POLITECNICO DI MILANO

lecco innovation hub

Marine Research Laboratory

the Learning Network on Sustainable energy systems

Sustainable Energy for All by Design

Dilemma – Design, development and sustainability

Cape Town, Wed 28th September 2016

ANTIFOULING WRAP

a sustainable solution for biofouling prevention

Andrea Ratti, Arianna Bionda

Design Department, Politecnico di Milano

POLITECNICO DI MILANO

lecco innovation hub

Marine Research Laboratory

PROBLEM SETTING

Scientific background

PURPOSE

The current research on **SUSTAINABILITY** applied to **YACHT DESIGN** and **NAVAL ARCHITECTURE** is focused on three main areas:

- EFFICIENCY OF THE HULL SHAPE
- EFFICIENCY OF THE PROPULSION SYSTEM
- **EFFICIENCY OF THE OBJECT-ENVIRONMENTAL INTERFACE**

Antifouling Wrap aims to study alternative and sustainable solutions for **BIOFOULING PREVENTION** developing a new generation of environmental friendly marine coatings for public and private water transport based on **WRAP AND NANOTECHNOLOGY STRATEGIES**.

THE PROBLEM - **INCREASE OF FUEL CONSUMPTION**

Slime film and heavy calcareous fouling caused

- **POWERING PENALTIES UP TO 86%** at cruising speed
- **FUEL CONSUMPTION UP TO 40%** at cruising speed
- **AIR EMISSIONS** due to increased bunker fuel consumption by the world's shipping fleet could **INCREASE BETWEEN 38% AND 72% by 2020** (without corrective actions and introduction of new technologies)

It's estimated that antifouling reduced emissions of 384 million of carbon dioxide and 3.6 million tones of sulphur dioxide per year, with annual fuel savings of $60 billion

THE PROBLEM – **ENVIROMENTAL IMPACT**

Biofouling effect

- increasing of fuel consumption causes **GREENHOUSE GAS EMISSIONS IN WATER**
- Transfers **ALIEN SPECIES** outside their distributional range

Antifouling coating effect

- **SPREAD OF BIOCIDES AND HEAVY METALS IN WATERS** (IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships, entered into force on 17 September 2008)
- Need of managing the **WASHING WATERS** in the dry dock areas

THE PROBLEM – **HEALTH RISK ON WORKERS**

Antifouling coating during the hull maintenance stages

- Exposition to **FINE DUST, ALLERGENES and VOCS** both during application and removing stages

