모의IMO총회
The Mock IMO Assembly

Proposal for Effective Anti-Fouling System

The 2017 Mock IMO Assembly

Presented by Tipping Point

CONTENTS

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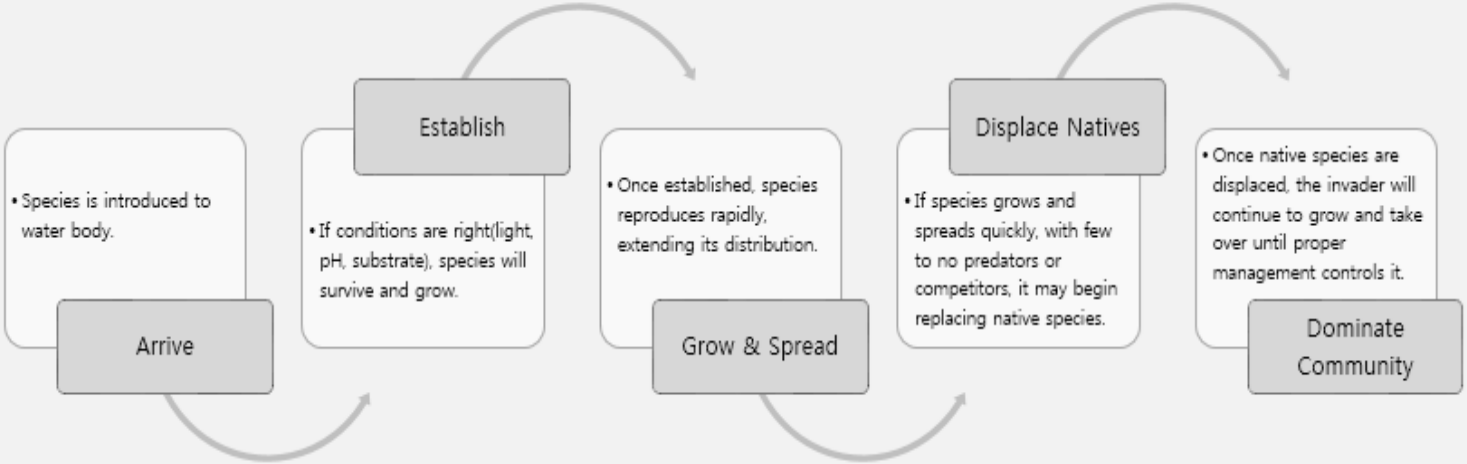
1.1 Problem of Invasive Species



- Invasive species have the potential to hybridize with the native species.
- Invasive species cause competition for native species and because of this 400 of the 958 endangered species under the Endangered Species Act are at risk.[1]

[1] Primtel, David(2005) Ecological Economics. 52: 173-288

1.1 Problem of Invasive Species

3 Regulation B-3.1 of the BWM Convention requires a vessel constructed before 2009, as follows:

"**Regulation B-3** Ballast Water Management for vessels

1 A vessel constructed before 2009:

.1 with a Ballast Water Capacity of between 1,500 and 5,000 cubic metres, inclusive, shall conduct Ballast Water Management that at least meets the standard described in regulation D-1 or regulation D-2 until 2014, after which time it shall at least meet the standard described in regulation D-2;

.2 with a Ballast Water Capacity of less than 1,500 or greater than 5,000 cubic metres shall conduct Ballast Water Management that at least meets the standard described in regulation D-1 or regulation D-2 until 2016, after which time it shall at least meet the standard described in regulation D-2.

2 A vessel to which paragraph 1 applies shall comply with paragraph 1 not later than the first intermediate or renewal survey, whichever occurs first, after the anniversary date of delivery of the vessel in the year of compliance with the standard applicable to the vessel."

Details of BWMS Regulations

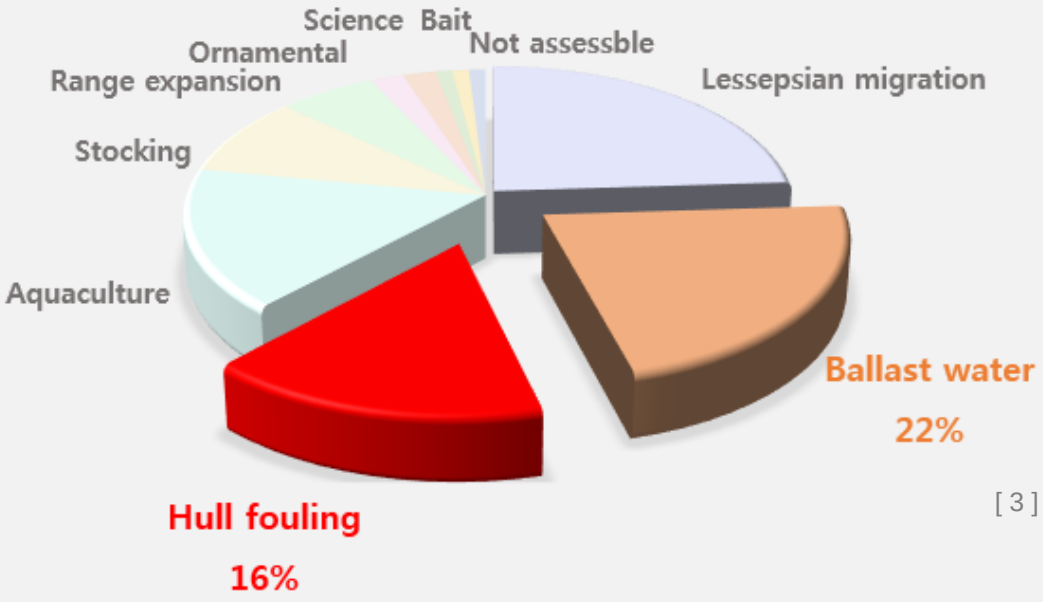
4 A vessel constructed before 2009 with ballast water capacity of between 1,500 and 5,000 cubic metres and with a capacity less than 1,500 or greater than 5,000 cubic metres will have to install the ballast water management system (BWMS) not later than the first intermediate or renewal survey after the anniversary date of delivery of the vessel in 2015 and 2017, respectively.

