Naval Information Warfare Center PACIFIC

NAVSEA WARFARE CENTERS Carderock

Impact of Cleaning Tools on Antifouling Coatings

Patrick Earley

Naval Information Warfare Center Pacific

Elizabeth Haslbeck

Naval Surface Warfare Center Carderock Division

SERDP • ESTCP SYMPOSIUM 2019 | Enhancing DoD's Mission Effectiveness

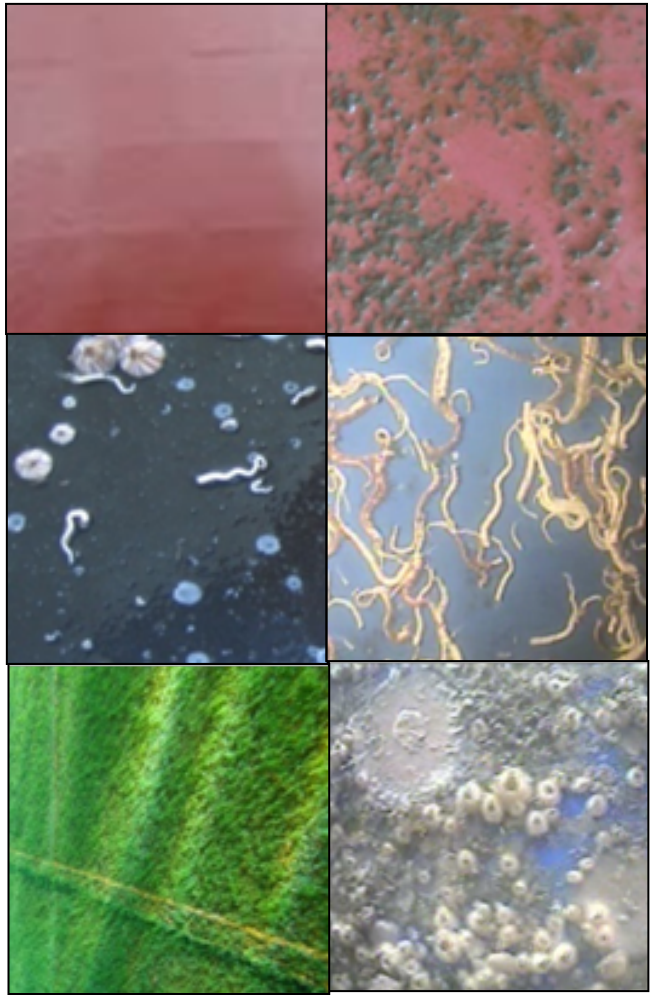
25 YEARS OF ESTCP

Agenda

- Biofouling and current management
- Biofouling impacts on DoD
- Hull cleaning technologies
- Data gaps
- Need for screening tool
- Standardized device development
- Conclusions

Biofouling and Current Management

- Attachment and growth of organisms on immersed, man-made objects
- DoD uses biocides
  - Copper ablative underwater hull coating systems
- Effectiveness of coating
  - Typically biofouling <10%
  - Significant, measurable impact
- Biofouling on ships
  - Drydock ship and replace coating
  - In-water cleaning
    - “Reactivates” coating surface
    - Abrades coating
    - Debris settles in water column