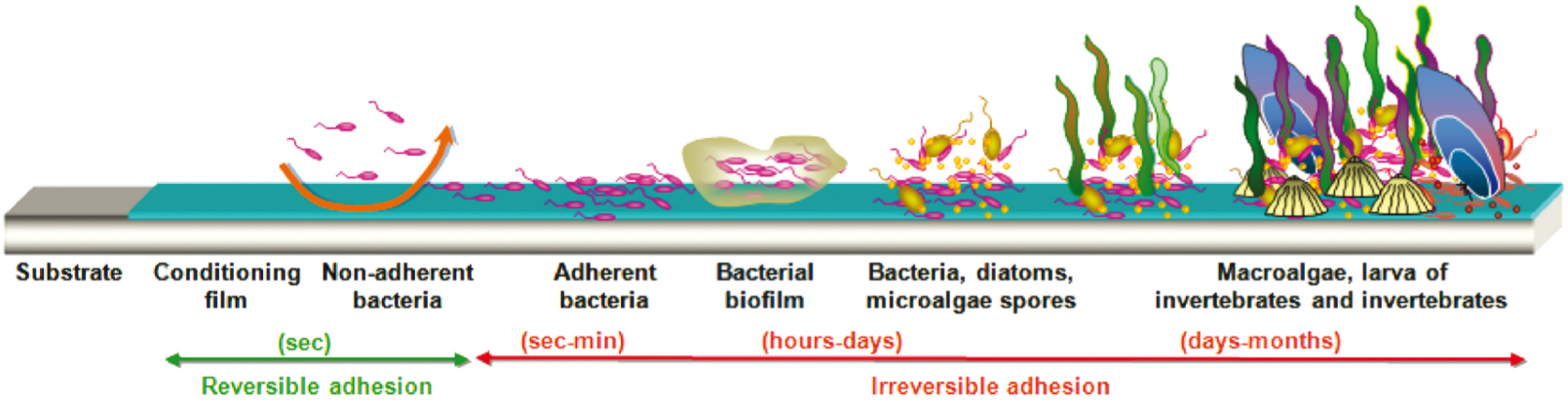
POLITECNICO DI MILANO

lecco innovation hub

Marine Research Laboratory

RESEARCH STRATEGY
Project rationale

STATE OF THE ART – **BIOFOULING SETTLEMENT AND ANTIFOULING STRATEGIES**



"NONTOXING" ACTIVE COATINGS

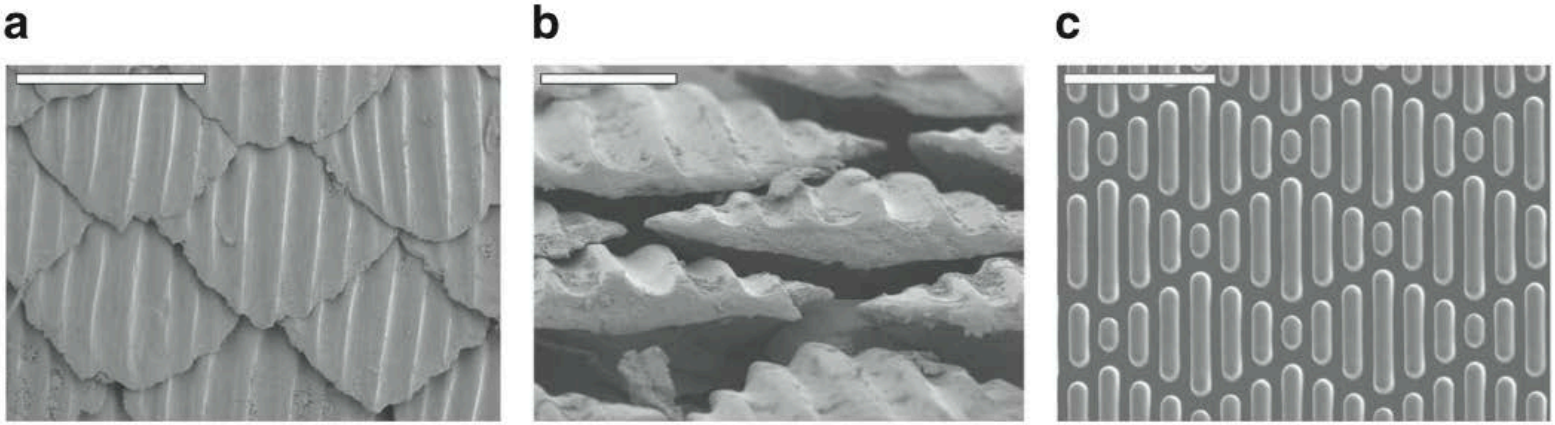
inhibiting or limiting biofouling settlement using **NATURAL BIOCIDES AGENTS**: ionic liquids, organic matrixes, advanced embedding and encapsulating technologies

NONFOULING AND SELF-CLEANING SURFACES

controlling the physicochemical, mechanical, and topographic properties of the hull surface (Silicones coating)

PROJECT RATIONALE – **NON FOULING AND SELF CLEANING SURFACE**

Cells and zoospores can be inhibited on micro- and nano-structural topography, which have also been proved to deter colonization of invertebrate shells and to alter settlement of algae, barnacles, and bacteria.



BIOINSPIRED TOPOGRAPHIES TO DETER FOULING*:*
the scanning electron micrographs show the skin denticles of spinner shark in face (a - scale bar 500 µm) and end views (b - scale bar 250 µm) and image of sharklet antifouling topography moulded in PDmse (c - scale bars are 20 µm). [ref. Schumacher J. F. (2007) Biofouling 23]

RESEARCH STRATEGIES – **ANTIFOULING WRAP**

design a new bio-inspired surfaces on a self-adhesive film having reduced adhesion strength with marine organism

- **NO TRANSFER OF SUBSTANCES IN WATER**
- **HEALTHIER WORKING ENVIRONMENTS**
- **HULL MAINTENANCE COST AND TIME REDUCED UP TO 80%**
- **RECYCLE OF SELF-ADHESIVE FILMS AT THE END OF THE LIFE CYCLE**

