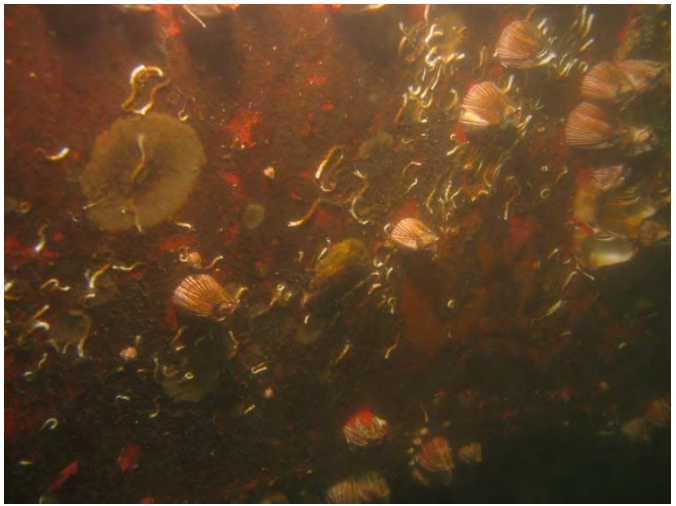
Evaluating the Efficacy and Environmental Impacts from Proactive In-Water Cleaning of Comercial Vessels

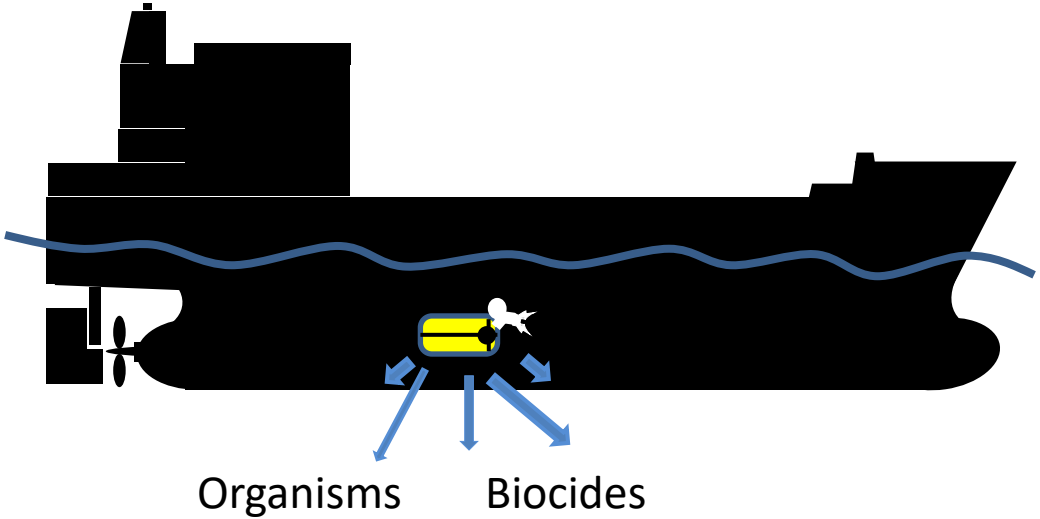
Chris Scianni
California State Lands Commission
Marine Invasive Species Program

Marinas Interagency Coordinating Committee
January 27, 2022

Reactive Cleaning

Traditional paradigm of reactive in-water cleaning





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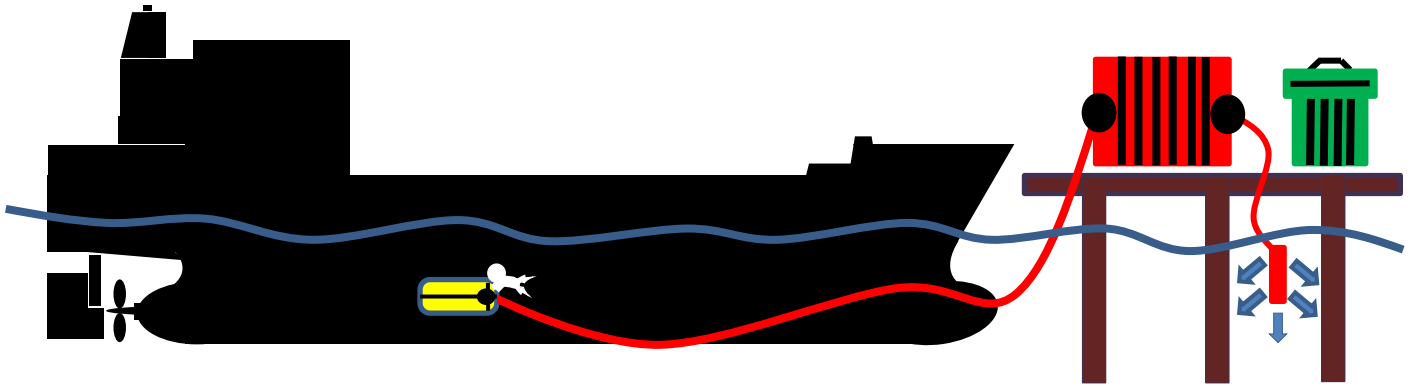
Newer Paradigm of Reactive In-Water Cleaning *and Capture*