[2]

Recently, IMO Regulated Ballast Water Management System.

[2] MEPC 61-2-17

1.1 Problem of Invasive Species



[3]

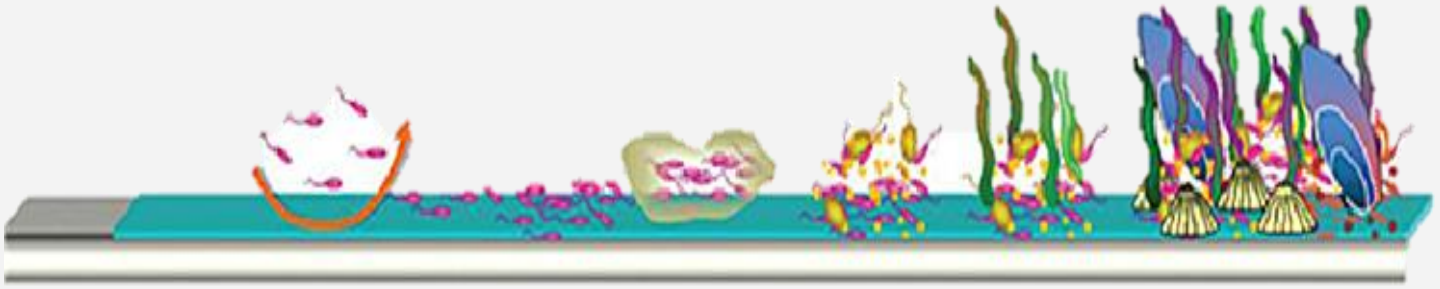
- Invasions caused by hull fouling are on the rise.
- Hull fouling is the biggest cause after ballast water.

[3] Gollasch, 2006

1.2 What is Fouling?

Fouling is an unwanted growth of biological material –
such as barnacles and algae -on a surface immersed in water.

[Development processes of marine fouling]

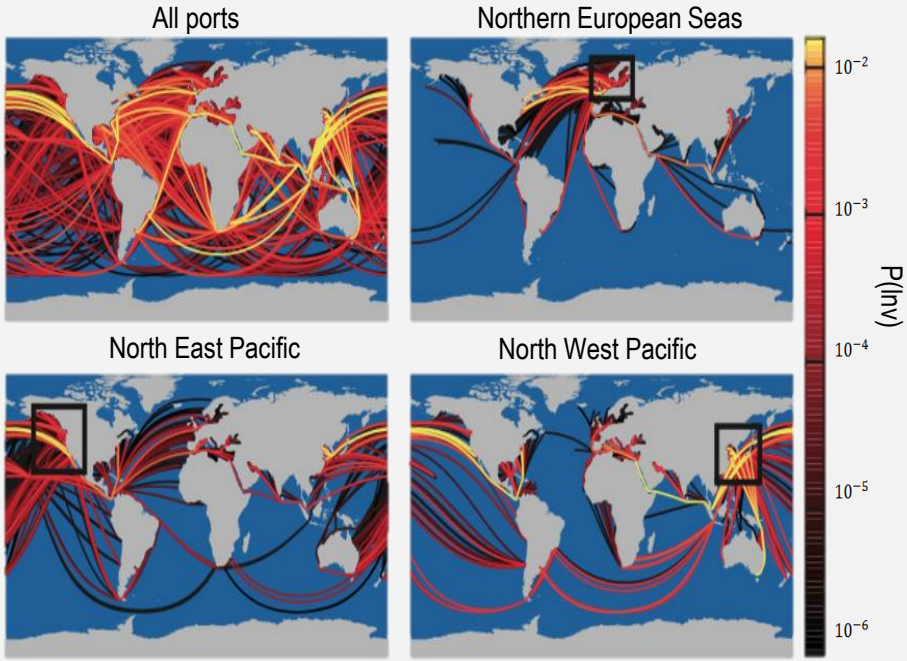


[4]

[4] D. M. Yebra, S. Kill, and K. Dam-Johansen, Progress of Urganic Coatings, 50, 75 (2004)

1.3 Why is Fouling a Problem?

- Fouling leads to an increase of the risks of introducing non-native, invasive species



[5]

[Mapping of global routes of ship-borne invasive species]

colonial tunicate
Didemnum vexillum

European fan worm
Sabella spallanzanii

Bay barnacle
Amphibalanus improvisus

North Pacific seastar
Asterias amurensis

Black striped mussel
Mytilopsis sallei

Asian green mussel
Perna viridis

[invasive species] [6]

[5] http://sites.google.com/site/invasivespeciez/

[6] Common Hull Fouling Invasive Species www.imo.org

1.3 Why is Fouling a Problem?

[7]

increase the drag resistance of the hull surface

↓

Low speed, maneuverability and more fuel consumption (increasing up to 40%)