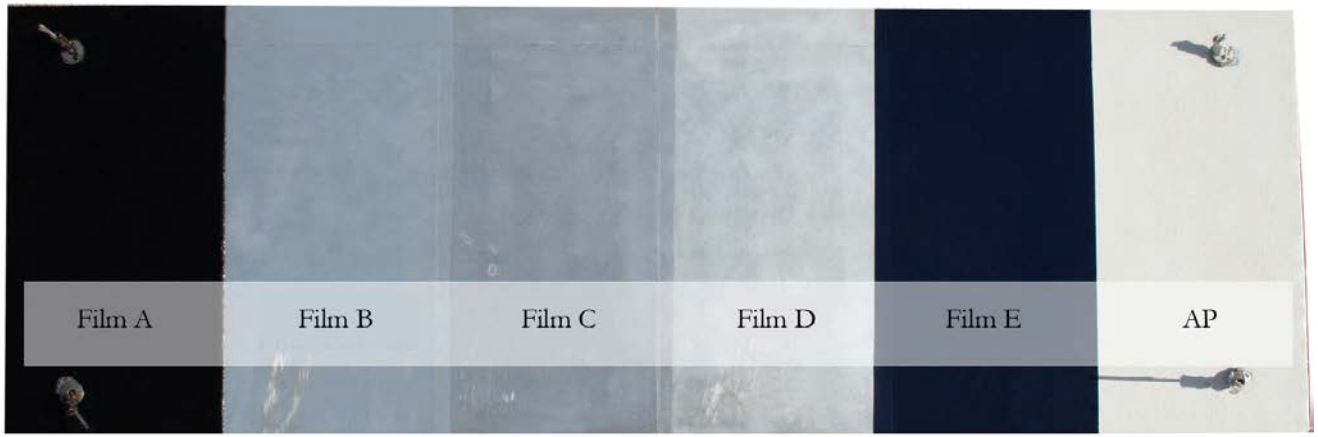
POLITECNICO DI MILANO

lecco innovation hub

Marine Research Laboratory

MATERIALS, TOOLS AND METHODS

SAMPLES



Film A: repositionable flocked PVC

Film B: repositionable transparent PVC cadmium free

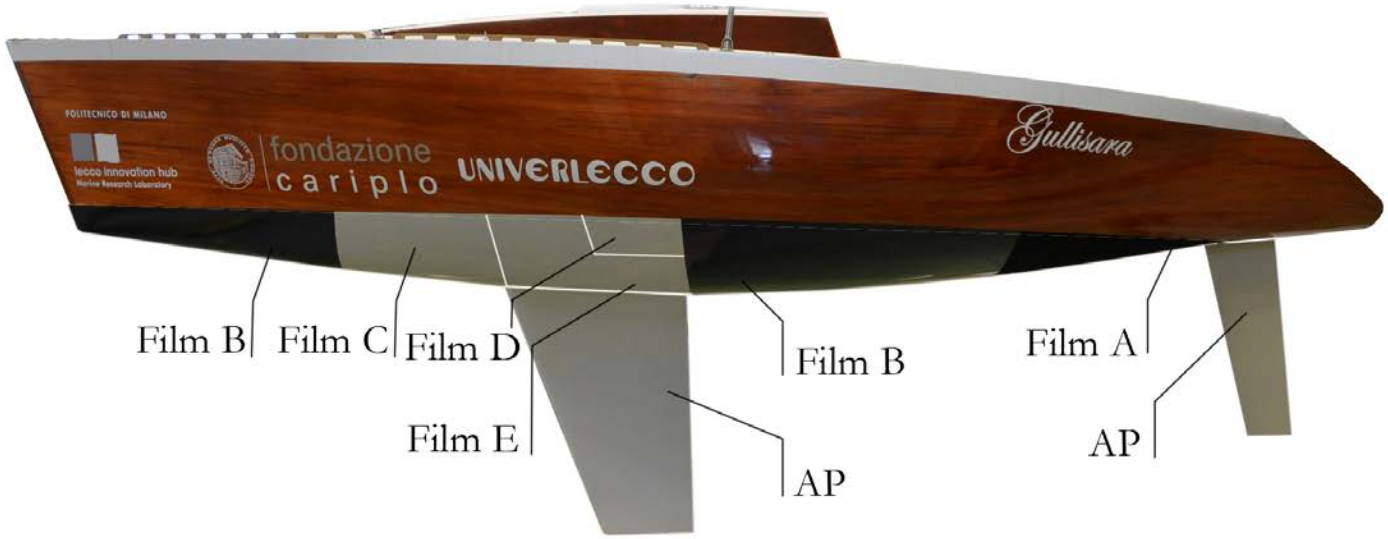
Film C: transparent polyurethane siliconized