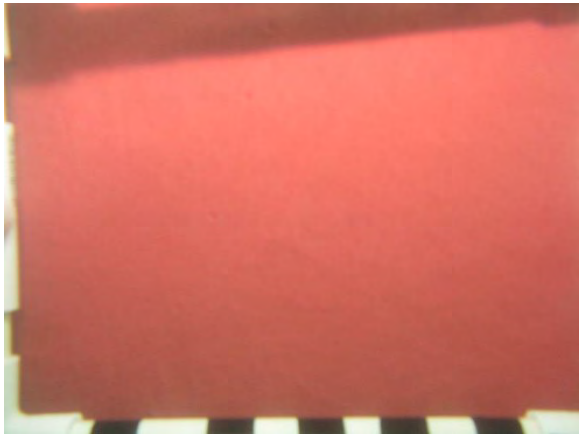
Modified from: Scianni and Georgiades 2019
https://www.frontiersin.org/articles/10.3389/fmars.2019.00467/full

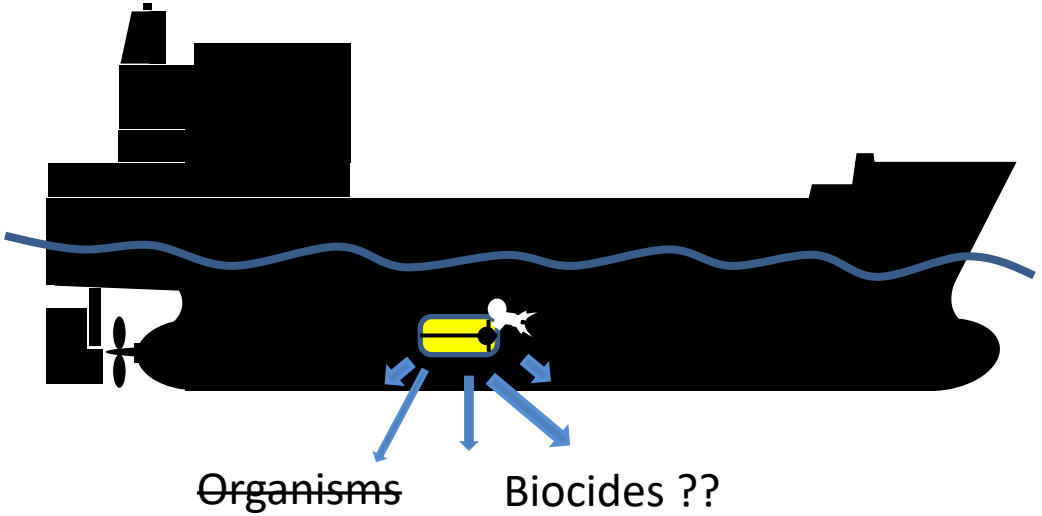
Questions:

- How well do the systems clean?
- How well do the systems contain the removed debris at the point of cleaning?
- How well do the systems filter/treat the effluent before discharge?

Proactive Cleaning

Proactive in-water cleaning



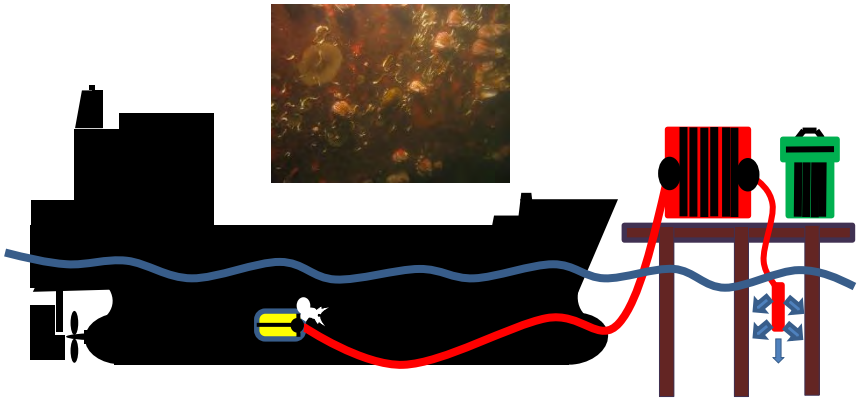


Modified from: Scianni and Georgiades 2019
https://www.frontiersin.org/articles/10.3389/fmars.2019.00467/full

Questions:

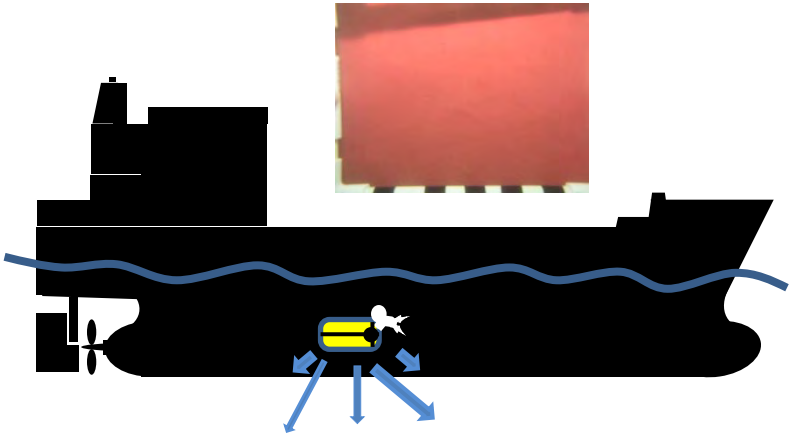
- How well do the systems clean?
- Are biocides released? If so, at what concentration?

Environmental risks associated with in-water cleaning



Reactive IWCC:

- Cleaning effectiveness
- Debris capture efficiency
- Filtration/treatment/removal efficiency



Proactive IWC:

- Cleaning effectiveness
- Biocide release?