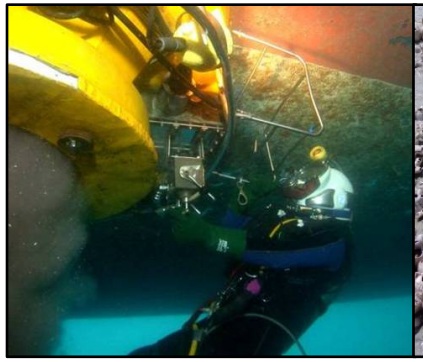
Biofouling Impacts on DoD

Negatively impacts mission, readiness, capability, environment

Speed/Range/Maneuverability

Signature

Projected Power/Mission



Maintenance/Safety Readiness

Air/Water Quality

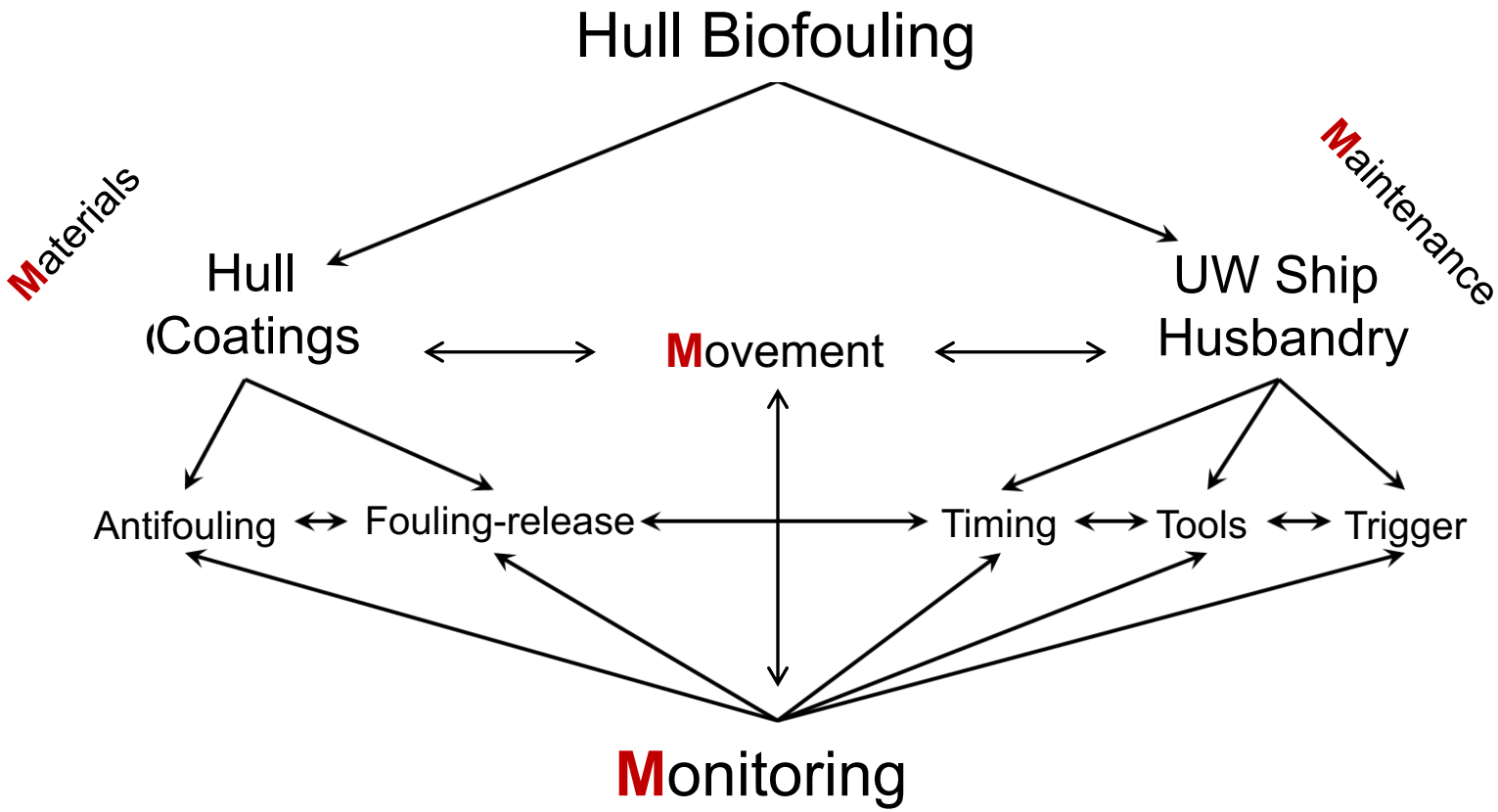
Single biggest factor affecting DoD fleet fuel efficiency

Naval Information Warfare Center PACIFIC

NAVSEA WARFARE CENTERS Carderock

SERDP • ESTCP SYMPOSIUM #SerdpEstcp2019

Interdependencies



Characterizing performance, service life, benefits, and costs is challenging

Biofouling Control

Coatings

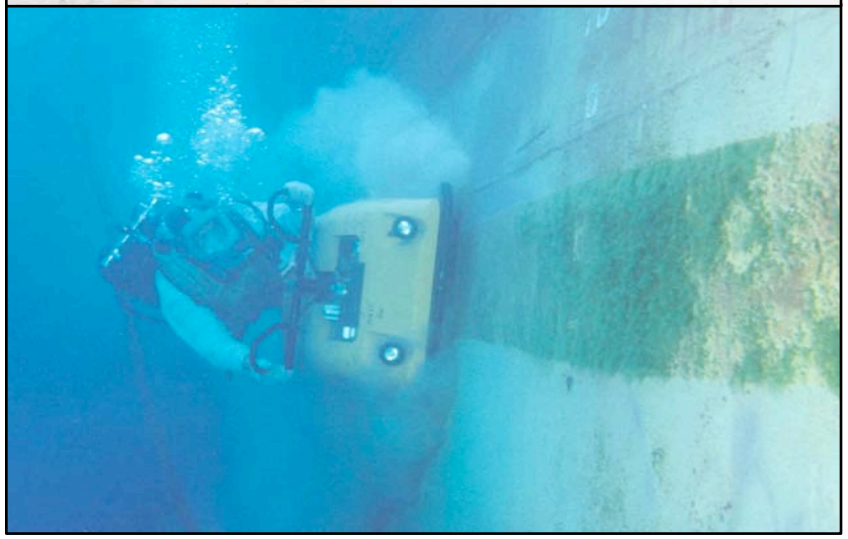
- Biocide-containing
  - Heavy metal
  - Organic
- Biocide-free
  - Fouling-release
- Hybrid coatings

Problems

- Regulatory concerns
  - Volatile organic content Biocide inputs
- Coating performance
  - Operational profile
  - Operational area
  - Niches

