject matter experts from 12 countries (and a liaison organization) who represent the shipping industry, IWC service providers, regulatory agencies, academic researchers, testing organizations, and other stakeholders.**

ISO 20679
Testing of Ship Biofouling In-Water Cleaning Systems

Scope

This document provides detailed and rigorous procedures for the independent performance testing of all forms of ship in-water cleaning (IWC), including on all types of biofouling (i.e. biofilms/microfouling and macrofouling), all external submerged surfaces (i.e. hull and niche areas), and both proactive and reactive IWC systems with or without the capture, processing, and disposal of debris. This document also includes testing protocols and describes how to produce data and report on the efficacy and safety of IWC systems to clean various ship surfaces and for the capture and disposal of cleaning debris.

The development of specific IWC performance requirements, criteria, or standards is outside the scope of this document and is the responsibility of individual authorities, agencies, or administrations. Similarly, while some methods and approaches described here can apply to other ship biofouling management approaches, systems designed to kill or prevent biofouling on external surfaces without removal (i.e. without in-water cleaning), and systems that remove or treat biofouling on internal surfaces (e.g. seawater pipes) or external surfaces of intricate mechanical components (e.g. external parts of propeller shaft seal), are also outside the scope of this document.

ISO 20679
Testing of Ship Biofouling In-Water Cleaning Systems

- **Table of Contents:**
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  - Fundamental information needed for testing IWC systems
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  - Quantification of changes to water quality
  - Quantification of debris processing and effluent
  - Quantification of IWC impacts on ship coatings
  - Data management
  - Quality assessments
  - Human health and environmental safety
  - Test reports
  - Annex A - Example of biofouling surveys
  - Annex B - Optional additional determination of IWC impacts on ship coatings
  - Bibliography

ISO 20679
Testing of Ship Biofouling In-Water Cleaning Systems

- **Test experimental design:**

A. Proactive IWC system

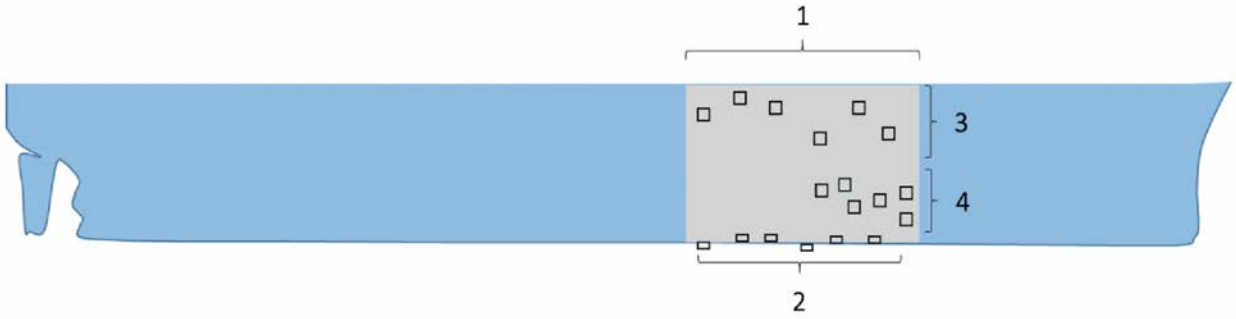
Clause 5: ≥ 3 test ships, with ≥ 2 different biocidal coatings, when applicable	**Clause 6:** Beginning and end of test period surveys on at least 1 control and 1 treated hull area, and 1 control and 1 treated niche area, when applicable	**Clauses 7 and 8**: Beginning of test period sampling event during cleaning on ≥ 2 different biocidal coatings, when applicable	**Clause 9**: Beginning and end of testing period surveys at least 1 control and 1 treated hull area, for ≥ 2 different coatings types, when applicable
Test Ship 1: • distinct type/function, age, size • distinct operational history • distinct/appropriate coating type & age • distinct/appropriate existing biofouling	**Biofouling Removal/Prevention** • hull biofilm removal efficacy, • macrofouling prevention efficacy, • niche biofilm removal, and/or • niche macrofouling prevention efficacy	**Environmental Impacts** • changes to water quality from hull and niche cleaning (if applicable) • debris capture and processing efficacy from hull/niche cleaning (if applicable)	**Coating Impacts** • changes to coating on hull • changes to coatings on niche (if applicable)
Test Ship 2: • as per test ship 1	**Biofouling Removal/Prevention** • as per test ship 1	**Environmental Impacts** • as per test ship 1	**Coating Impacts** • as per test ship 1
Test Ship 3: • as per test ship 1	**Biofouling Removal/Prevention** • as per test ship 1	**Environmental Impacts** • as per test ship 1	**Coating Impacts** • as per test ship 1