Film D: transparent PVC stabilized

Film E: transparent PVC UV rays and abrasions resistant

Antifouling Paint (AP): hydrophilic self-polishing with carbon additive

SAMPLES



Film A: repositionable flocked PVC

Film B: repositionable PVC cadmium free

Film C: transparent polyurethane siliconized

Film D: transparent PVC stabilized

Film E: transparent PVC UV rays and abrasions resistant

Antifouling Paint (AP): hydrophilic self-polishing with carbon additive

METHOD – **TEST PROTOCOL**

LABORATORY tests, **IN SITU** tests and visual and photographic inspection, with the support of **CHROMATIC ANALYSIS SOFTWARE**, are performed in order to:

- evaluate the possibility to apply different films selected on **DOUBLE-CURVED SURFACE**;
- verify the **ADHESIVE POWER** of the films **IN WATER**;
- analyse the antifouling effect, **QUANTIFY AND QUALIFY THE BIOFOULING GROWTH** on the surfaces;
- determine the possibility to **CLEAN** the wraps instead to replace them.

METHOD – **TEST PROTOCOL**

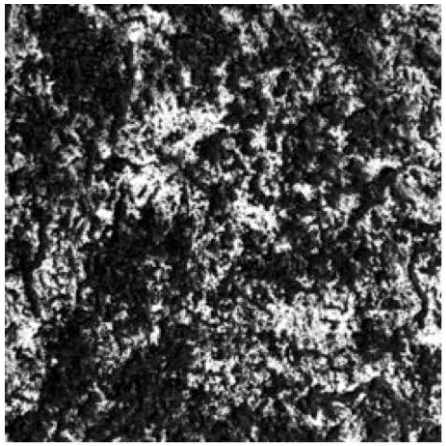
Data collecting on month 1, 2, 3, 6 (3 summer + 3 winter).
Results images were processed through photo-editing tools and computer analysis for the **definition of the biofouling saturation percentage.**

ORIGINAL IMAGE AND PROCESS OF PHOTO-EDITING WITH BLACK CHANNEL PROPORTION ON 200,000 PIXELS:

Original image

adjustment of brightness and contrast (-10%) (+ 100%); tonal values correction to reflected light exclusion

exposure adjustment to highlight the biofouling on the film colour background (+ 9%, 0%, 5%)



colour dropout with a selective filter of green and yellow channels; white and black channels reverse on A and B films