↓

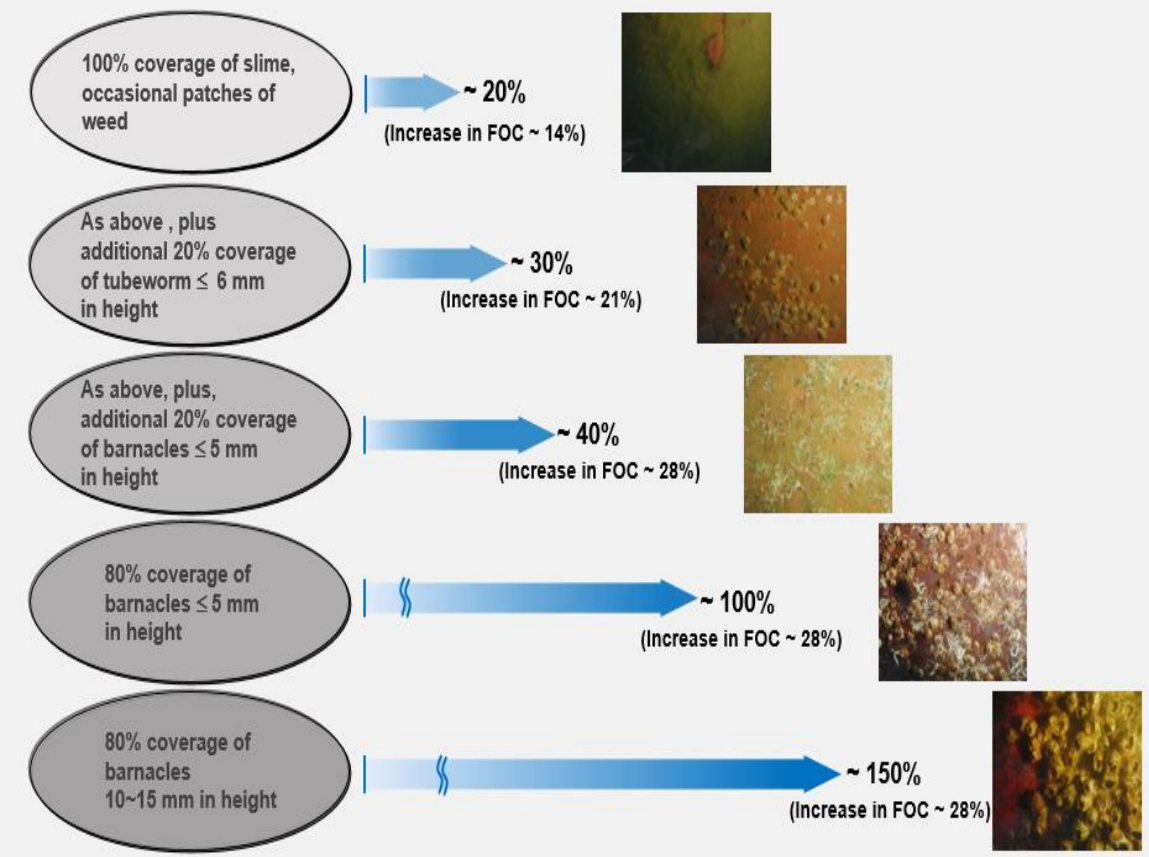
higher costs and higher emissions of polluting gases

[7] Robert F. Brandy.Jr, “Composition and Performance of Fouling Release Coatings”, 2000, p1

1.3 Why is Fouling a Problem?

[8]

[Increase in frictional resistance (C_F) according to fouling patterns]



[8] M.P.Schultz,(7 OCtober 2010),Economic impact of biofouling on a naval surface ship

1.4 Anti-fouling and TBT

- To prevent the formation of a fouling layer, anti-fouling paints using metallic compounds, in particular the organotin compound **tributyltin(TBT)** were used to coat ship's hull.

However, these compounds persist in the water and cause deformations in some kinds of sea life.

[9]

[During anti-fouling paint removal can result in deleterious substances being released into the aquatic environment.]

[9] http://www.coastalwiki.org/wiki/TBT_and_Imposex#cite_note-omae-3

1.5 Restrictions to TBT

S. h/sphere	Year	Regulations
Australia	1989	Prohibited the use of TBT-based paints on vessels less than 25 m) LOA. Maximum leaching rate of 5 micrograms per square centimetre per day (µg/cm2/day) for vessels greater than 25m LOA. All dry-docks must be registered with the Environmental Protection Agency because of discharges. All antifoulants must be registered.
New Zealand	1989 1993	The application of TBT copolymer antifouling paint is banned with three exceptions: hulls of aluminium vessels, the aluminium out-drive or any vessel greater than 25 m LOA. The application of TBTO free-association paints is banned. Maximum leaching rate of 5µg/cm^2/day for vessels greater than 25 m LOA. All antifoulants must be registered. Use of any organotin containing antifouling paint prohibited.
South Africa	1991	Prohibited the use of TBT-based paints on vessels less than 25 m LOA. TBT antifoulants available only in 20 L containers All antifoulants to be registered.
Hong Kong, China	NA	All TBT antifoulants must have a valid permit for import/supply. All antifoulants must be registered.
Japan	**Year**	**Regulations**
Japan	1990 1992	TBT banned for all new vessels. TBT banned for all vessels.
IMO measures	**Year**	**Regulations**
World-wide ban proposal	2003-2008	Proposed ban for 1st Jan 2003 – no reapplication of TBT. 1st Jan 2008 No ships or structures shall bear TBT. To enter into force 12 months after 25 States representing 25%of the world's merchant shipping tonnage have ratified the Convention.

[10]

There have been regulations in countries that have previously detected the danger of TBT.

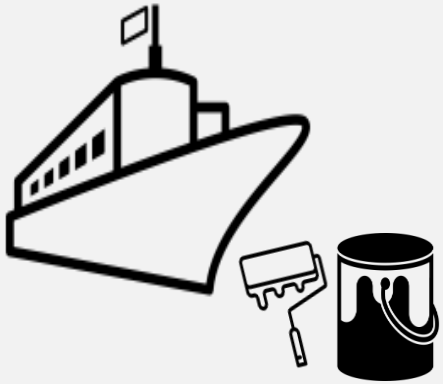
IMO completely prohibited TBT's application after 1 January 2003 and its presence on ships after 1 January 2008.

[10] MEPC 55 INF.4

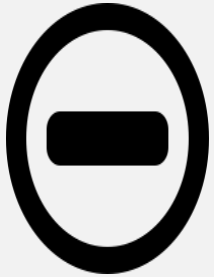
2.1 Alternative Anti-Fouling Paint

- After the TBT was banned, the replacement for tin coatings appeared.
- Most common replacements are Copper-based coating and Silicone coating.