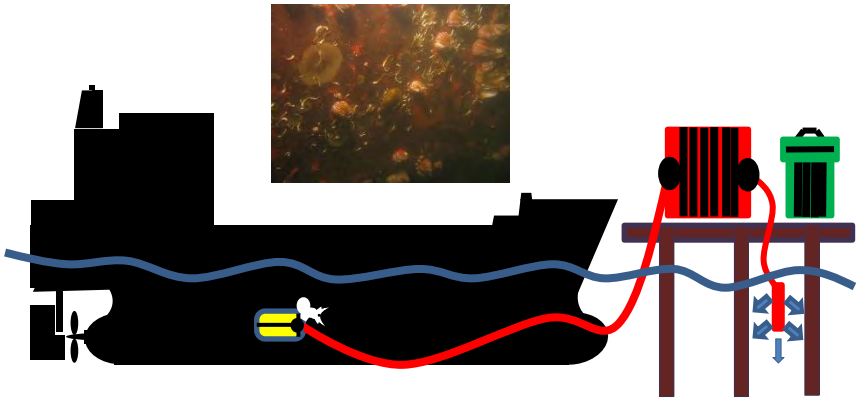
Modified from: Scianni and Georgiades 2019
https://www.frontiersin.org/articles/10.3389/fmars.2019.00467/full

Project Team

https://www.act-us.info/

https://www.maritime-enviro.org/index.php

Environmental risks associated with *reactive in-water cleaning with capture*



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Environmental risks associated with *reactive in-water cleaning with capture*

Vessel 1:

- Baltimore, MD
- Heavy biofouling: 60-100%
- Low visibility: < 1m

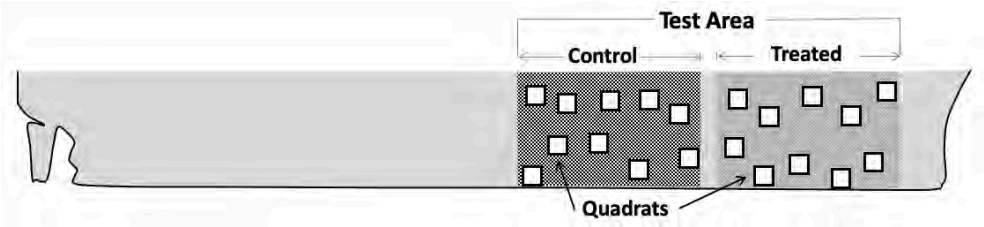
Vessel 2:

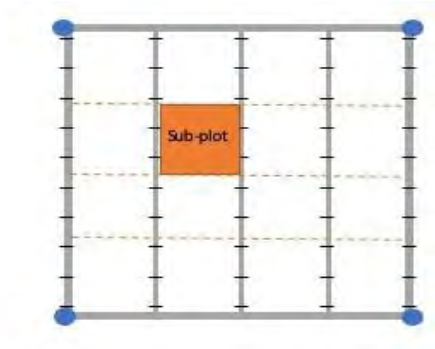
- Alameda, CA
- Moderate biofouling: 50-75%
- Low visibility: < 1m

Evaluation of efficacy and environmental impact from *reactive in-water cleaning with capture*

Reactive IWCC:

- Cleaning effectiveness





Surface Type	Number of Plots	Number of Images Within One Plot	Total Photos
Vertical flat	6	16	96
Horizontal flat	6	16	96
Vertical curved	6	16	96
Angled Surfaces	6	5	30

Modified from: Tamburri et al., 2020.
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Evaluation of efficacy and environmental impact from *reactive in-water cleaning with capture*

Reactive IWCC:

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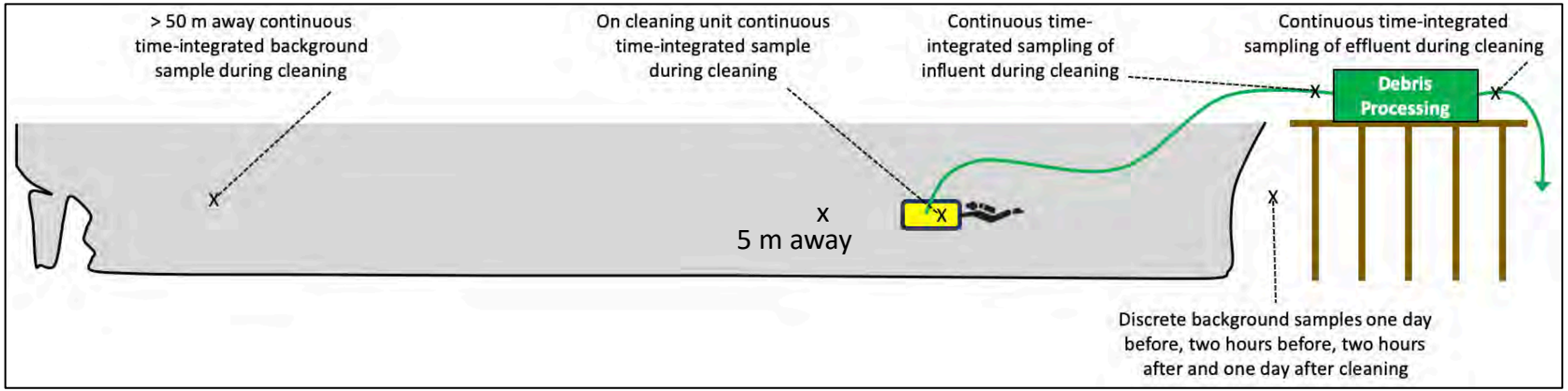
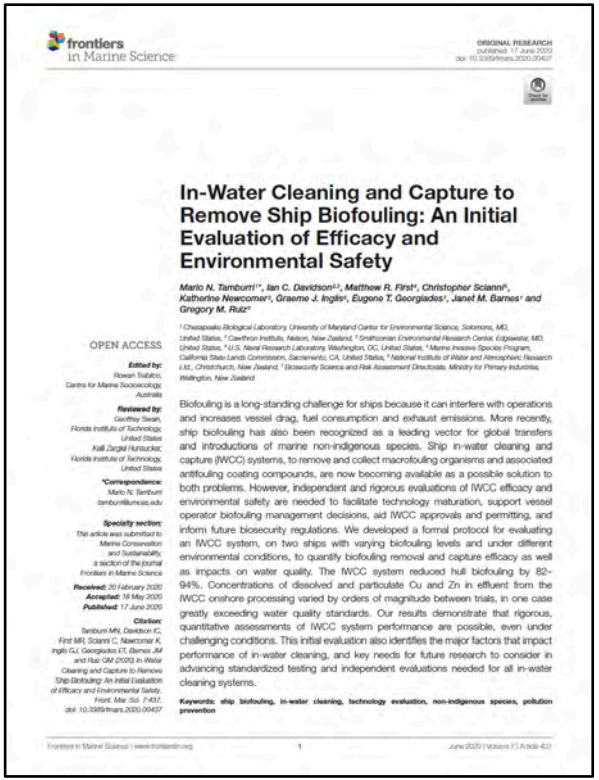


