Final Report

Brilliant Marine Research Idea 2017

This report should be submitted **no later than 28 February 2018** via filantropie@vliz.be and consist of the following documents:

- A final report listing the work done and the problems encountered. This report will be made available online. If any of the tasks has not been completely finished, the report should clearly mention this, including a short explanation. **max. 5 pages**
- An overview of all expenditures including invoices.
- A set of five pictures (low resolution in this document). The five High Resolution pictures should be delivered to VLIZ by email to karen.rappe@vliz.be. Pictures should be free from use - to upload on the VLIZ website and to use in VLIZ communications.

Keep in mind that VLIZ should be mentioned in the acknowledgements of publications following the results of this Brilliant Marine Research Idea.

1. General information

Title of the idea	A dynamic testing platform for anti-Fouling coatings
Name PhD student	Raf Meskens
Name supervisor	Prof. Dr. Silvia Lenaerts - UA Prof. Capt. Dr. Kris De Baere - HZS
Flemish University or Flemish University College	Antwerp Maritime Academy.

2. Brilliant Marine Research Idea – Report about the activities

Abstract

The ships' hull seems to be an excellent transport vehicle for marine plants and animals from one location to another. This so-called "hull fouling" has important ecologic and economic consequences on the environment.

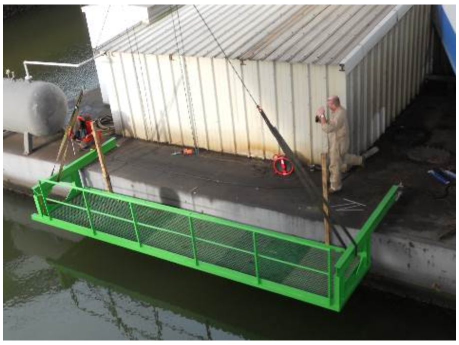
Firstly, when these non-indigenous species are able to settle in their new environment, they are able to disrupt the local marine ecosystem and even to destroy local species. Secondly, biofouling generates a substantially increased frictional resistance of the ship's hull during sailing. An increased frictional resistance of hulls causes a rise in fuel consumption and a waste of time and money when ships have to be cleaned and/or recoated. Yet even a light slime layer has been shown to increase fuel consumption by 8% or more and a heavy slime formation can result in a fuel consumption

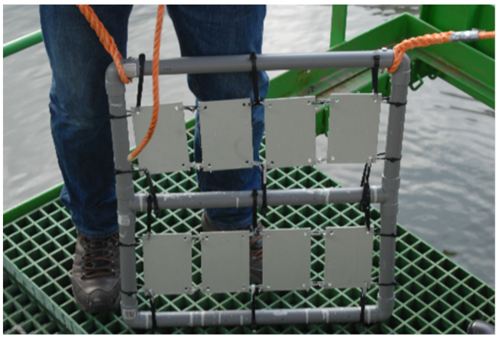
increases of 18% or more (Kane, 2010). A boost of 5% in the biofouling on the hull may trigger an augmentation of 17 % of the ships' fuel consumption, leading to increased emissions of CO_2, NO_x and SO_x (Lewthwaite et al. 1985, Evans et al. 2000, Dobretsov 2009). The International Maritime Organization (IMO) estimates that the air emissions, due to the risen fuel consumption by shipping, may grow with 38% and 72% by 2020, unless corrective measures are taken or new technologies are introduced (Demirel et al. 2013). Finally, biofouling causes microbiologically induced corrosion (MIC) by stimulating the biotic and abiotic electron-transfer reactions of the corrosion redox-reaction. (Mertens et al, 2015), leading to accelerated ship damage.

Organotin compounds were long considered as the final solution in the battle against fouling. However, due to the mid/long term effects as endocrine disruptors, these compounds have been banned in 2008 (IMO, 2002). Since then the industry has been searching for an equivalent substitute. The result is chaos: every coating producer went his own way and developed an anti-fouling technique he claims to be the absolute best. Today, a huge range of anti-fouling products and methods are available and the ship-owner is left in the middle without any objective means to select the best available product for his type of ship.

