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EVALUATING THE EFFECTIVENESS AND ENVIRONMENTAL CONSEQUENCES OF ANTIFOULING TECHNOLOGIES IN INDIAN MARITIME ZONES

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ABSTRACT

This article is going to address both effectiveness and environmental consequences of antifouling technologies in Indian maritime zones. Before moving to antifouling let's get clear with what is biofouling, invasive aquatic species like microorganisms, flora and fauna of ocean will get attached to the hull of the ship, this might slow down speed of the ship and increase fuel consumption, they are also harmful to biodiversity, the process of protecting a ship from these invasive aquatic species is known as antifouling. In early days lime and other arsenic were used as antifouling agents. Present day, effective antifouling paints were created using high composition chemical and metallic compounds. It kills the marine organism attached to the ship and remains in the ocean and damages the marine environment. In 2001 using tributyltin on ship hulls was banned. Later harmless repealing paints like hydrophobic foul release coating, copper free antifouling, nano antifouling and standard for underwater hull and propeller cleaning were invented. In 1989, the International Maritime Organisation recognised, harmful environmental effects due to harmful antifouling systems on ships. Later in 1990 Marine Environment Protection Committee 1992, adopted resolution to eliminate the use of tributyltin antifouling paints on non- aluminium hulled ships less than 25 meters and recommended governments to adopt the measures. On October 5, 2001, International Convention on Control of Harmful Anti-fouling Systems on Ships was held by IMO, and it entered into force ON 2008.[2] In 2016, the Ministry of Shipping released notification on control on antifouling systems. Yet we have to move technologically, by adopting electrolytic and ultrasonic systems, to attain a sustainable marine environment.

CHAPTER I

INTRODUCTION:

[1]The author is a student at Tamilnadu dr. Ambedkar law university

[2] International Convention on the Control of Harmful Anti-fouling Systems on Ships, https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-the-Control-of-Harmful-Anti-fouling-Systems-on-Ships-(AFS).aspx

Maritime transport provides inevitable chief support to world economy. In accordance with UNCTAD's, Review of Maritime Transport 2021, 80 per cent of international trade takes via sea transport.[3] There are numerous hindrances for ocean transportation, it includes unpredictable weather conditions, adverse effect of maritime crimes like piracy and Hull fouling. In this article we are going to have brief discussion over hull fouling, effects of hull fouling, requirement of Anti-fouling, environmental and health hazardous caused by anti-fouling coatings, international level legal frame works, and domestic level legal frame works by India, availability of alternative anti- fouling coatings and obstructive measures on ships and suggestions. Let's get clear with concept of fouling, biofouling and anti-fouling. Fouling is defined as "*the accumulation of contaminants (colloids, organic, inorganic, or bio-foulants) on or into the surface of the membrane.*"[4] Biofouling means, structural and functional sparseness caused by pile of microorganisms, flora or fauna on wet surfaces, which has mechanical purposes.[5] As per MEPC assessment report, "even a small amount of fouling can lead to an increase in fuel consumption of 40 percent, due to the increased resistance to movement." Which also slowdowns the speed of ship and causes delay in delivery. "Hull fouling can increase fuel consumption up to $500,000 per year, according to a study released by Eniram".[6]

CHAPTER II

2.1. DEFINITIONS OF ANTIFOULING:

2.1.1. "Biofouling is the accumulation of aquatic organisms such as microorganisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment. Biofouling can include pathogens. For microfouling and macrofouling".[7]

2.1.2. "*Macrofouling is biofouling caused by the attachment and subsequent growth of visible plants and animals on structures and ships exposed to water. Macrofouling is large, distinct multicellular individual or colonial organisms visible to the human eye such as barnacles,*

[3] Review of Maritime Transport 2021, https://unctad.org/publication/review-maritime-transport-2021
[4] Petroleum Industry Wastewater, 2022, https://www.sciencedirect.com/topics/chemical-engineering/fouling.
[5] What is biofouling and how can we stop it? Sofar Ocean, February 3, 2021, https://www.sofarocean.com/posts/what-is-biofouling-and-how-can-we-stop-it
[6] Hull Fouling Can Cost $500,000 Per Year in Fuel, October 4, 2012, https://cruiseindustrynews.com/cruise-news/2012/10/hull-fouling-can-cost-500000-per-year-in-fuel/
[7] 2023 GUIDELINES FOR THE CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING TO MINIMIZE THE TRANSFER OF INVASIVE AQUATIC SPECIES, ANNEX 17 RESOLUTION MEPC.378(80), 2 definition, 7, adopted on 7 July 2023.