➡ <u>But Copper-based coating and Silicone coating have drawbacks.</u>



Alternative Anti-fouling paints

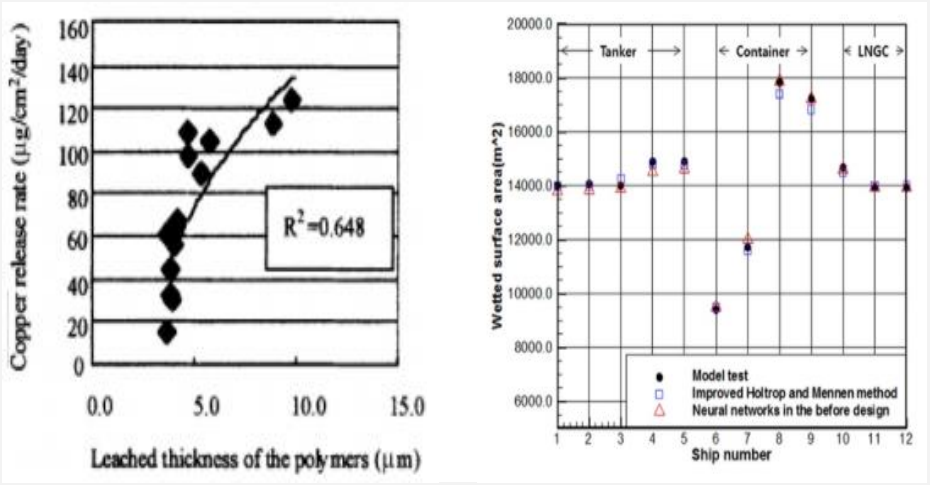


Drawbacks

2.1 Alternative Anti-Fouling Paint

▪ Drawbacks of Copper-based coating

- Copper-Based Coatings can be release its toxicity elements while operating ships.
- Secondary biocides which is included in Copper based coating can be harmful if dissolved in water.[11]



[12]

According to the above references, about 11kg of copper is released per day from the container ship, which has wetted surface area of 14000㎡.

[11] Robert F. Brandy.Jr, “Composition and Performance of Fouling Release Coatings”, 2000, p2

[12] Yoichi Yonehara,"A new antifouling paint based on a zinc acrylate copolymer",Progress in Organic Coatings,2001,p155

2.1 Alternative Anti-Fouling Paint

- **Drawbacks of Silicone coating**

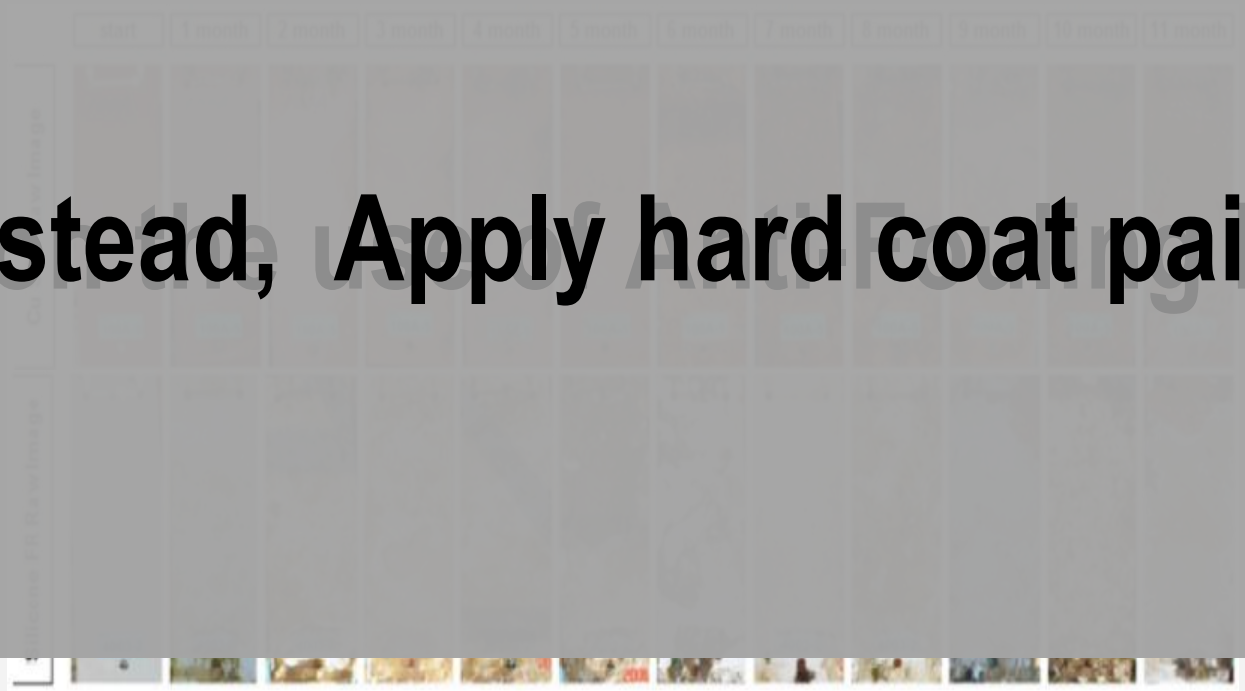
- The silicone oils are lost, usually within two years in temperate waters.

- Silicone oils are released into the environment.
  They have at least the potential for environmental impact
  while these oils leach from the coating. [13]

[13] Robert F. Brandy.Jr, “Composition and Performance of Fouling Release Coatings”, 2000, p5

2.1 Alternative Anti-Fouling Paint

- Even after applying anti-fouling paints, marine organisms adhere to the surface of hull.