POLITECNICO DI MILANO

lecco innovation hub

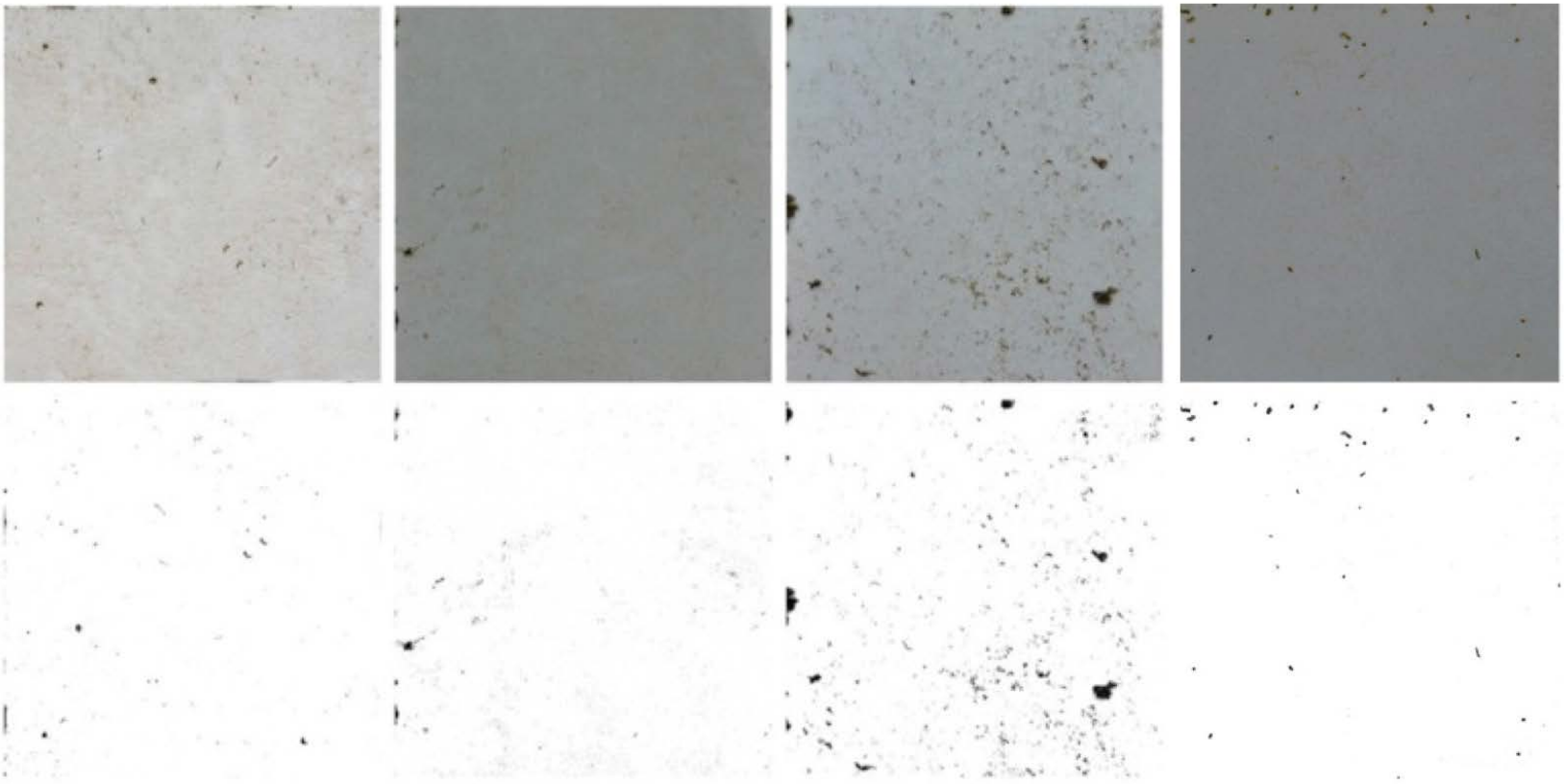
Marine Research Laboratory

RESULTS

Conclusion and Future developments

RESULTS – **QUANTIFY AND QUALIFY THE BIOFOULING GROWTH**