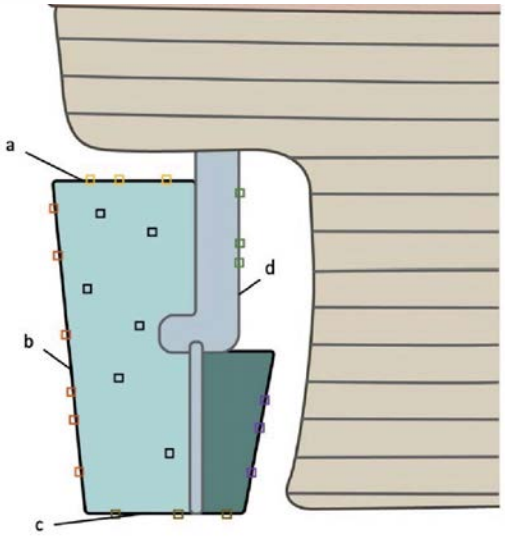
B. Reactive IWC system

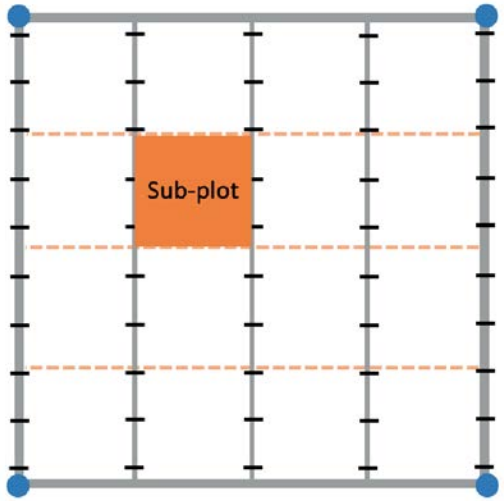
Clause 5: ≥ 3 test ships, with ≥ 2 different biocidal coatings, when applicable	**Clause 6:** Before and after cleaning surveys on at least 1 control and 1 treated hull area, and 1 control and 1 treated niche area, when applicable	**Clauses 7 and 8**: Sampling during cleaning event conducted on ≥ 2 different biocidal coatings, when applicable	**Clause 9**: Before and after cleaning surveys at least 1 control and 1 treated hull area, for ≥ 2 different coatings types, when applicable
Test Ship 1: • distinct type/function, age, size • distinct operational history • distinct/appropriate coating type & age • distinct/appropriate existing biofouling	**Biofouling Removal** • hull macrofouling removal efficacy • niche macrofouling removal efficacy (if applicable)	**Environmental Impacts** • changes to water quality from hull and niche cleaning (if applicable) • debris capture and processing efficacy from hull/niche cleaning (if applicable)	**Coating Impacts** • changes to coating on hull • changes to coatings on niche (if applicable)
Test Ship 2: • as per test ship 1	**Biofouling Removal/Prevention** • as per test ship 1	**Environmental Impacts** • as per test ship 1	**Coating Impacts** • as per test ship 1
Test Ship 3: • as per test ship 1	**Biofouling Removal/Prevention** • as per test ship 1	**Environmental Impacts** • as per test ship 1	**Coating Impacts** • as per test ship 1

ISO 20679
Testing of Ship Biofouling In-Water Cleaning Systems

- **Quantification of biofouling removal and/or prevention:**
  - **Utilizes current/proven best available method (before and after diver biofouling photographic surveys) but allows for new approaches (e.g., automated ROV video surveys) to be incorporated as they are developed and accepted.**