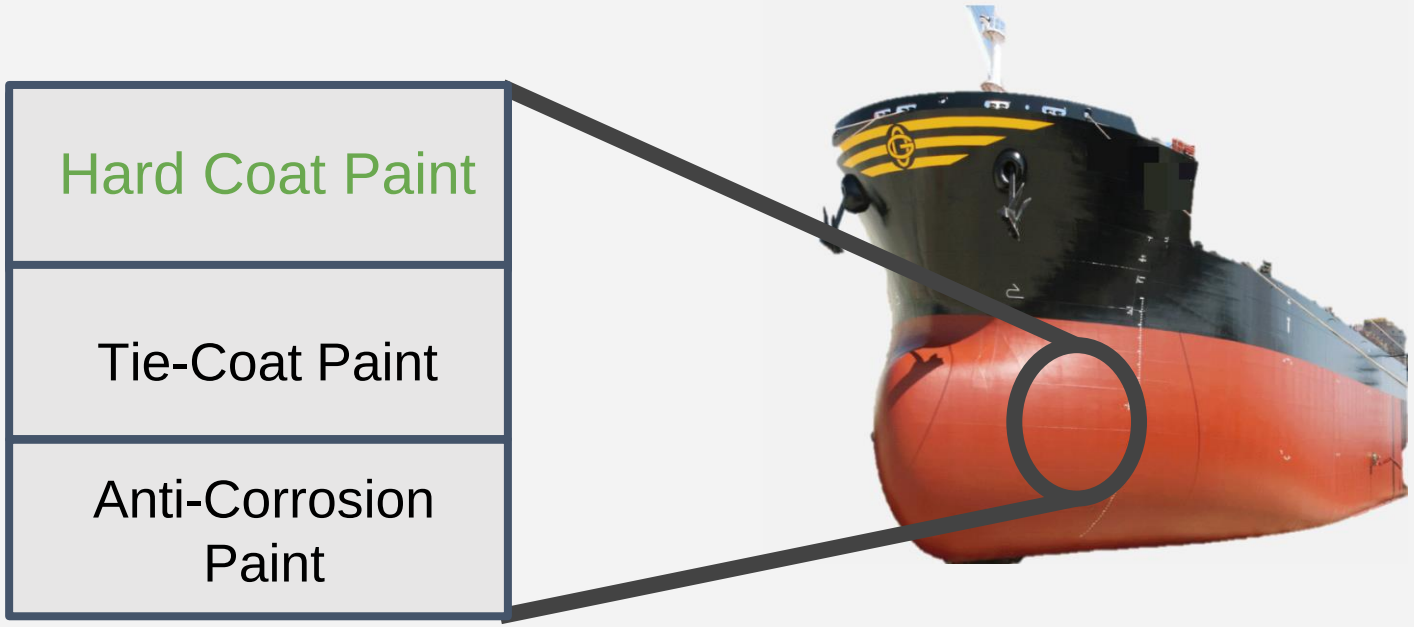


[Instead, Apply hard coat paint]

[14] https://www.researchgate.net/publication/264149856_Image_Analysis_Method_for_the_Performance_Evaluation_of_Marine_Antifouling_Coatings

2.2 Hard Coat Paint

Hard coating is a paint that they are applied for the entire lifespan of a ship.
Moreover, hard coatings do not contain substances to prevent biofouling on ship hulls.



2.2 Hard Coat Paint

Hard coat paint does not contain biocide materials

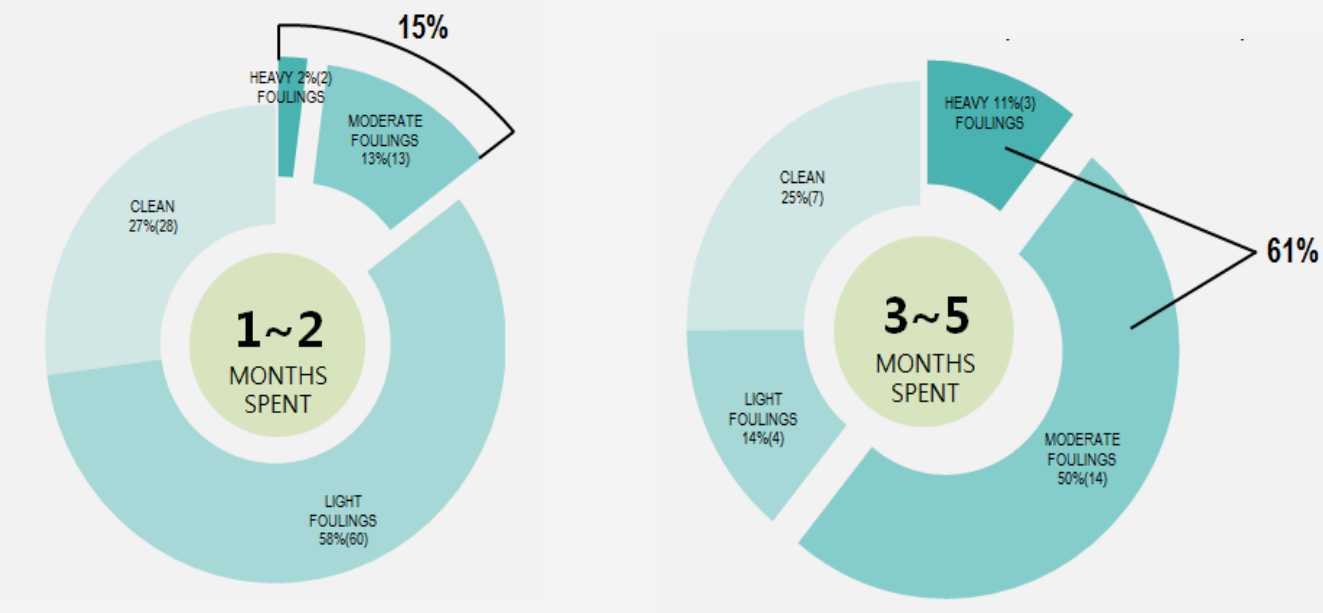
[Clean periodically once every three months]

Fouling occur easily and quickly

Remove it more often.

2.3 Why 3 months?

Relation between the degree of fouling and the amount of time spent in port [15]



After <u>three months</u> in the port, macrofouling began to occur.

[15] U.S. Naval Institute,Annapolis,Maryland,The Effects of Fouling,1,3

2.3 Why 3 months?

In-water cleaning and maintenance [16]

7.5 In-water cleaning can be an important part of biofouling management. In-water cleaning can also introduce different degrees of environmental risk, depending on the nature of biofouling (i.e. microfouling versus macrofouling), the amount of anti-fouling coating system residue released and the biocidal content of the anti-fouling coating system. Relative

Microfouling can be removed with gentler techniques.

may enhance a ship's hull efficiency, reducing fuel consumption and greenhouse gas emissions. It is, therefore, recommended that the ship's hull is cleaned when practical by soft methods if significant microfouling occurs. In-water cleaning can also reduce the risk of spreading invasive aquatic species by preventing macrofouling accumulation.

According to MEPC 62, microfouling can be removed easily and it takes less time to remove.

It is therefore advisable to removed the microfouling before macrofouling occurs.

[16] MEPC 62-24-Add.1

2.4 Current Cleaning Methods

- In-water hull cleaning

In-water cleaning is carried out by divers using a cleaning tool.

It takes 3-4 days depending on the size of the ship.

- Dry dock cleaning

Dry-dock the vessel and physically remove fouling by high pressure water blasting.