Antifouling Paint: hydrophilic self-polishing with carbon additive

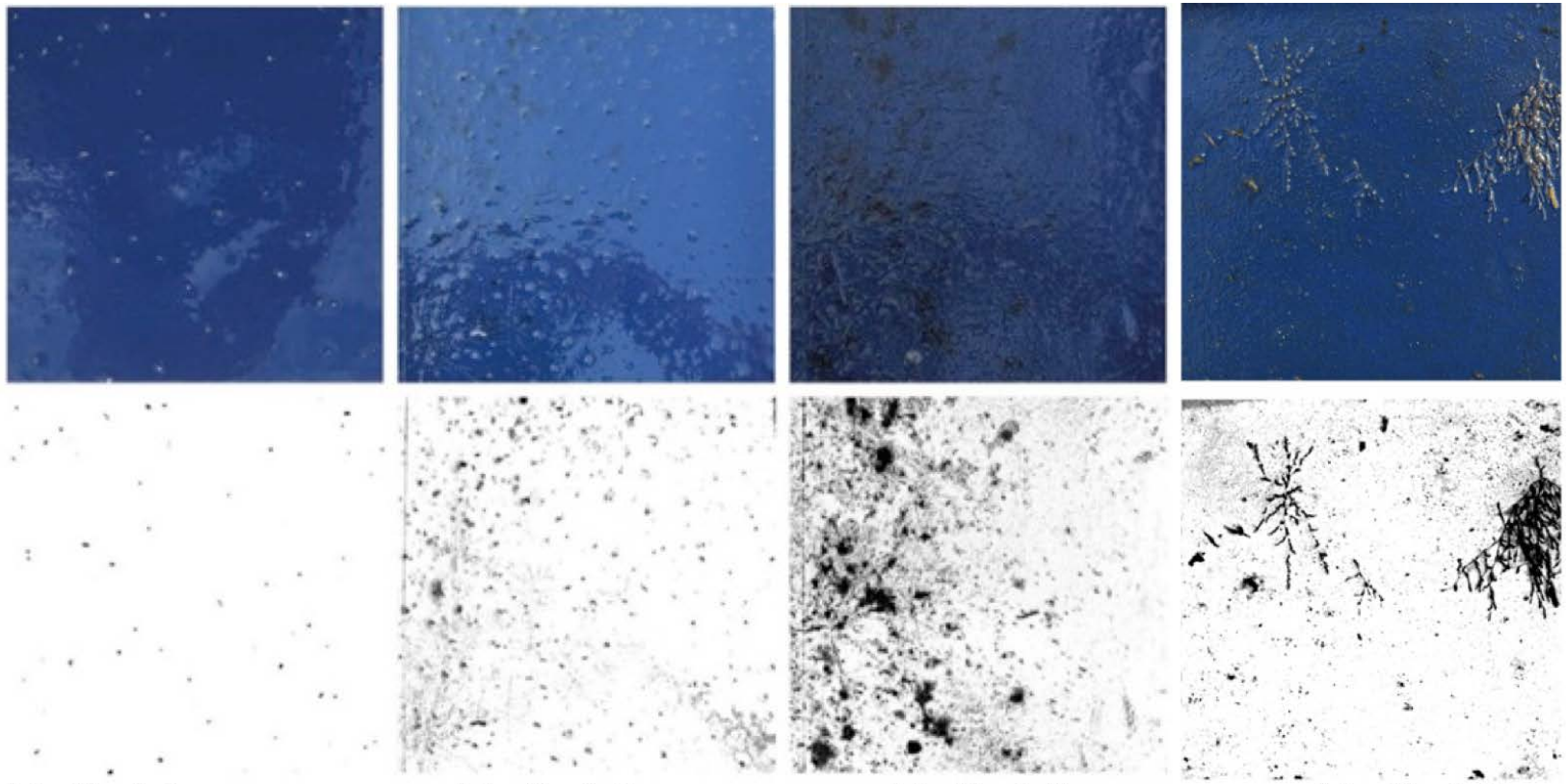


9.1 - Month 1 9.2 - Month 2 9.3 - Month 3 9.4 - Month 6

[Figure 9] *Antifouling Painting at (9.1) first, (9.2) second, (9.3) third and (9.4) sixth month of test*