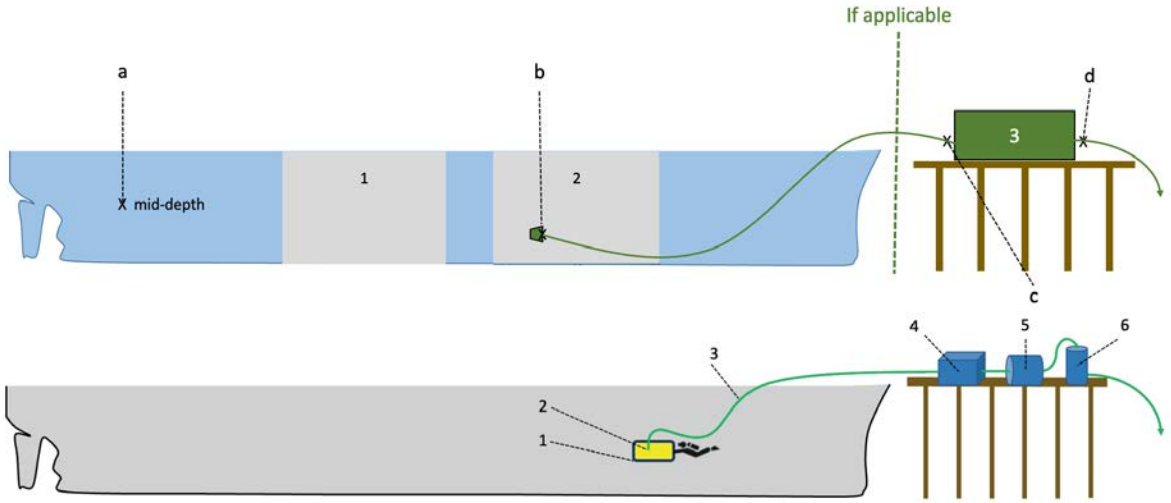


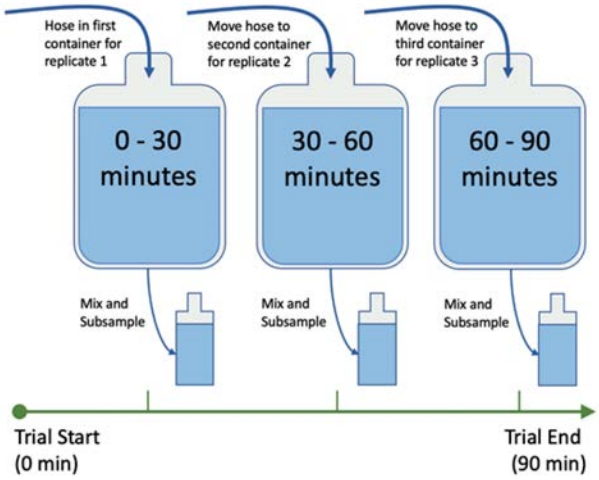




ISO 20679
Testing of Ship Biofouling In-Water Cleaning Systems

- **Quantification of changes to water quality:**
- **Quantification of debris processing and effluent:**
  - **Comparisons of ambient background, ships coating background (away from IWC), cleaning unit during IWC, and when applicable waste treatment influent and effluent.**
  - **Biofouling organisms (TSS, PSD, POC, and DOC as proxies)**
  - **Particulate and dissolved biocides**
  - **Microplastics (polymers associated with coatings and IWC system)**





ISO 20679
Testing of Ship Biofouling In-Water Cleaning Systems

- **Next Steps:**
  - **Developing efforts to support capacity building and implementation ISO 20679, including demonstrations and training.**
  - **Exploring approaches to supplement, expand, or adapt ISO 20679 for other ship IWC approaches (e.g., IWC while underway) and other IWC applications (e.g., offshore platforms and aquaculture pens).**
  - **Approval/permitting of ship IWC based on ISO 20679.**

GESAMP WG44
Biofouling and Non-Indigenous Species

GESAMP
Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

- **An inter-agency body of the United Nations, established in 1969, that works closely with the IMO and other sponsoring organizations.**
- **Purpose - to provide authoritative, independent, interdisciplinary scientific advice to organizations and governments to support the protection and sustainable use of the marine environment.**
- **10 active working groups, including:**
  - **WG34 – review of applications for 'active substances' in ballast water management systems – IMO (self-funded)**
  - **WG44 – Biofouling and Non-Indigenous Species – IMO, IOC-UNESCO, UNDP**

IMO FAO UNESCO IOC WMO UNIDO IAEA UN UNEP UNDP ISA

GESAMP WG44
Biofouling and Non-Indigenous Species

- **16 subject matter experts from around the world.**
- **Terms of Reference:**
  1. **Identification and description of both primary and secondary pathways for the transfer of NIS, including:**
     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, 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
Biofouling and Non-Indigenous Species