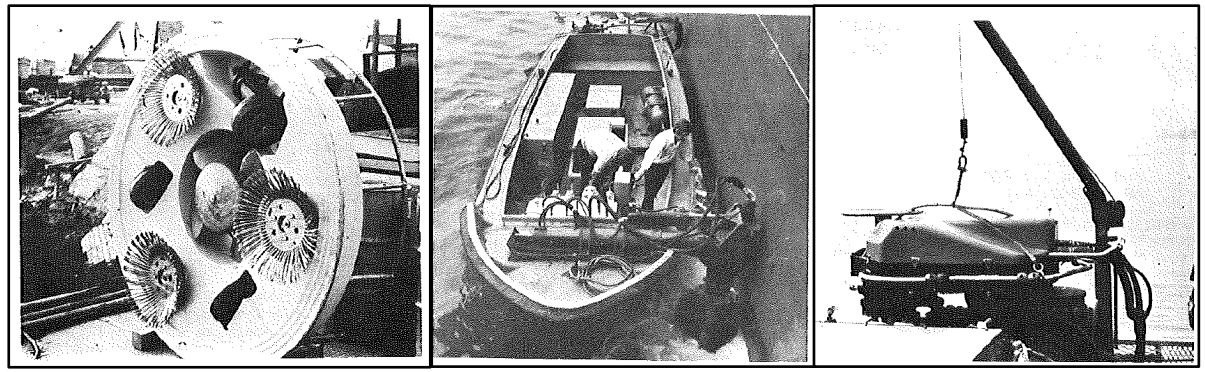
Hull Cleaning When Coating Fails

- In dry dock
  - Expensive
  - Time consuming
  - Limited dock availability
- In water
  - Less expensive
  - Quick



History of In-Water Cleaning
U.S. Navy Experience

- 1970s and 1980s
  - Vinyl copper-based coatings life
  - Drydock cycle from 1-2 → 3+ years
  - Rotating brush tools
  - Removes cupric salts/compounds
- 1980s and 1990s
  - Ablative copper-based coatings
  - Drydock cycle from 3-5 → 8-12 years
  - Rotating brush tools
  - Removes leached layer
  - Extended time between dry-docking



In-Water Cleaning Practices
U.S. Navy Experience

- Rotating brush
- Limited use of waterjets
- Biannual inspections
- Cleaning triggers
  - Antifouling coatings
    - 40 rating over 20% of hull
  - Fouling-release coatings
    - 50 rating over 10% of hull

Fouling Rating	Organisms
10-20	Slime/diatom
30	Soft macrofouling
40-50	Small calcareous
60-100	Larger forms and/or mixed forms

In-Water Hull Cleaning

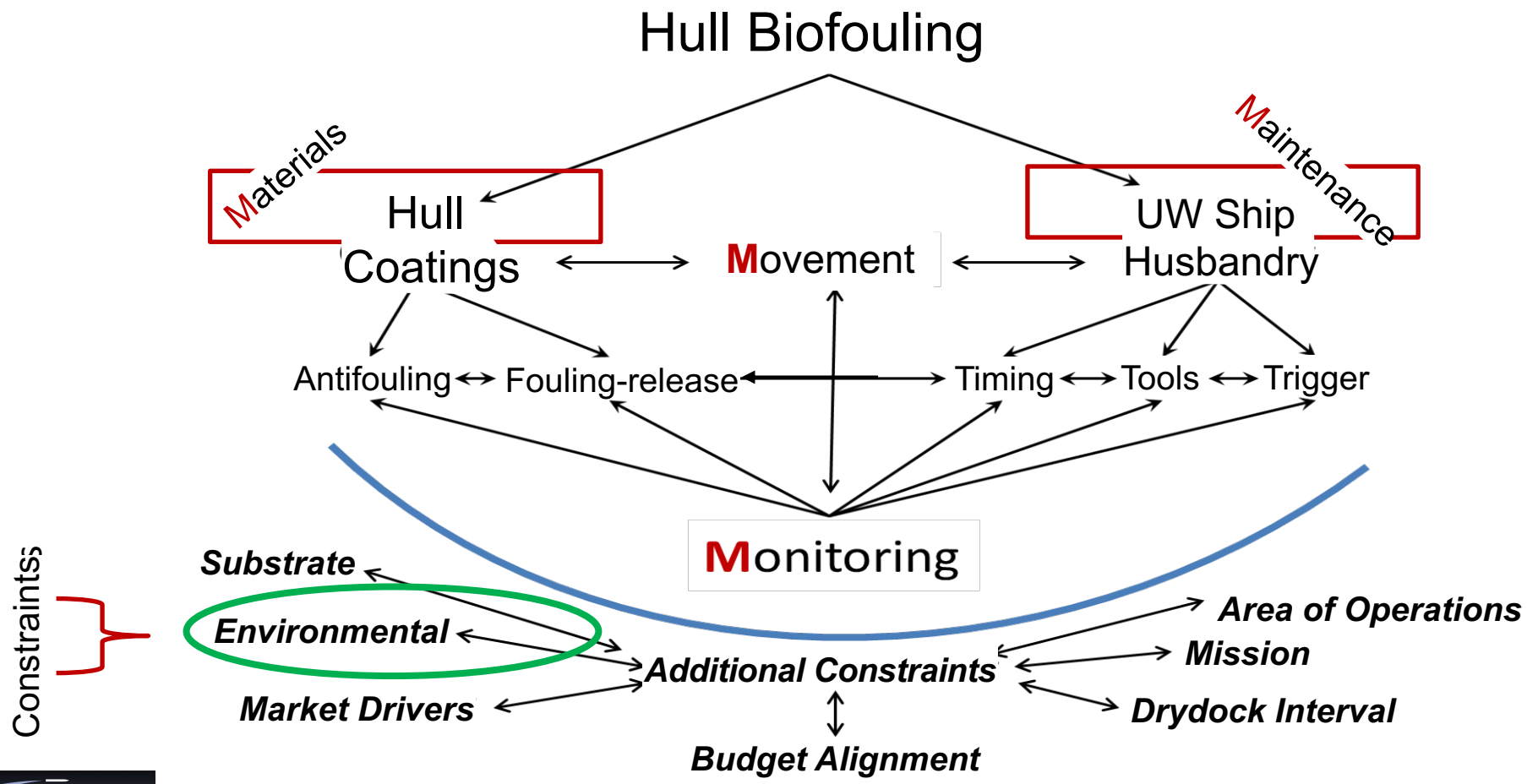
Benefits

- Cost-effective for vessel operating efficiency
- Restores coating efficacy

Consequences

- Discharge of paint components
- Impact coating integrity
  - Paint thickness
  - Surface properties
- Release of attached biofouling
- Regulatory scrutiny