tubeworms, mussels, fronds/filaments of algae, bryozoans, sea squirts and other large attached, encrusting or mobile organisms".[8]

2.1.3. "Microfouling is biofouling caused by bacteria, fungi, microalgae, protozoans and other microscopic organisms that creates a biofilm also called a slime layer."[9]

2.1.4. "Anti-fouling coating (AFC) means a surface coating or paint designed to prevent, repel or facilitate the detachment of biofouling from hull and niche areas that are typically or occasionally submerged".[10]

2.1.5. According to the International Convention on the Control of Harmful Anti-fouling Systems on Ships, i.e., AFS Convention, Anti-fouling systems is defined as *"a coating, paint, surface treatment, surface or device that is used on a ship to control or prevent attachment of unwanted organisms"*[11].[12] The same defined under section 356Q(a) of PART XIB, control of harmful antifouling systems on ships of, The Merchant Shipping Act 1958.

2.2 BACTERIAS TO HUMANS; THE EFFECT OF TBT ANTIFOULING PAINT:

The primary substance of TBT antifouling pain is tin, which is immensely harmful to multifarious aquatic species. These Antifouling paints are applied to ship hulls for preventing attachment of invasive marine organisms, but this paint gets discharge into the marine environment. TBT not only impacts marine life, such as bacteria, algae, tubeworms, shellfish, barnacles that adheres to a ship's hull, but also impacts non-targeted marine creatures, like mussels and oysters by increasing the untypical shell growth and unusual decrease in weight. It is discovered that TBT also causes metal toxicity i.e., bioaccumulation, in an array of invertebrates, fishes, dolphins, seals, whales and other marine mammals. It gives rise to barrenness and even mortality of marine beings. As a resultant, it damages the marine environment, and it indirectly impacts the tourism and commercial fishing. When ships are dry-docked in shipyards or harbours for maintenance or painting, there is an increased danger of water body pollution. High levels of TBT were found in shellfish off the coast of France in the 1970s and 1980s, which led to the disintegration of commercial shellfish harvesting in

[8] *Ibid*
[9] *Ibid*
[10] *Ibid*
[11] *Ibid*
[12] https://www.imo.org/en/OurWork/Environment/Pages/Anti-fouling.aspx#:~:text=The%20Convention%20defines%20%22anti%2Dfouling,prevent%20attachment%20of%20unwanted%20organisms%22.

one or more regions. During 1980's, in south-west England TBT toxicity was connected to the reduction in dog-whelk populations by an evolving state called "imposex", which expand male sexual organs in female, and it leads to infertility. Shipyard workers may also suffer negative health impacts from washing, scraping, and repainting boat hulls. It has been discovered that seabirds and mammals both have elevated TBT concentrations. Human blood contains tributyltin, and Liver has sparked worries regarding the transmission of TBT through seafood eating by humans.[13]

CHAPTER III

3. HISTORY AND EVOULTION OF TBT BAN:

Antifouling is a problem that has been there for as long as marine activity.[14] Even during ancient days, lime and as well as arsenic in later part, used as anti-fouling coating for ships.[15] Some of the first methods for preventing marine fouling on ship hulls were applying various coatings that contained the employment of copper, tin, lead, or other metal sheaths. Antifouling techniques underwent a radical change in 1970 when TBT was introduced into antifouling paint. TBT Is extremely harmful to invasive marine species. Though Tin was cost effective than conventional copper coatings, long lasting nature of tin created great demand. Copper only has a shorter half-life than tin, the primary ingredient in TBT. But, despite argumentation, the fouling issue was not resolved. Midway through the 1980s, scientists from the UK and France published findings concerning TBT's impact on marine life. Numerous research conducted worldwide have also brought attention to the negative effects of antifouling coatings. Numerous research conducted worldwide have also brought attention to the negative effects of antifouling coatings. TBT not only damages Invasive marine species, like bacteria, algae, tubeworms, but also damaged off- targeted marine organisms and caused abnormal health issues and infertility in them. Example, oysters and mussels. In addition, the metal toxicity of TBT, created great negative impacts and death of fishes, dolphins, whales and other marine mammals. Still discourses were focused on the unaffordability of TBT, because the use of other alternatives increases the fuel consumption and also migrate marine organisms, but not on the environmental consequences of TBT. It is clear that the number of