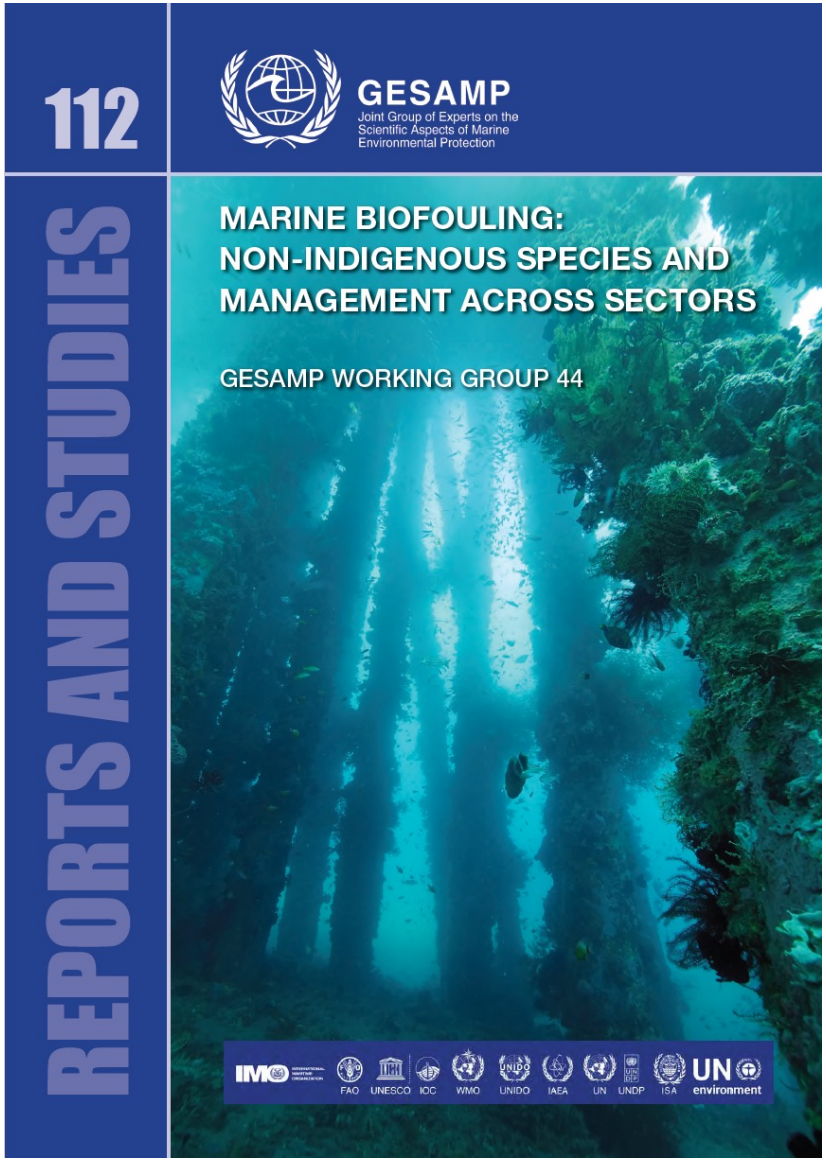
- 10 peer-reviewers
- Released 30 August 2024
- Download available at:

  www.gesamp.org/publications

  www.glofouling.imo.org/publications-menu

  unesdoc.unesco.org/home

- New Terms of Reference under development (likely in support of new IMO convention on biofouling)



IMO GloFouling and ACT-Biofouling

- The GloFouling Partnerships project was launched in 2018 and ending in May 2025
- Made strides in managing biofouling on ships to curb the spread of aquatic invasive species
- Strengthened capacity in developing countries, promoted best management practices, and informed IMO policy development

- ACT-Biofouling (Accelerating Collaboration and Transformation) is now being proposed to:
  - Build the capacity of developing countries to align national frameworks with IMO 2023 Biofouling Guidelines;
  - Support technology demonstration for IWC and biofouling prevention;
  - Strengthen stakeholder engagement, including the private sector;
  - Provide policy and regulatory support; and
  - Facilitate global and regional cooperation to harmonize the implementation of Guidelines.

ICES Working Groups

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

- **Working Group on Ballast and Other Ship Vectors (WGBOSV)**
  - **Terms of Reference d. Provide support for the implementation of the IMO Guidelines for the Control and Management of Ships' Biofouling (2023) through investigating and evaluating understudied aspects of vessel biofouling, such as risk of non-native species introductions associated with various levels of biofouling, and the release of organisms (including larval stages) and waste material from ships and recreational vessels during voyages and cleaning operations, such as in-water cleaning.**

- **Working Group on Introductions and Transfers of Marine Organisms (WGITMO)**
  - **Terms of Reference c. Investigate biofouling as a vector for the introduction and transfer of aquatic organisms on vessels and artificial hard structures, their pressure and impact on the ecosystem, with a comparison of prevention or selective mitigation methodologies.**

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