Finding the Right Solution



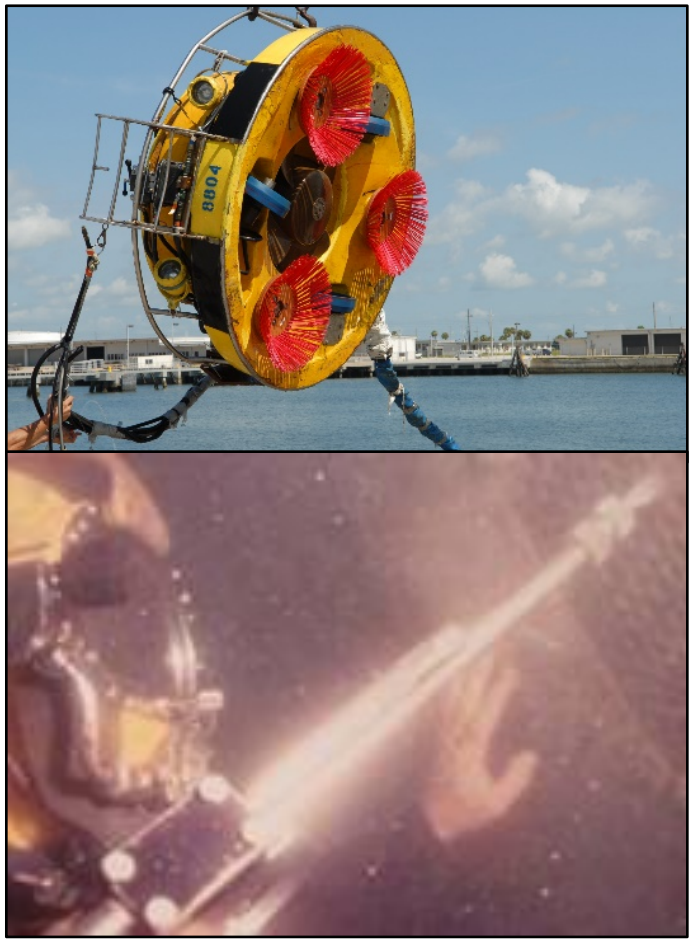
Knowledge and Capability Gaps

- Lack of comprehensive understanding of in-water cleaning

Environmental inputs
Chemical
Biological

As affected by
Coating type
Cleaning tool
Cleaning strategy

Impact on coatings
Thickness
Damage
Subsequent efficacy



- Need standard testing and impact measurement

Options for Testing
Elcometer Washability Tester

- ASTM* D2486, D4828, D4213, D3450
- DIN*, ISO* methods

- Advantages
  - High quality data, reproducible

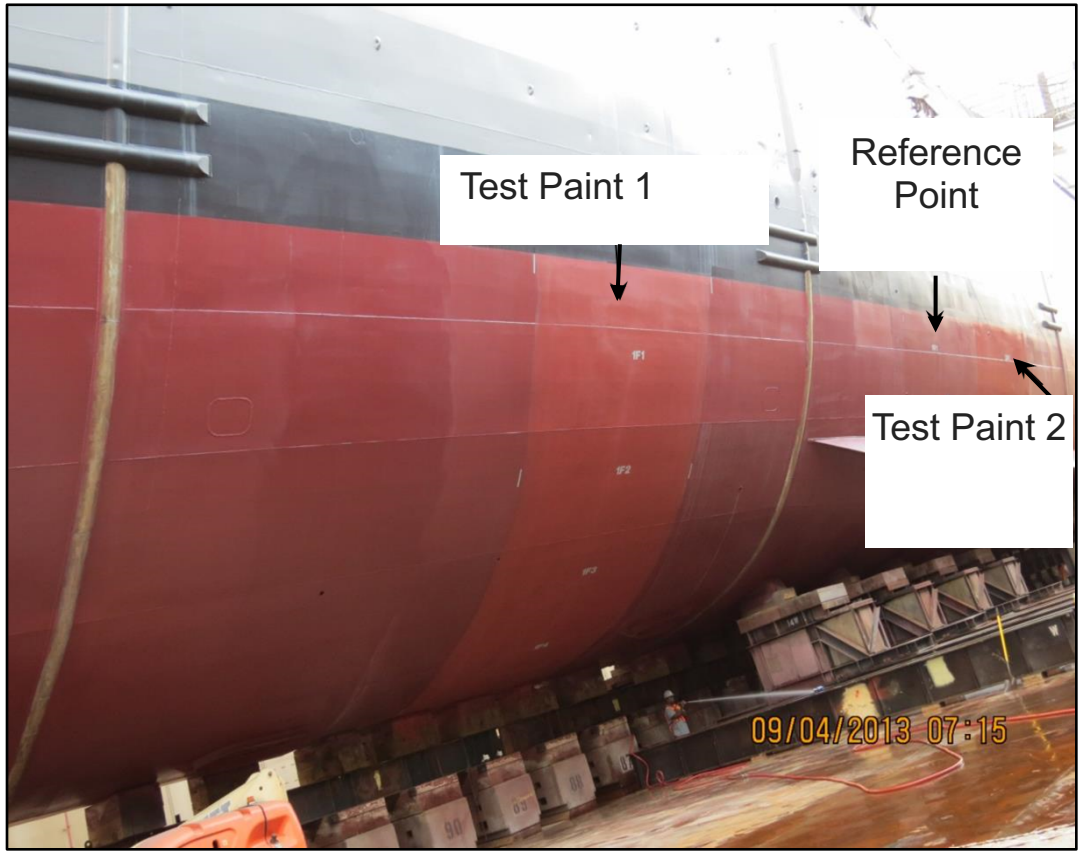
- Disadvantages
  - Architectural focus
  - Limited for relevant cleaning tools
  - Cannot measure environmental inputs