Water Quality Parameters:

- Biocides (Cu, Zn)
- TSS, POC, DOC
- Particle size distribution

Evaluation of efficacy and environmental impact from *reactive in-water cleaning with capture*



frontiers in Marine Science

ORIGINAL RESEARCH

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In-Water Cleaning and Capture to Remove Ship Biofouling: An Initial Evaluation of Efficacy and Environmental Safety

Mario N. Tamburri[1], Ian C. Davidson[2,3], Matthew R. First[4], Christopher Sciann[5], Katherine Newcomer[5], Graeme J. Inglis[6], Eugene T. Georgiades[7], Janet M. Barnes[7] and Gregory M. Ruiz[5]*

[1] Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, United States, [2] Cawthron Institute, Nelson, New Zealand, [3] Smithsonian Environmental Research Center, Edgewater, MD, United States, [4] U.S. Naval Research Laboratory, Washington, DC, United States, [5] Marine Invasive Species Program, California State Lands Commission, Sacramento, CA, United States, [6] National Institute of Water and Atmospheric Research Ltd., Christchurch, New Zealand, [7] Biosecurity Science and Risk Assessment Directorate, Ministry for Primary Industries, Wellington, New Zealand

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Biofouling is a long-standing challenge for ships because it can interfere with operations and increases vessel drag, fuel consumption and exhaust emissions. More recently, ship biofouling has also been recognized as a leading vector for global transfers and introductions of marine non-indigenous species. Ship in-water cleaning and capture (IWCC) systems, to remove and collect macrofouling organisms and associated antifouling coating compounds, are now becoming available as a possible solution to both problems. However, independent and rigorous evaluations of IWCC efficacy and environmental safety are needed to facilitate technology maturation, support vessel operator biofouling management decisions, aid IWCC approvals and permitting, and inform future biosecurity regulations. We developed a formal protocol for evaluating an IWCC system, on two ships with varying biofouling levels and under different environmental conditions, to quantify biofouling removal and capture efficacy as well as impacts on water quality. The IWCC system reduced hull biofouling by 82–94%. Concentrations of dissolved and particulate Cu and Zn in effluent from the IWCC onshore processing varied by orders of magnitude between trials, in one case greatly exceeding water quality standards. Our results demonstrate that rigorous, quantitative assessments of IWCC system performance are possible, even under challenging conditions. This initial evaluation also identifies the major factors that impact performance of in-water cleaning, and key needs for future research to consider in advancing standardized testing and independent evaluations needed for all in-water cleaning systems.

Keywords: ship biofouling, in-water cleaning, technology evaluation, non-indigenous species, pollution prevention