The goal of this project is to devise methods for objectively comparing hull antifouling coatings, investigating the way these paints interact with the fouling fauna and (micro)flora. The main objective of this line of research is to develop a standard, as broad as possible, for objective comparison of anti-fouling coatings based on an academic methodology.

As it is impossible to simulate a complete marine environment, testing of anti-fouling techniques can only be done in open sea. So far, we constructed a static test facility, which is operational in the port of Ostend. In order to simulate the influence of the ship's speed on hull-fouling, a dynamic test facility should be added to the existing set-up.





Biography

Kane, D. (2010). Hull and propeller performance monitoring, presentation SNAME, Climate change ans ships, Feb. 2010. These figures reported by US Navy for a frigate in 1991.
Demirel, Y. K., Khorasanchi, M., Turan, O., & Incecik, A. (2013). On the importance of antifouling coatings regarding ship resistance and powering. In 3rd International Conference on Technologies, Operations, Logistics and Modelling for Low Carbon Shipping.
Mertens et al. (2015). Biocorrosion. Acco
IMO (2002). Anti-fouling systems. www.imo.org/en/OurWork/Environment/.../FOULING2003.pdf, consulted 07/12/2016
Lewthwaite, J. C., Molland, A. F., & Thomas, K. W. (1985). An investigation into the variation of ship skin frictional resistance with fouling. *Royal Institution of Naval Architects Transactions*, *127*
Evans, S. M., Birchenough, A. C., & Brancato, M. S. (2000). The TBT ban: out of the frying pan into the fire?. *Marine Pollution Bulletin*, *40*(3), 204-211
Dobretsov, S. (2009). Expected effect of climate change on fouling communities and its impact on antifouling research. *Advances in marine antifouling coatings and technologies*, 222-239

Intro

As mentioned above, the main goal of our research is to develop methods for objective comparison of hull antifouling coatings. Coatings are tested using three different methodologies, namely static, dynamic and by measuring the hydrodynamic resistance. In all the cases coated test plates are immerged during a certain period of time and afterwards evaluated on a number of parameters.

So far, we were able to construct a test platform for static immersion of coated test plates. At the same time preparations were started for testing the hydrodynamic resistance of a number of recent anti fouling coatings. Steel plates (1520 x 760 x 6 mm) for this setup were painted and a transport cage was constructed. A second structure was built next to our static platform to immerge the test plates (see materials and methods part 3).

The technique of dynamic testing of antifouling coatings involves different approaches. Firstly, one can run seawater over a set of fixed plates where speed and volume of the fluid are fixed parameters during the test period (Designation: D 4938 – 89 (Reapproved 2002) Standard Test Method for Erosion Testing of Antifouling Paints Using High Velocity Water). Afterwards the condition of the coating is evaluated according to a set of parameters.

Alternatively, a set of test plates can be mechanically rotated in a volume of seawater during the test period. Here the choice of orientation of the test plates defines the design of the test setup. ASTM Designation D4939 − 89 (Reapproved 2013) Standard Test Method for Subjecting Marine Antifouling Coating to Biofouling and Fluid Shear Forces in Natural Seawater connects the test plates on the outside of a rotating drum. Another method can be to connect the test plates horizontally orientated on a disc. In both systems diameters and angular speed allow to reproduce the speeds of ships to be simulated. The way ahead has been shown by prof. Swain (Florida Institute of Technology, USA) and Poseidon Science (Mathias, 2010). They devised a method to mount the test plates (with a specific coating) horizontally on discs rotating at a certain angular speed, driven by an electric engine.

Standard metal plates coated with a selection of anti-fouling paints are immerged in the North Sea water for at least one year. Micro- as well as macro-fouling will be identified and quantified over time. It gives a very good idea of the eagerness by which organisms will colonize on a specific coating. But, it is also important to be able to measure the easiness by which these species will be flushed of the coating once the ship start to move at a certain speed. A dynamic testing facility is therefore inevitable.

DEME NV offered to build this dynamic platform in their workshops. Most of the material to make the platform and the supporting construction is second hand material, obtained at a negligible cost. The electro motors themselves, the control electronics, the electrical connections and the hoisting equipment will be paid from the budget thanks to this initiative (see part 3: budget). Hence, this call creates the opportunity to enhance the functionality of the platform.