Source: https://www.elcometer.com

*ASTM = American Society of Testing and Materials;
*DIN = German Institute for Standardization;
*ISO = International Standards Organization

Options for Testing
Non-Standard Methods: On-ship Evaluation

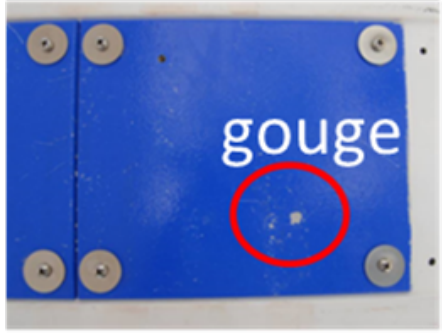
- Quantify paint thickness decrease
- Advantage
  - Application of full-scale tool
- Disadvantages
  - Cannot resolve small changes
  - Limited environmental inputs measurement
  - High risk to ship – coating failure



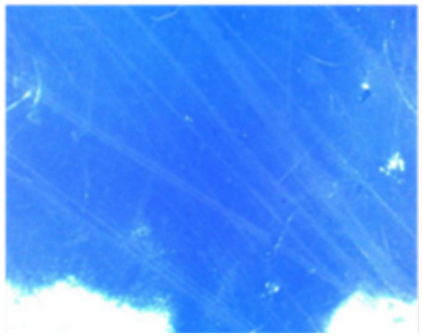
Options for Testing
Non-Standard Methods: Raceway Test

- Panel tests – mounted coated panels
- Advantages:
  - Application of full-scale tool
  - High data quality
  - No risk to a ship
- Disadvantages:
  - High cost
  - Limited ability to measure environmental inputs

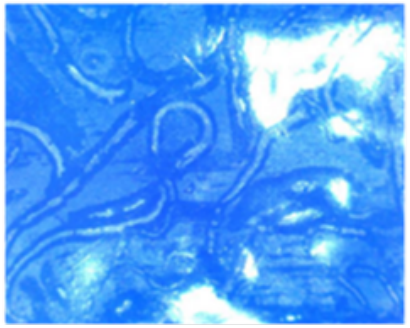
Cleaning damage test – cleaning w-brushes **damaged paint**



Macroscopic damage



Microscopic scratching (50x)



Calcareous tubeworm residue (50x)

Source: NSWCCD, Florida Institute of Technology

Options for Testing
Non-Standard Methods: Diver Handheld Tool

- In-water hull cleaning sampling device
- Quantify biocide inputs following “surface refreshment”
- Advantages
  - Quantify biocide inputs
- Disadvantages
  - Does not utilize diver-operated tools
  - Does not replicate true impact to coating

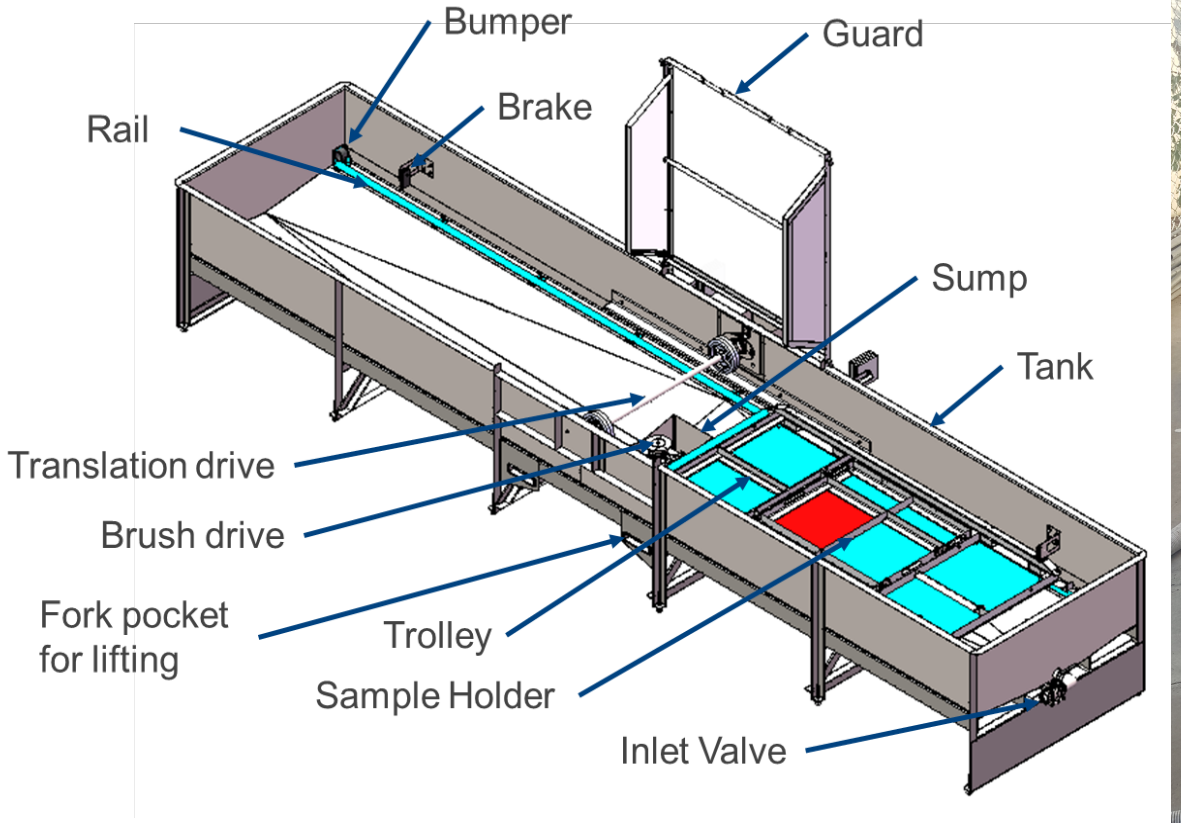
Naval Information Warfare Center PACIFIC
NAVSEA WARFARE CENTERS Carderock