RESULTS – **QUANTIFY AND QUALIFY THE BIOFOULING GROWTH**

Film B: repositionable PVC cadmium free

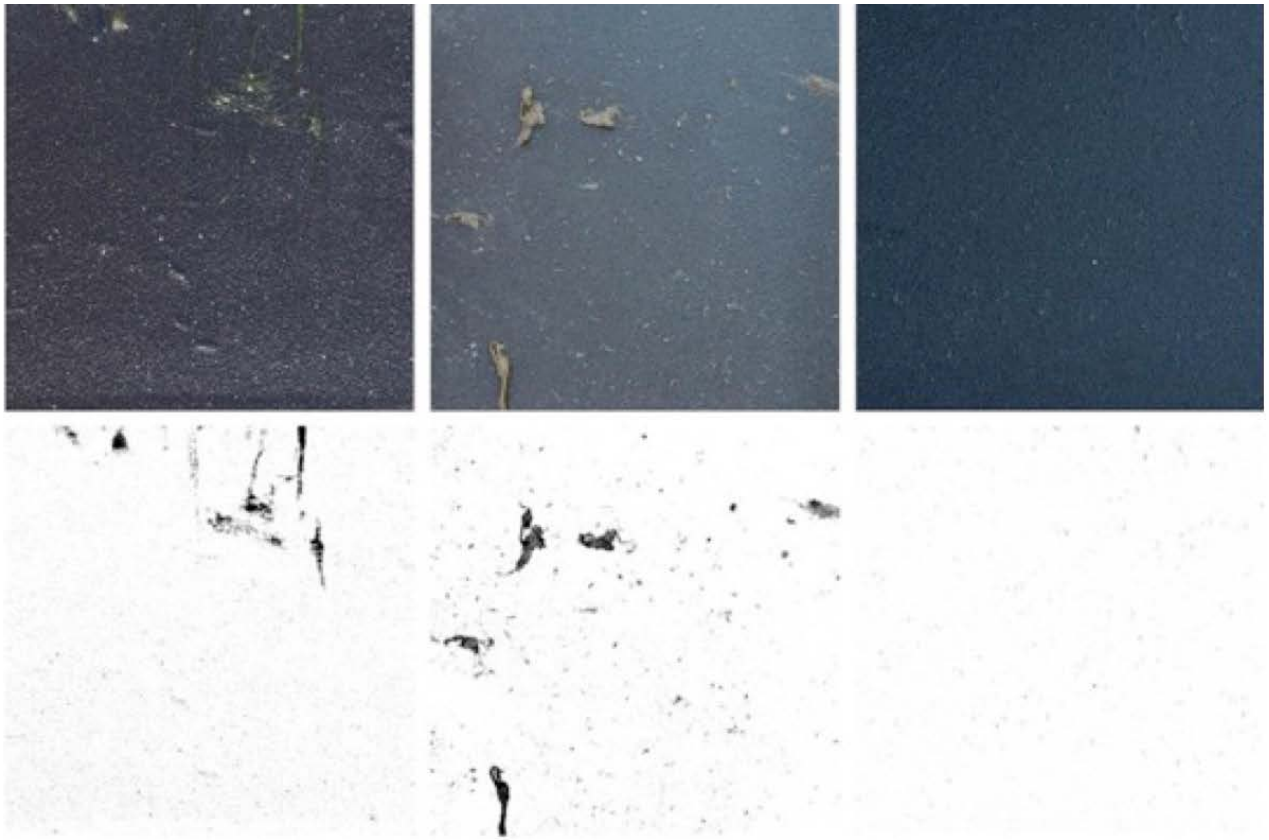


5.1 - Month 1 5.2 - Month 2 5.3 - Month 3 5.4 - Month 6

[Figure 5] *Film B at (5.1) first, (5.2) second, (5.3) third and (5.4) sixth month of test*

RESULTS – **QUANTIFY AND QUALIFY THE BIOFOULING GROWTH**

Film A: repositionable flocked PVC



4.1 - Month 1 4.2 - Month 2 4.3 - Month 3

[Figure 4] *Film A at (4.1) first, (4.2) second, (4.3) third month of test*

RESULTS – **QUANTIFY AND QUALIFY THE BIOFOULING GROWTH**

	Film A	Film B	Film C	Film D	Film E	AP
Month1	2%	1%	7%	1%	1%	1%
Month2	2%	4%	11%	11%	2%	1%
Month 3	1%	13%	35%	26%	14%	2%
Month 6 (3summer+3winter)	dnf	8%	5%	4%	6%	1%

Film A: repositionable flocked PVC

Antifouling Paint (AP): hydrophilic self-polishing with carbon additive

FUTURE DEVELOPMENTS

It's experimentally demonstrate that **THE FLOCKED SURFACE HAS FOULING RELEASE AND SELF-CLEANING PROPRIETIES**. Hull maintenance **TIME REDUCED UP TO 80%** in comparison with traditional painting techniques.

These first results lead us to explore the following areas of investigation:

- **FILM SURFACE DESIGN**
- **FRICTIONAL RESISTANCE OF RUGGED SURFACE**
  Naval basin test on flat sheets samples and on hull model samples
- **INTEGRETIONAL OF ANTIBACTERIACAL COMPOUNDS**

POLITECNICO DI MILANO

lecco innovation hub

Marine Research Laboratory

ANTIFOULING WRAP

Thanks for your attention