We foresee the installation of two parallel set ups, which will be turning at two different angular speeds, in order to test the AF coatings at six different linear speeds.

Biography

Mathias, J.R. et al. (2010), Simulation of marine coating performance under natural tropical seawater conditions using the Poseidon Dynamic Test System. EC Conference Marine Coatings II, Berlin, Germany, Feb. 9-10, 2010.

Material & Methods

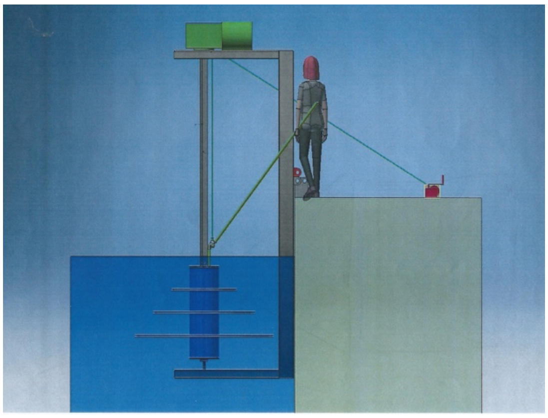
1. Static test setup:

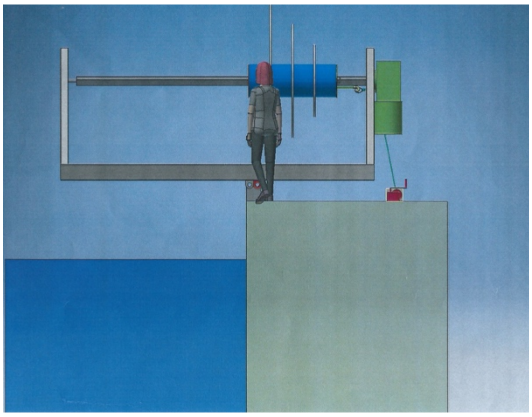
A set of grade A standard steel plates, dimensions 150 mm x 100 mm x 3 mm, were coated by the paint manufacturers according to their standards. Paints to be tested in this project are Ecospeed®, Humidur®, Liocyl®, Dynamic 9000®, Globic 9000® and X7®, Intersleek® and Ecofleet® & Foil®. We tried to have samples of the most current coating types. Hard, self-polishing as well as non-stick coatings are represented. Prior to the start of this test, a number of variables has to be measured. For variations in seawater temperature, ph, dissolved oxygen and nitrogen, two 24-hour sessions were organized for hourly measurement of these parameters. An additional two sessions will be organized to bring seasonal changes into account.

2. Dynamic test setup:

For this setup an identical set of test plates as mentioned above was prepared.

Possible set ups of the dynamic test platform were discussed with Mr. Marc De Boom and Mr. Jorne Beyen of Messrs. Deme NV, resulting in the following preliminary design. Instead of attaching the test plates at different radii on the disc, it was opted to construct 3 discs with different radii and with attachment of the test plates at the outer edge of each disc. Doubling of the setup results in six testing speeds. Radii of the discs is chosen as such to simulate ships' speeds as realistic as possible.





Rotor and engine are mounted on a hinged structure order to achieve easy and safe sampling and census of fouling adhering to the test plates (according to ASTM Designation D4939 – 89 (Reapproved 2013). Design of the setup has to be so that the test plates are continuously immerged at a depth of at least one foot during the test period. A rotating and static period of one month are alternated during the one-year test period. Sampling and census of the fouling should happen at least once a month. In this way monthly and seasonal changes / development of the fouling can be evaluated. Furthermore, performance of the paint is studied over a longer period to achieve a uniform image.

3. Resistance of fouling:

Third pillar of the project is measuring the resistance of fouling on a number of grade A steel plates coated with abovementioned anti-fouling coatings.