Source: Earley et al. (2014) Biofouling 20:41-68

Standardized Device and Method

- Evaluate in-water cleaning tool impact on hull paint
- Address weaknesses of other methods
- Cleaning tools applied to test surfaces
- Match operational characteristics as used in field
  - Transit speed
  - Rotation rate, shear force
  - Normal force
- Materials to minimize interfering chemicals into sample water
- 20+ detailed design requirements including
  - Logging operational parameters
  - Easy swapping of cleaning brushes and hydraulic motors

Standardized Device and Method



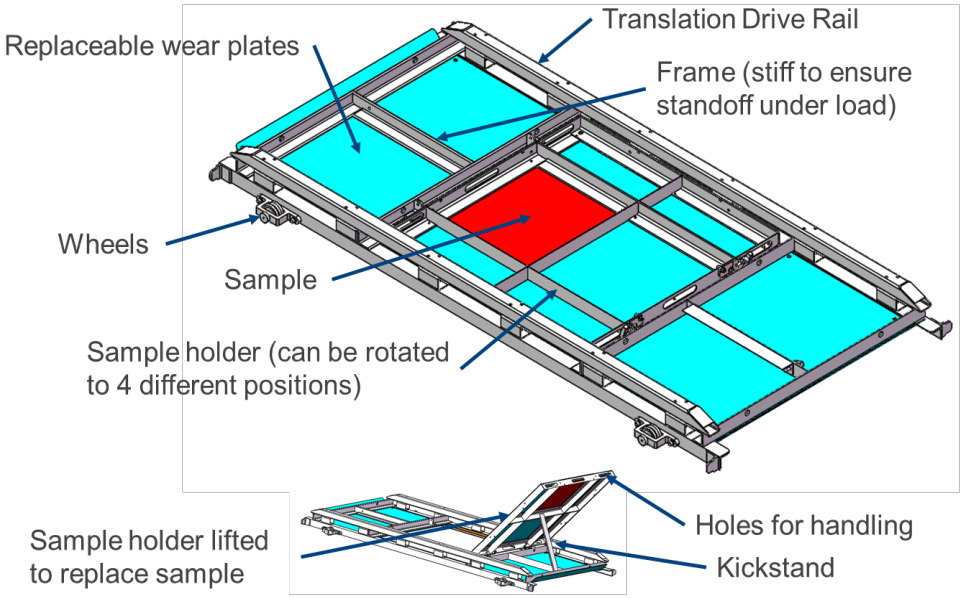
Naval Information Warfare Center PACIFIC