Dry dock cleaning is about once every five years.

2.4 Current Cleaning Methods

- **Drawbacks of In-water cleaning**
  - Because In-water cleaning do not collect fouling debris, it facilitates the translocation of harmful marine species.
  - Underwater cleaning operations remove not just biofouling, but layers of anti-fouling paint' chemicals.
  - The diver labour costs are expensive ($18,810~$31,950)

[Cleaning methods need improvement]

- **Drawbacks of Dry dock cleaning**

- Water blasting for removing fouling causes paints' pealing off.
  - ► The vessel needs to be repainted.
- Due to cost, time and location constraints, Dry dock cleaning is often not conducted.

2.5 Suggestion of Cleaning Methods

- Necessary Conditions for Cleaning Methods

  - Holding all the debris
  - Reasonable Cost (cheaper than existing cost)
  - Fast speed (1000~1500㎡/h, completed while ships are anchored in a harbor)

Type of Ship		Designed Fuel Cost (per annum) in USD	Actual Fuel Cost (per annum) in USD	Additional Loss (per annum) in USD
Container-ship		27 million	32.4 million	5.4 million
		18 million	21.6 million	3.6 million
Tanker		8.1 million	9.7 million	1.6 million
LNG ship		18.7 million	22.4 million	3.7 million
Bulker		6.1 million	7.3 million	1.2 million
Naval ship		12 million	14.4 million	2.4 million

(for a 9,000TEU Container vessel, 160K LNG, VLCC 319K DWT)

[17]

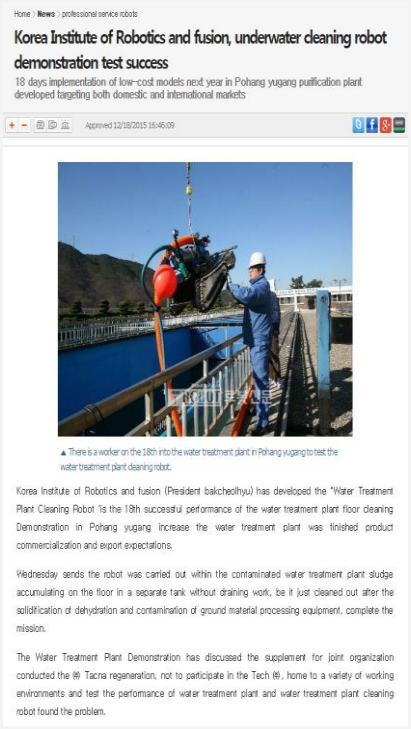
[Cost loss due to increased fuel consumption]

	Ship size	Number of ports	Number of days to sail	Average berth time
	15550	21	80	21
Large	9220	8	40	19
	8160	18	80	17
	4360	10	35	14
Medium	4275	9	53	15
	4258	10	40	
	1860	6	22	
Small	1367	11	63	21
	1118	5	40	

[Average docking time per port according to ship's linearity .]

[17] James A. Callow, "Trends in the development of environmentally friendly fouling-resistant marine coatings",(nature communications),p2

2.5 Suggestion of Cleaning Methods



Home > News > professional service robots

Korea Institute of Robotics and fusion, underwater cleaning robot demonstration test success

18 days implementation of low-cost models next year in Pohang yugang purification plant developed targeting both domestic and international markets

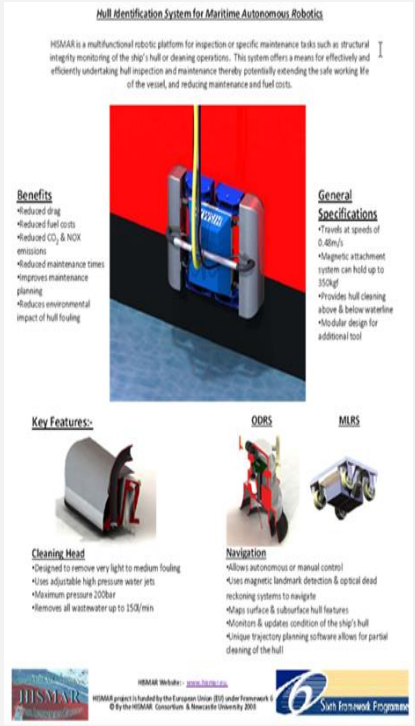
Approved 12/18/2015 16:46:09

▲ There is a worker on the 18th into the water treatment plant in Pohang yugang to test the water treatment plant cleaning robot.

Korea Institute of Robotics and fusion (President bakcheolhyu) has developed the "Water Treatment Plant Cleaning Robot 'is the 18th successful performance of the water treatment plant floor cleaning Demonstration in Pohang yugang increase the water treatment plant was finished product commercialization and export expectations.

Wednesday sends the robot was carried out within the contaminated water treatment plant sludge accumulating on the floor in a separate tank without draining work, be it just cleaned out after the solidification of dehydration and contamination of ground material processing equipment, complete the mission.

The Water Treatment Plant Demonstration has discussed the supplement for joint organization conducted the ㈜ Tacna regeneration, not to participate in the Tech ㈜, home to a variety of working environments and test the performance of water treatment plant and water treatment plant cleaning robot found the problem.



Hull Identification System for Maritime Autonomous Robotics

HISMAR is a multifunctional robotic platform for inspection or specific maintenance tasks such as structural integrity monitoring of the ship's hull or cleaning operations. This system offers a means for effectively and efficiently undertaking hull inspection and maintenance thereby potentially extending the safe working life of the vessel, and reducing maintenance and fuel costs.