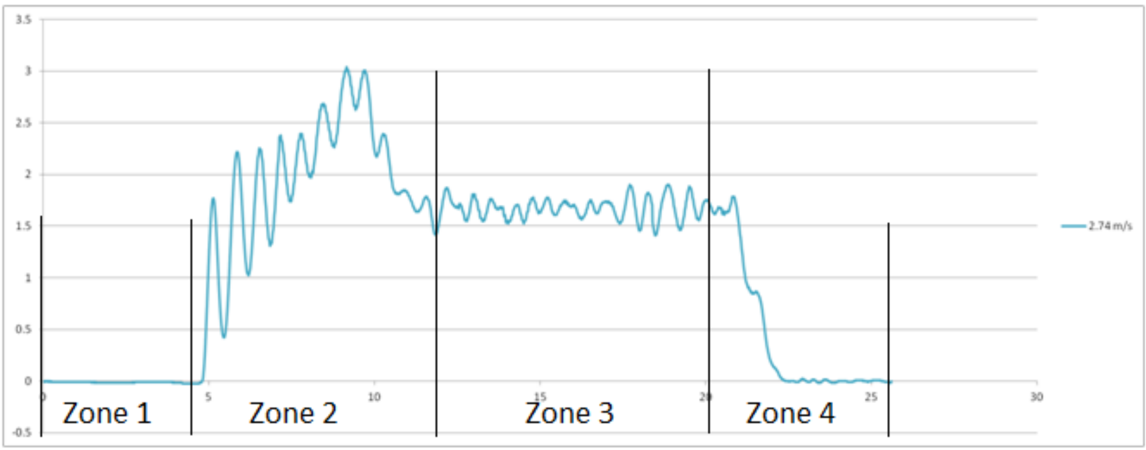
The test set up is a reproduction of earlier tests carried out by Professor Shulz in 2004, whereby the coated plates are towed in a towing tank under three conditions: new, fouled and cleaned. Schultz attempted to relate the hull fouling to an equivalent sand roughness height (k_s) and the average coating roughness (Rt_{50}).

July 2017 all coated plates were tested in the deep-water towing tank of the University of Liège for resistance measuring in newly coated condition. All plates were of grade A steel with dimensions 1520 x 760 x 6 mm – R3 rounded head sides. Immersed part when suspended on the driving unit of the towing tank was 1520 x 450 x 6 mm. The plate was suspended by 4 cables on the drive unit of the towing tank and laser aligned. Each plate was towed over a distance of 100 meter at speeds of 1.86 (x1), 2.44 (x2), 2.74 (x1) 3.01 (x2); 3.29 (x1) and 3.59 (x1) m/s.

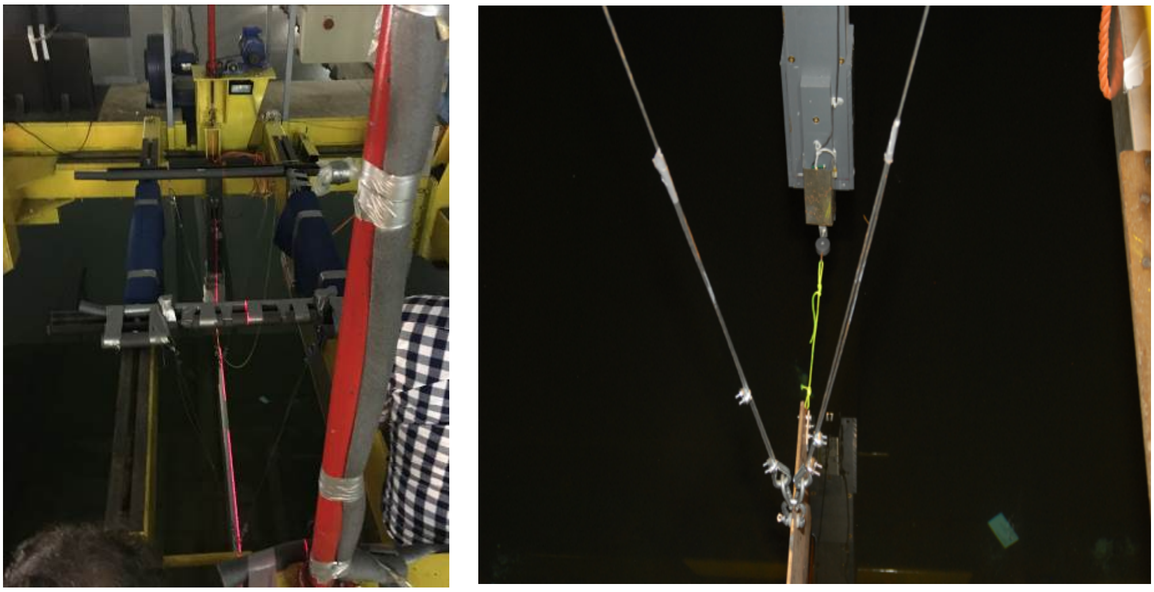
Resistance was measured by means of an analog-digital weight cell of 5 kg with strain gauges placed in a Wheatstone bridge. After amplification the analog signal was converted from 1023 into a 10-bit digital signal. The recorded signals were stored in files in ASCII (TXT) format. Accompanying plates and paint types with test speeds were recorded in a separate file. Conversion of the recorded signal into raw results was again stored in a separate file, wherein resistance converted to kg and accompanying graphs of each paint type were included. A resistance curve was drawn for four zones of interest:

- o Zone 1 – part of the signal where the plate is at a standstill. In this zone a mean value is calculated for all values in order to find the relative zero for measuring.
- o Zone 2 – recorded signal when accelerating.
- o Zone 3 – recorded signal at constant speed. Similar to zone 1 a mean is calculated over the recorded signal.
- o Zone 4 – recorded signal when decellerating.

After processing the results, a resistance curve was drawn up with the use of the following formula: R = mean (zone 3) – mean (zone 1) [N]



Graph 1 : recorded signal from the weigh cell. X-axis = time in seconds, Y-axis is recorded force in kilogram.



Photographs : alignment of the test plates with laser and connection of the weigh cell with the test plate.

After the initial towing Shulz set a period of 287 days during which the plates accumulated fouling. In order to simulate this, we were in need of an extra platform to hang out the plates. On 14th December 2017, the construction was ready to be installed at the test site. Immersion of the test plates took place the same day.

Photographs: new construction for immersion of towing tank test plates for 287 days.

The third and final stage of this "resistance & fouling" part is scheduled for September 2018. Again, in the deep-water towing tank of the ULiège the hydrodynamic resistance of the plates will be measured in fouled and cleaned condition. The latter will allow us to assess the damage of coating caused by the attachment mechanisms of the fouling organisms.

Results

1. Static test setup:

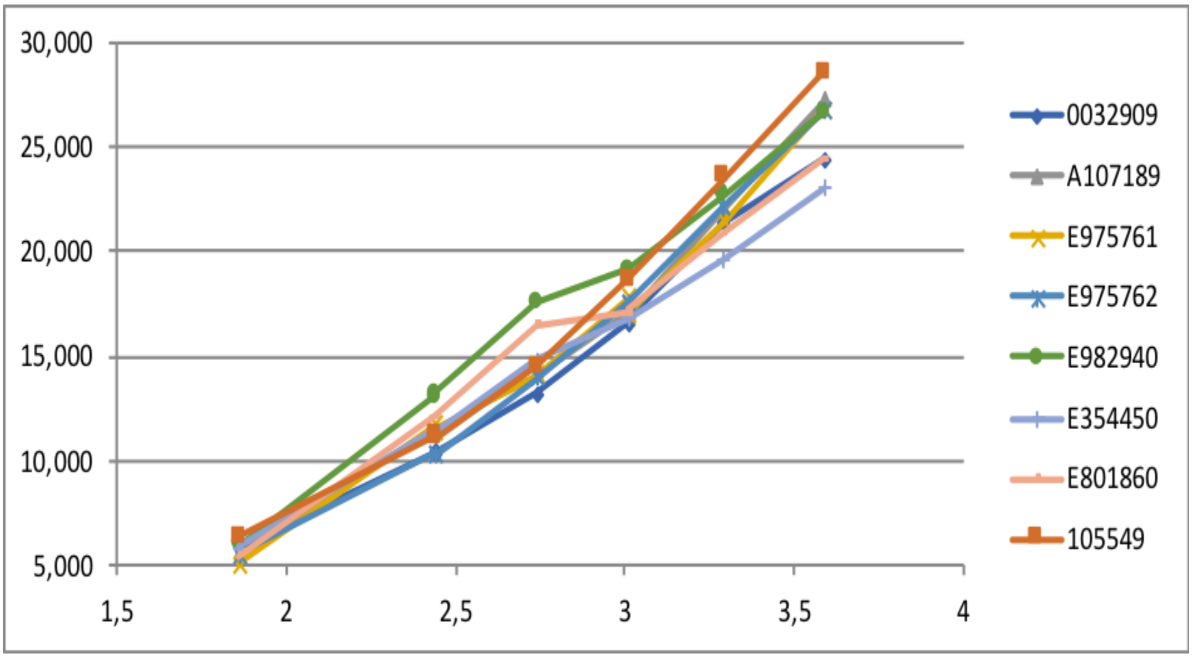
At this stage no reporting can be done since measuring and analyzing the various paramaters and discussing possible variations is in progress.