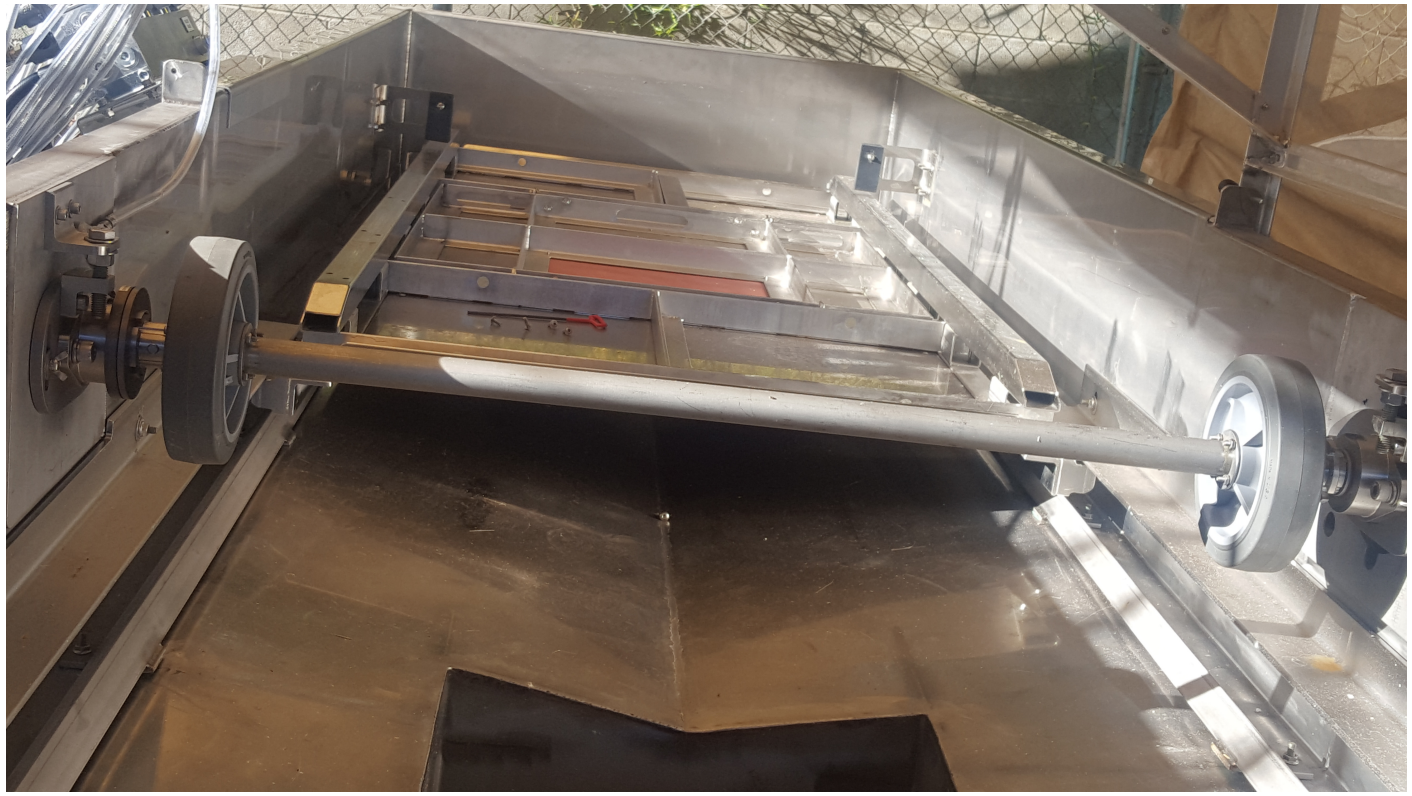
NAVSEA WARFARE CENTERS Carderock

Patent Pending - Navy Case #112047

SERDP • ESTCP SYMPOSIUM #SerdpEstcp2019

Standardized Device and Method



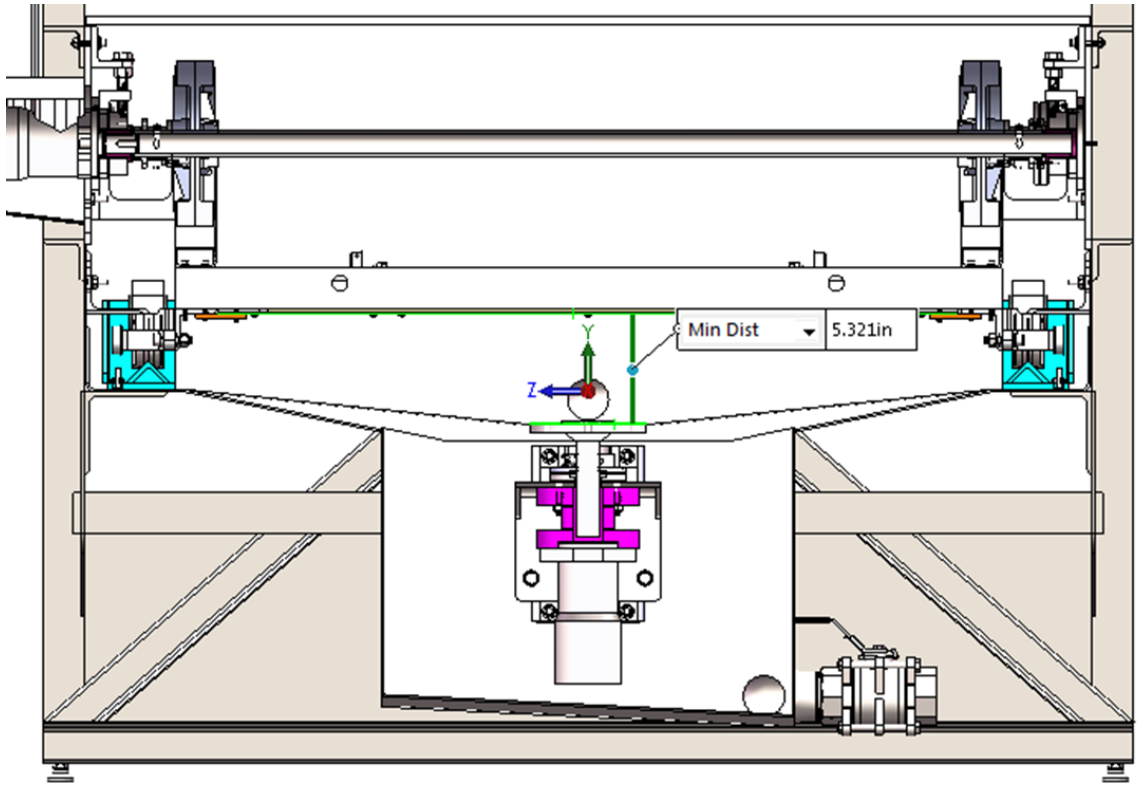


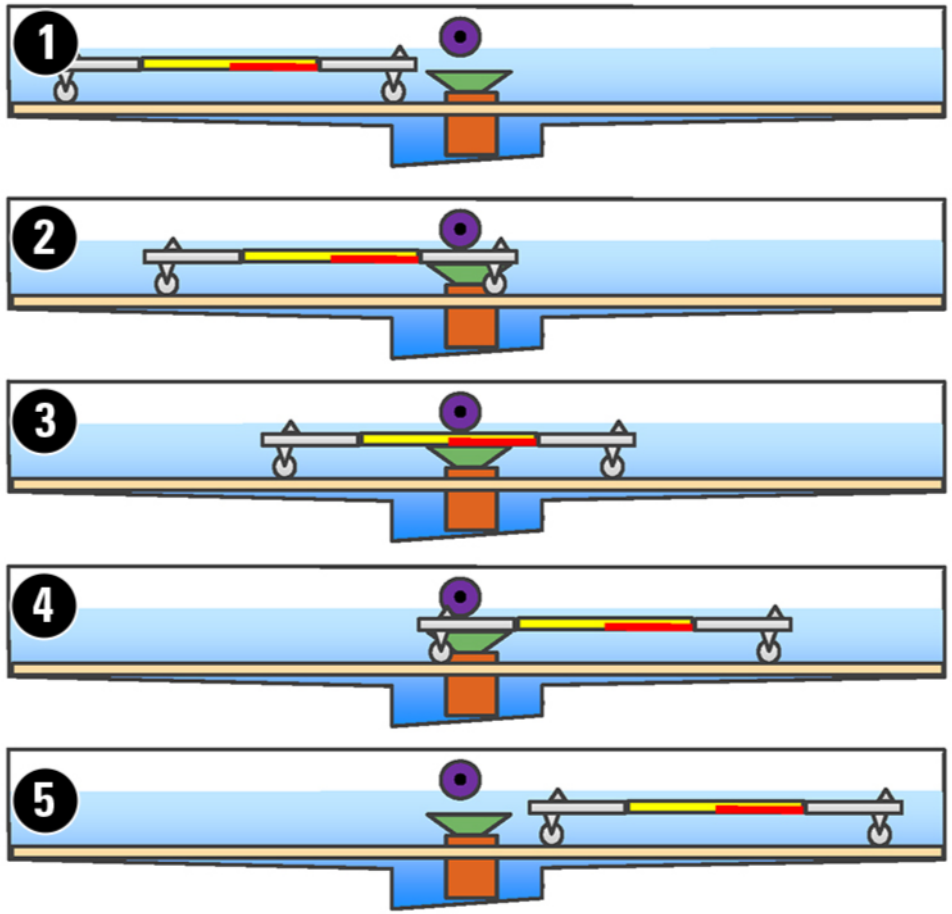
Patent Pending - Navy Case #112047

Standardized Device and Method

- Single pass of coated test panel over cleaning tool
  - Cleaning head for multiple tools types
  - Currently configured to handle brushes
  - 7 brushes in initial test (U.S. Navy qualified)
- Quantify changes in paint thickness or surface properties
- Sample for water quality
  - Dissolved metals
  - Particulate matter
  - Copper, zinc
- Screening test – compare legacy to emerging technologies
  - No analysis of biological inputs
    - Would need lengthy exposure time in order for coatings to develop biofouling

Standardized Device and Method





Conclusions
In-Water Hull Cleaning

- Cost-effective coating restoration
  - Coating regulations may conflict with cleaning regulations
  - Need benefit-cost balance
- In-water cleaning impacts coatings
- Poor understanding of:
  - Paint thickness
  - Coating system service life
  - Environmental inputs
- Improved understanding may aid regulators, technology developers, and end users
- A standardized tool and method may help inform the problem
- Could evaluate environmental biological material inputs
  - Efficacy and post-cleaning survival