Benefits
- Reduced drag
- Reduced fuel costs
- Reduced CO_2 & NOX emissions
- Reduced maintenance times
- Improves maintenance planning
- Reduces environmental impact of hull fouling

General Specifications
- Travels at speeds of 0.4m/s
- Magnetic attachment system can hold up to 350kgf
- Provides hull cleaning above & below waterline
- Modular design for additional tool

Key Features:-

ODRS

MLRS

Cleaning Head
- Designed to remove very light to medium fouling
- Uses adjustable high pressure water jets
- Maximum pressure 200bar
- Removes all wastewater up to 150l/min

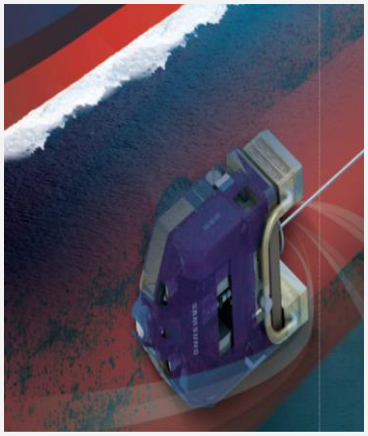
Navigation
- Allows autonomous or manual control
- Uses magnetic landmark detection & optical dead reckoning systems to navigate
- Maps surface & subsurface hull features
- Monitors & updates condition of the ship's hull
- Unique trayectory planning software allows for partial cleaning of the hull

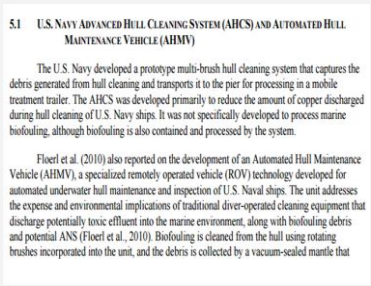
HISMAR Website:- www.hismar.eu

HISMAR project is funded by the European Union (EU) under Framework 6

© By the HISMAR Consortium & Newcastle University 2005

Sixth Framework Programme





5.1 U.S. Navy Advanced Hull Cleaning System (AHCS) and Automated Hull Maintenance Vehicle (AHMV)

The U.S. Navy developed a prototype multi-brush hull cleaning system that captures the debris generated from hull cleaning and transports it to the pier for processing in a mobile treatment trailer. The AHCS was developed primarily to reduce the amount of copper discharged during hull cleaning of U.S. Navy ships. It was not specifically developed to process marine biofouling, although biofouling is also contained and processed by the system.

Floerl et al. (2010) also reported on the development of an Automated Hull Maintenance Vehicle (AHMV), a specialized remotely operated vehicle (ROV) technology developed for automated underwater hull maintenance and inspection of U.S. Naval ships. The unit addresses the expense and environmental implications of traditional diver-operated cleaning equipment that discharge potentially toxic effluent into the marine environment, along with biofouling debris and potential ANS (Floerl et al., 2010). Biofouling is cleaned from the hull using rotating brushes incorporated into the unit, and the debris is collected by a vacuum-sealed mantle that

Many countries are developing hull cleaning equipment such as a underwater cleaning robot.

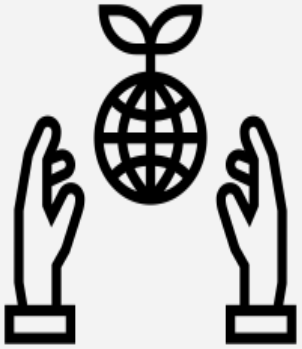
3.1 Our Proposals to IMO

Ban on the use of anti-fouling paint.

Load a hull cleaning equipment in all ships.

Clean ships periodically once every three months with the equipment.

3.2 Advantages



1. Reducing fuel consumption and greenhouse gas emissions.

2. Reducing the risk of spreading invasive marine species

3. Cost effectiveness

3.2 Advantages

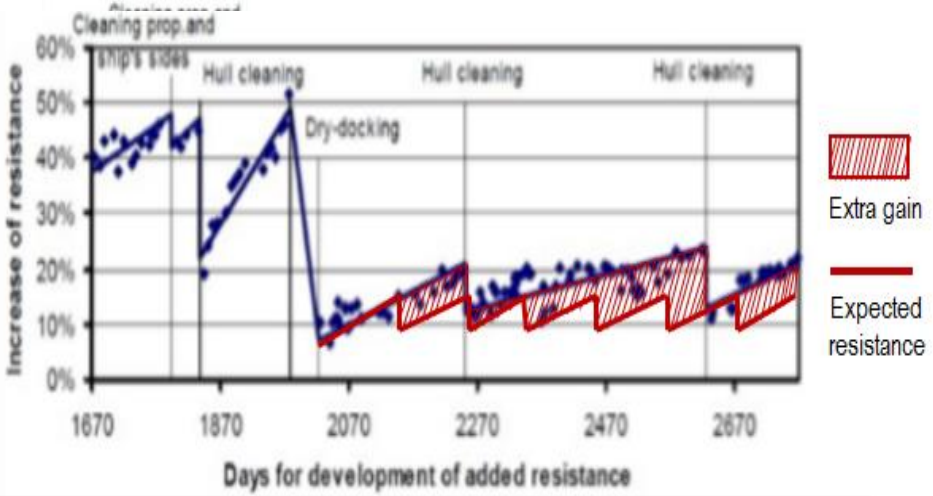
In-water cleaning and maintenance [18]

7.5 In-water cleaning can be an important part of biofouling management. In-water cleaning can also introduce different degrees of environmental risk, depending on the nature of biofouling (i.e. microfouling versus macrofouling), the amount of anti-fouling coating system residue released and the biocidal content of the anti-fouling coating system. Relative to macrofouling, microfouling can be removed with gentler techniques that minimize degradation of the anti-fouling coating system and/or biocide release. Microfouling removal

Hull cleaning can reduce fuel consumption and greenhouse gas emissions.

soft methods if significant microfouling occurs. In-water cleaning can also reduce the risk of spreading invasive aquatic species by preventing macrofouling accumulation.