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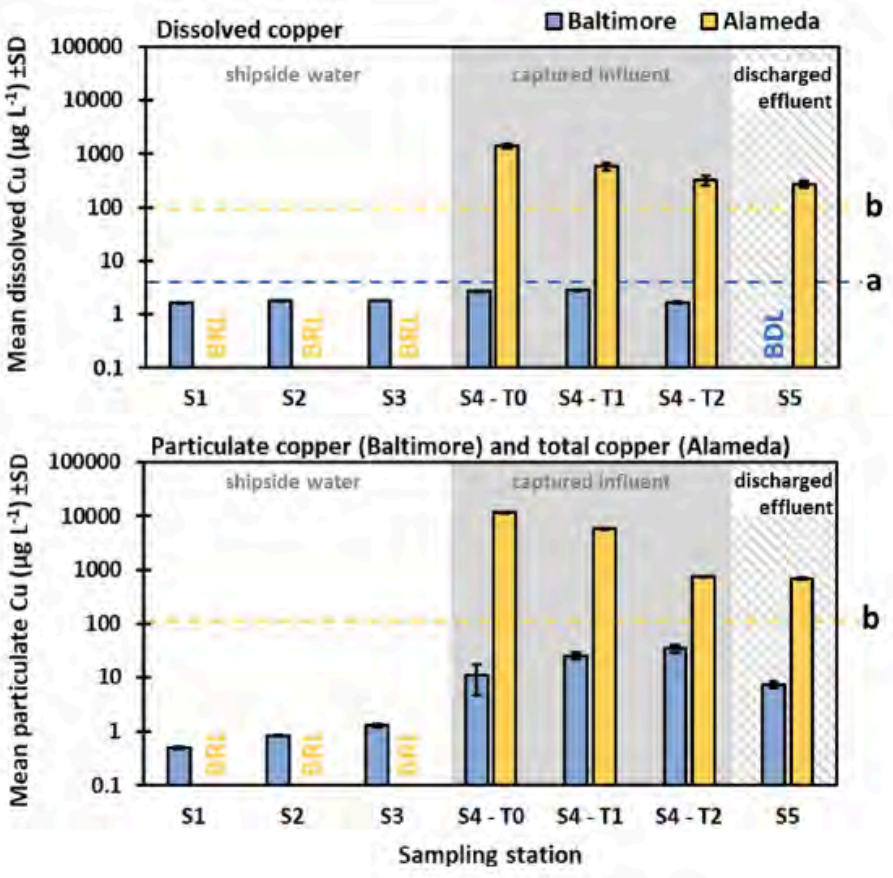

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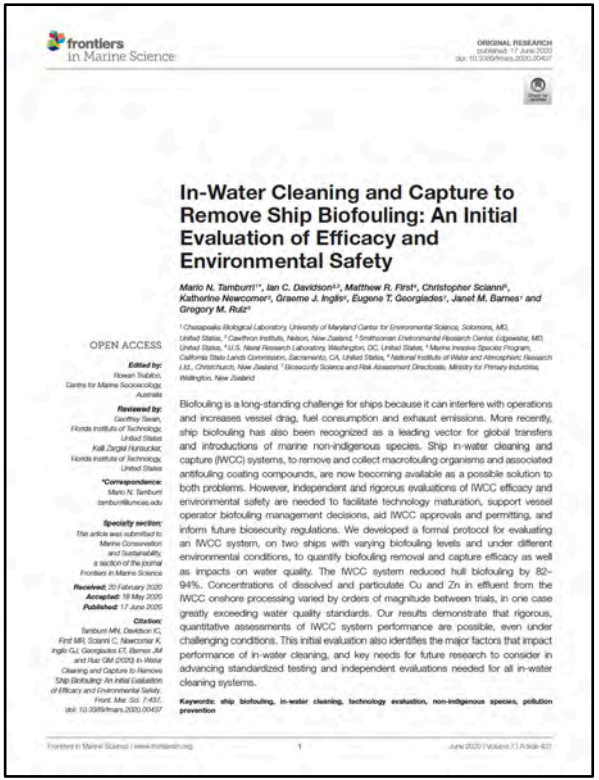

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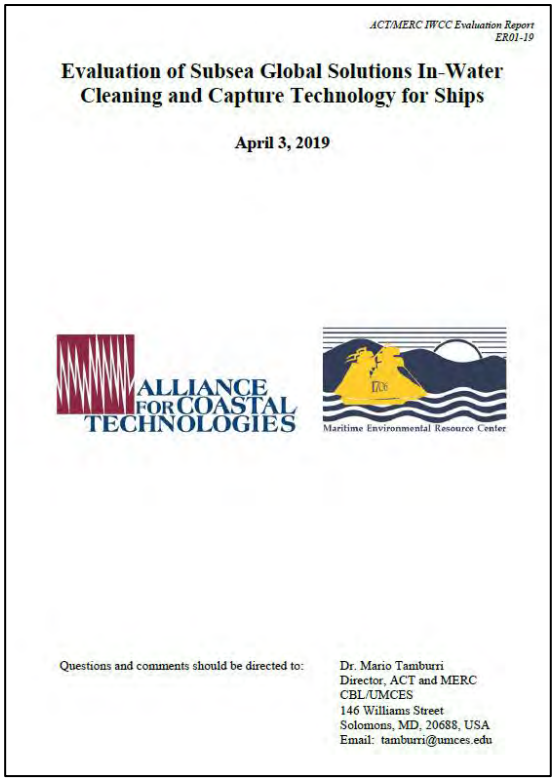

ACT/MERC IWCC Evaluation Report ER01-19

Evaluation of Subsea Global Solutions In-Water Cleaning and Capture Technology for Ships

April 3, 2019

ALLIANCE FOR COASTAL TECHNOLOGIES

Maritime Environmental Resource Center

Questions and comments should be directed to:

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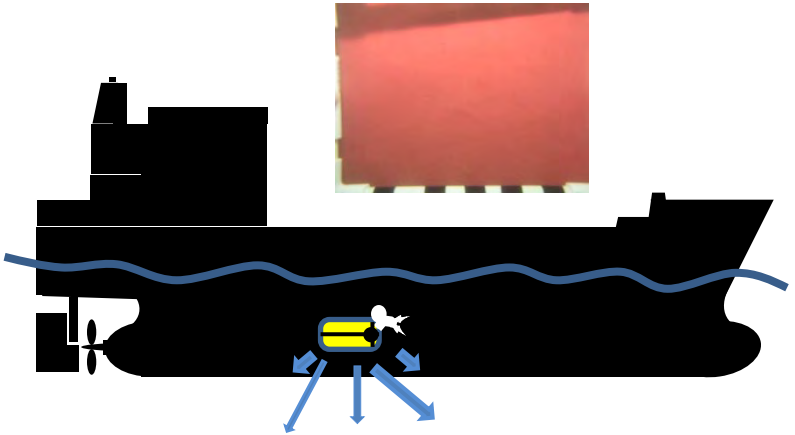
https://www.maritime-enviro.org/Downloads/Reports/MERC_Inwater/ACT_MERC_SGS_IWCC_Evaluation_Report.pdf

Evaluation of efficacy and environmental impact from *proactive in-water cleaning*



Proactive IWC:

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- Biocide release?