  - Impact of in-water hull cleaning/biofouling removal on biological oxygen demand

Benefits to DoD

- A Standard method closes critical knowledge and capability gaps
  - Reduce risk – new coating transition
  - Predict coating system service life
  - Assess the use of in-water cleaning as a biofouling mitigation strategy
  - Modular system that can be adapted to test alternative cleaning technologies

- Supports key environmental quality considerations
  - Air quality – solvents and combustion emissions
  - Water quality – hull coating leachate, in-water cleaning, non-indigenous species/ accurate environmental loading parameters.

Team

- Naval Surface Warfare Center, Carderock Division, Bethesda, Maryland
  - Project Lead
  - Biofouling control and coatings expertise
  - CTTD design
  - Method development
  - Full-scale validation
- Naval Information Warfare Center, Pacific (Formerly SPAWAR, Pacific)
  - Environmental/water quality expertise
  - Seawater test rack (panel exposure/hydration)
  - CTTD design and “home”
  - Method development
  - Test execution - water chemistry, cleaning tool impact
- Battelle, Columbus, Ohio
  - Cleaning Tool Test Device (CTTD) design and build team

Contact Information

Project Manager (Carderock)
elizabeth.haslbeck@navy.mil
(301) 227-4784

NIWC Technical Lead
Patrick J. Earley
patrick.earley@navy.mil
(619) 553-2768

Equipment unloading

Equipment Delivery

https://images.app.goo.gl/GBcmQzq9sZrL43G18