2. Dynamic test setup:

Unfortunately, we received news about possible new economic activities at the test site, so that this part of the project is postponed until further details and consequences are clear. Instead we chose for the way ahead and focused on the third pillar of the research, namely measuring the hydrodynamic resistance of fouling on a number of plates coated with novel antifouling paints. It goes without saying that as soon as the platform is operational relevant invoices will be submitted.

3. Resistance of fouling:

The test runs of all coated plates took place in July 2017 at the premises of Messrs. Anast in the deep-water towing tank of the University of Liège. Following results were put together on a single graph. Momentarily relevancy of the first test results is under study. Since this is the first step in this part of the research, further comments are preliminary. The test runs need to be repeated with the plates in fouled condition, after 287 days of exposure, and with the plates in cleaned condition (according to the paint manufacturers' instructions).



Graph 2: measured resistance in Newton of the various test plates (Y-axis) against speed in m/s on the X-axis.

3. Overview of the expenditures

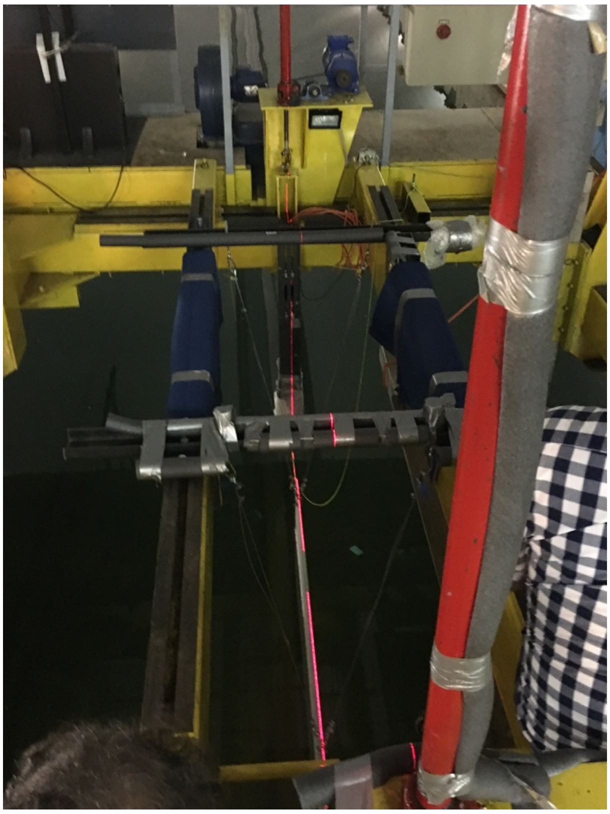
Describe in detail how the requested fund was spent within the implementation period (1 March 2017 and 28 February 2018). Be as specific as possible.

Article	Cost
2 electro motors splash water tight	€ 2120
Electrical provisions	€ 435
Frequency control to vary speed of the motors	€ 1945
Hoisting device – 2nd hand material	€ 500
TOTAL	€ 5000

Note : the material is ready for purchase. Relevant invoices will be submitted as soon as the material is delivered.

4. Pictures

A set of five pictures (low resolution in this document). The five High Resolution pictures should be delivered to VLIZ by email to karen.rappe@vliz.be.



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