Modified from: Scianni and Georgiades 2019
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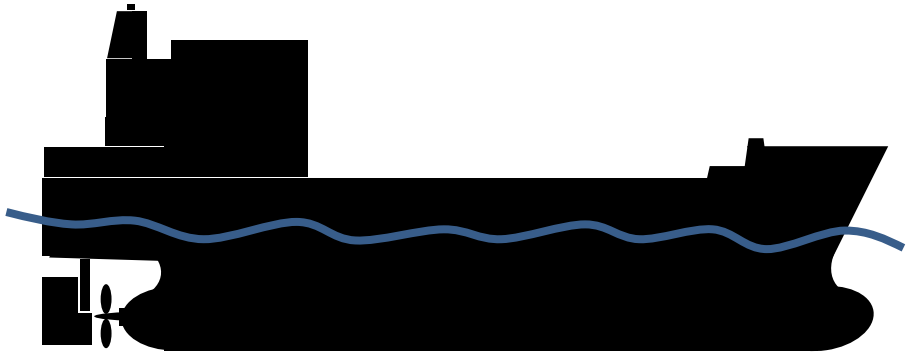
Evaluation of efficacy and environmental impact from *proactive in-water cleaning*

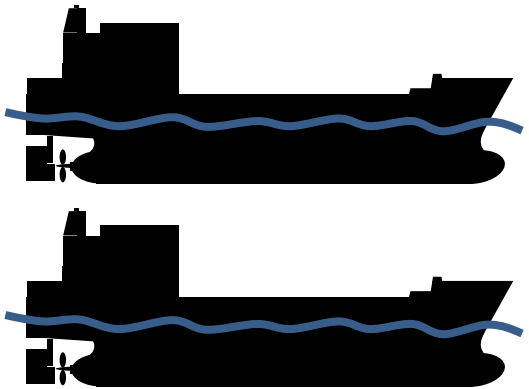
Primary vessel:

- Start project immediately after dry dock
- 3x Biofouling/biofilm presence absence sampling
- 3x Water Quality sampling during cleaning



Secondary vessels (2):

- 1x Water Quality sampling per vessel during cleaning



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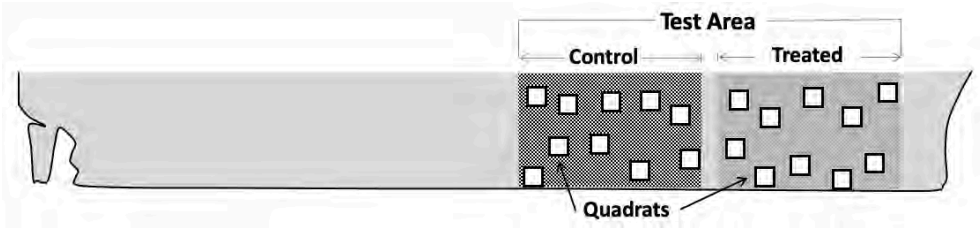
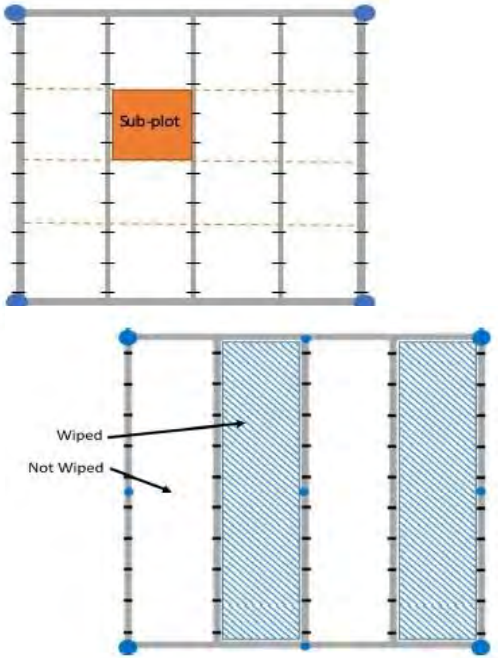
Proactive IWC:

- Cleaning effectiveness





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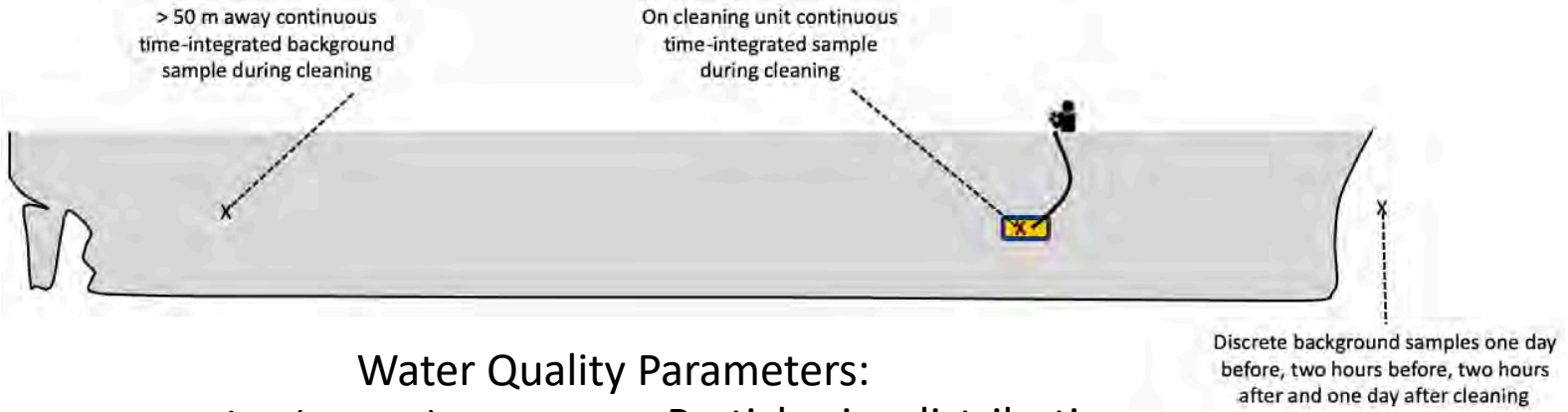


Water Quality Parameters:

- Biocides (Cu, Zn)
- TSS, POC, DOC
- Particle size distribution
- Microplastics

Modified from: Tamburri et al., 2020.
https://www.frontiersin.org/articles/10.3389/fmars.2020.00437/full

Evaluation of efficacy and environmental impact from *proactive in-water cleaning*

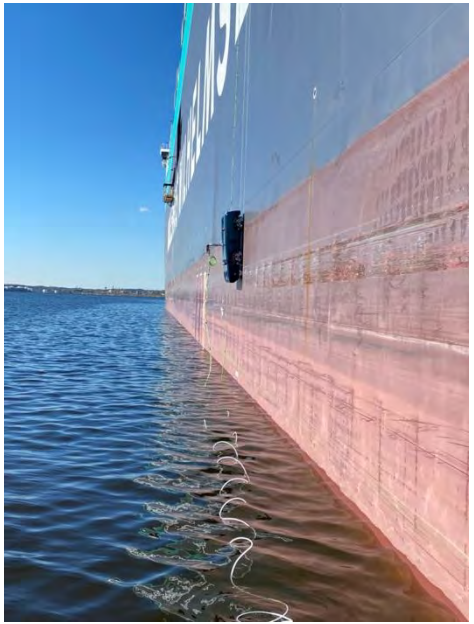
Sample schedule for Primary Vessel:

- Dry dock and new coating: September 17, 2021

- Dive survey 1: October 2021 in Long Beach
- WQ sampling 1: November 2021 in Baltimore

- Dive Survey 2: *March 2022 in Long Beach*
- WQ sampling 2: *March 2022 in Baltimore*

- Dive survey 3: [TBD]
- WQ sampling 3: [TBD]

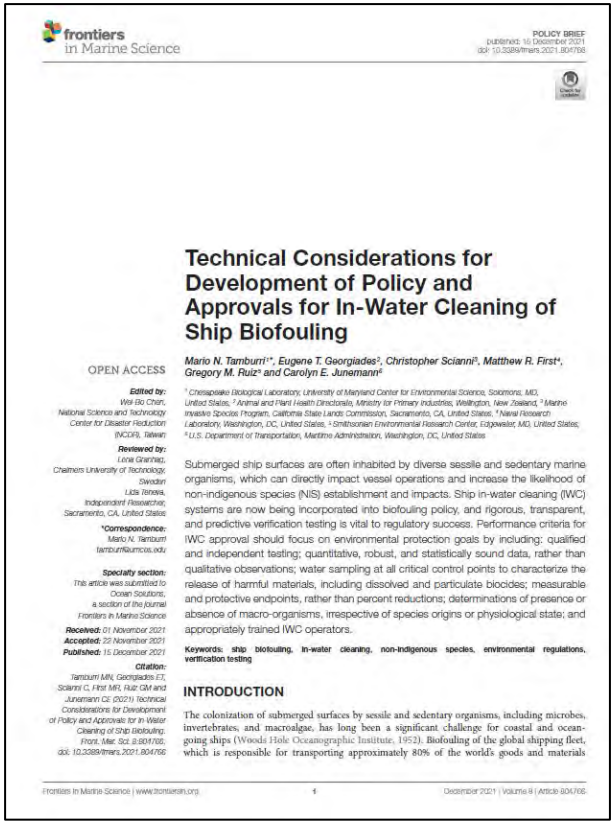


Next Steps

- Finish last two rounds of sampling for primary vessel
- Identify secondary vessels and conduct WQ sampling during proactive cleaning operations
- Produce public report and prepare manuscript for journal peer-review

- Use our experience to offer guidance to permitting agencies on important considerations (next slide)

Technical Considerations for IWC Policy



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

Mario N. Tamburri[1]*, Eugene T. Georgiades[2], Christopher Scianni[3], Matthew R. First[4], Gregory M. Ruiz[3] and Carolyn E. Junemann[5]

[1] Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, United States, [2] Animal and Plant Health Directorate, Ministry for Primary Industries, Wellington, New Zealand, [3] Marine Invasive Species Program, California State Lands Commission, Sacramento, CA, United States, [4] Naval Research Laboratory, Washington, DC, United States, [5] Smithsonian Environmental Research Center, Edgewater, MD, United States, [6] U.S. Department of Transportation, Maritime Administration, Washington, DC, United States