[19]



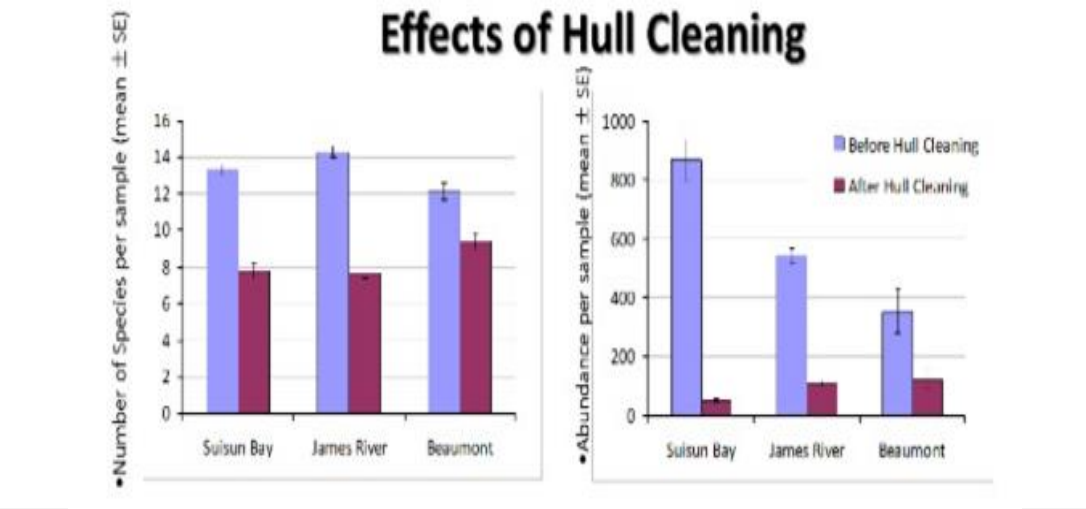
3.2 Advantages

In-water cleaning and maintenance

7.5 In-water cleaning can be an important part of biofouling management. In-water cleaning can also introduce different degrees of environmental risk, depending on the nature of biofouling (i.e. microfouling versus macrofouling), the amount of anti-fouling coating system residue released and the biocidal content of the anti-fouling coating system. Relative to macrofouling, microfouling can be removed with gentler techniques that minimize degradation of the anti-fouling coating system and/or biocide release. Microfouling removal may enhance a ship's hull efficiency, reducing fuel consumption and greenhouse gas emissions. It is, therefore, recommended that the ship's hull is cleaned when practical by

[20]

Hull cleaning can reduce the risk of spreading invasive aquatic species.



[21]

[20] MEPC 62-24-Add.1
[21] PB Tankers SPA, PIETRO BARBARO GROUP- Training - Biofouling Onboard -27

3.2 Advantages

The cost of { more fuel consumption + loss of income during relocation and docking time. + dive labour } ≈ The cost of hull cleaning regularly

<Vessel applied by current anti-fouling systems> [22]

[22] Department of Fisheries, Western Australia, "In-Water Hull Cleaning System Cost & Cost Benefit Analysis", Fisheries Occasional Publication No. 115, 2013,p13

3.3 Amendments to MEPC-62 Annex

MEPC 62 ANNEX 26

GUIDELINES FOR THE CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING TO MINIMIZE THE TRANSFER OF INVASIVE AQUATIC SPECIES AND POLLUTION

6 ANTI-FOULING SYSTEM INSTALLATION AND MAINTENANCE

6.1 Anti-fouling systems and operational practices are the primary means of biofouling prevention and control for existing ships' submerged surfaces, including the hull and niche areas. An anti-fouling system can be a coating system applied to exposed surfaces, non-toxicity and non-biocide materials used for piping and other unpainted components for sea chests and internal seawater cooling systems, and driving portions, or other innovative measures to control biofouling.

6.2 The anti-fouling system used should comply with the AFS Convention, where necessary.

[Coatings have to be painted only for protect.]

3.3 Amendments to MEPC-62 Annex

Choosing the anti-fouling system

6.3 Different anti-fouling systems are designed for different ship operating profiles so it is essential that ship operators, designers and builders obtain appropriate technical advice to ensure an appropriate system is applied or installed. If an appropriate anti-fouling system is not applied, biofouling accumulation increases.

6.4 Some factors to consider when choosing an anti-fouling system include the following:

.1 planned periods between dry-docking – including any mandatory requirements for ships survey;
.2 ship speed – different anti-fouling systems are designed to optimize anti-fouling performance for specific ship speeds;
.3 operating profile – patterns of use, trade routes and activity levels, including periods of inactivity, influence the rate of biofouling accumulation;
.4 ship type and construction;
.5 any legal requirements for the sale and use of the anti-fouling systems;

New factors are added as follows

.6 control foulings – load hull cleaning equipment to wash periodically; and
.7 cleaning hull has to do in impermeable systems.

3.3 Amendments to MEPC-62 Annex

AMENDMENT TO ANNEX

CONTROLS ON ANTI-FOULING SYSTEMS

Anti-fouling system	Control measures	Application	Effective date
All of anti-fouling compounds, needless to say including biocides; and wash periodically	Ships shall not bear all of compounds as an active anti-fouling substance on their hulls or external parts or surfaces And Ships have to be cleaned periodically [per 3months]	All ships that have been constructed prior to 1 January 2019; Have to clean Hull when every times to dock	1 January 2024 [or entry onto force of the Convention, which ever is later]
		Ships to be built after 1 January 2019; Have to load cleaning equipment	

References

[1] Primtel, David(2005) Ecological Economics. 52: 173-288

[2] MEPC 61-2-17

[3] Gollasch, 2006

[4] D. M. Yebra, S. Kill, and K. Dam-Johansen, Progress of Urganic Coatings, 50, 75 (2004)

[5] http://sites.google.com/site/invasivespeciez/

[6] Common Hull Fouling Invasive Species www.imo.org

[7] Robert F.Brandy.Jr, "Composition and Performance of Fouling Release Coatings", 2000, p1

[8] M.P.Schultz,(7 OCtober 2010),Economic impact of biofouling on a naval surface ship

[9] http://www.coastalwiki.org/wiki/TBT_and_Imposex#cite_note-omae-3

[10] MEPC 55 INF.4

[11] Robert F. Brandy.Jr, “Composition and Performance of Fouling Release Coatings”, 2000, p2

[12]] Yoichi Yonehara,"A new antifouling paint based on a zinc acrylate copolymer",Progress in Organic Coatings,2001,p155

[13] Robert F. Brandy.Jr, “Composition and Performance of Fouling Release Coatings”, 2000, p5

[14]https://www.researchgate.net/publication/264149856_Image_Analysis_Method_for_the_Performance_Evaluation_of_Marine_Antifouling_Coatings

[15] U.S. Naval Institute,Annapolis,Maryland,The Effects of Fouling,1,3

[16] MEPC 62-24-Add.1

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Thank you!