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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

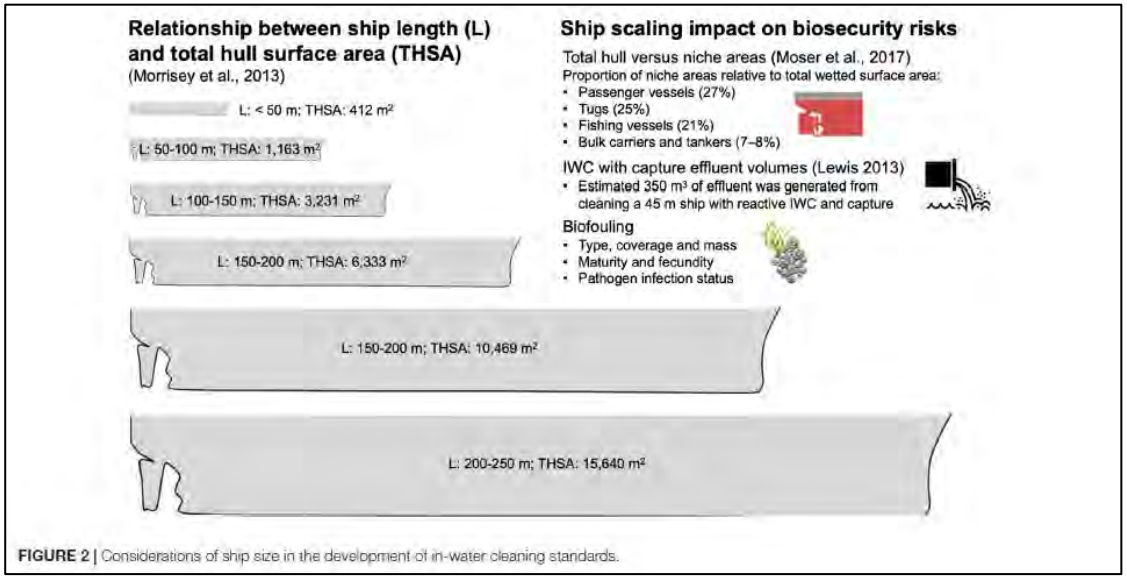

FIGURE 2 | Considerations of ship size in the development of in-water cleaning standards.

Tamburri et al., 2021. https://www.frontiersin.org/articles/10.3389/fmars.2021.804766/full

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THANK YOU & QUESTIONS

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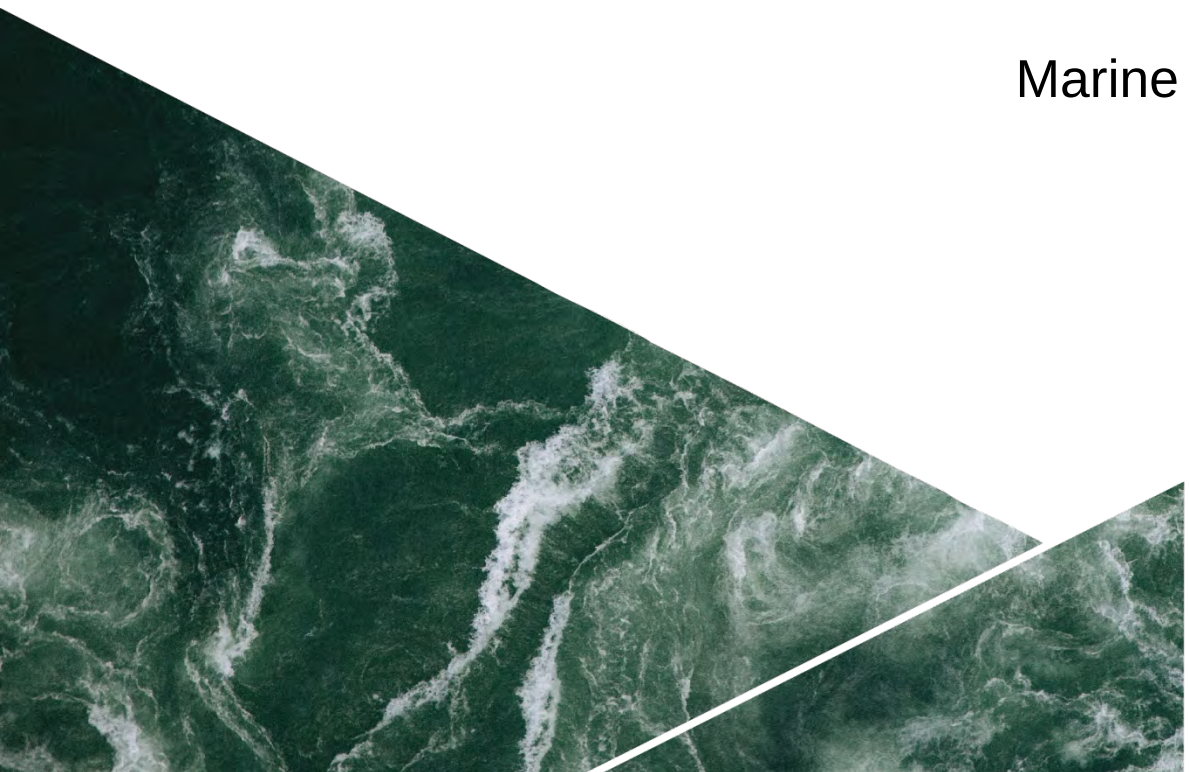

California State
Lands Commission