[13] Capt. Ahmed Saad Hassan Noufal and Capt. Mohamed Hussein Nassar Hassan, The Impact of Implementing the International Convention on the Control of Harmful Anti-fouling Systems in Ships (AFS Convention) on the Marine Environment, Journal of Shipping and Ocean Engineering, 59, 57-63 (2016).
[14] Lena Gipperth, the legal design of the international and European Union bans on tributyltin.
antifouling paint: Direct and indirect effects, journal of Environmental Management 90, S87, S86–S95, (2009)
[15] *Supra-1*

legislative frameworks has not been enough. But without outright banning TBT-based antifouling paint, the workable substitutes were created, most likely they are substantially slower. Over the past 60 years, various paint types have been used globally, and the development of TBT antifouling system substitutes has also usually related to paints. Because many alternative paints include hazardous metals and biocides, using them could harm the environment. The most popular substitute is to use paints made of copper; however copper is harmful to marine life, much like tin is. In accordance with EC rule 2032/2003 regarding the 10-year program's second phase Referenced in the Scientific Committee on Health and Environmental Risks; SCHER, 2007; and mentioned in Article 16(2) of Directive 98/8/EC governing the placing of biocidal products on the market (EC, 2003b), antifouling copper compounds are being assessed and may be banned by the EC. It has been forbidden to use copper-containing anti-fouling paint on smaller boats and recreational boats along Sweden's east coast since 2002. Denmark has had a similar restriction in place since 2003. Furthermore, the cost of the various antifouling chemicals currently in use is generally much higher than that of TBT paint. The Organisation for Economic Co-operation and Development (OECD) reported that the cost of a five-year dry-dock cycle for a vessel or container carrier ranges from $200,000 to $270,000 (OECD,2003). There are additional elements involved in the higher cost of employing alternative paints in addition to the paint's increased price. Ineffective antifouling paint can lead to increased fuel consumption, more frequent hull cleanings and repainting, as well as a loss of trading income while the ships are dry-docked. Increased antifouling paint costs deter ship owners and the shipping sector but benefit paint producers and distributors. Using TBT-free antifouling methods comes at a cost of probably going to decline as more effective paint and hull-cleaning options become accessible (OECD, 2003). In addition to being a financial burden on ship owners, increased fuel consumption brought on by hull fouling also results in a rise in greenhouse gas emissions. In the maritime environment, less effective paints have also been found to introduce alien species. [16]

CHAPTER 5

5.1. REVOLUTIONS ON CONVENTIONAL COVERING:

5.1.1. INITIAL DAYS INITITATIVE ON PREVENTION OF COVENTIONAL COVERING:

[16] *Supra- 13*

a) Tin-free Self-polishing Anti-fouling Coatings: It was created from the antipollution principle of organic tin self-polishing anti-fouling paint. These coatings were developed on acrylic, in addition to new materials, these paints were less harmful when compared to Tin Self-polishing Anti-fouling Coatings. For several years, it became the standard anti-fouling paint product. But the European Union has prohibited the use, due to the presence of copper and other metals in coating caused in black pollution.[17]

b) Low Surface Energy Anti-Fouling Coatings: These paints have low surface-energy, it creates an onerous top on hull, which prevent sea fouling species from getting attached. Low surface energy anti-fouling paints were halved into two categories, modified organic silicone Anti-fouling Coatings and modified organic fluorine Anti-fouling coatings. Silicone- based anti-fouling paints were enlarged by American experimenter, in 1972 and obtained patent, yet due to low adherence, it cannot stand more than three years in market. Fluorine coating has acquired omnipresent attention, because of its virtuosic execution in low surface energy anti-fouling coat and they are extremely weather-resistant in nature.[18]

c) Conductive Anti-Fouling Coating: it is operated based on conductivity of the system, in this process seawater is electrolyzed to make hypochlorite, which hinders the pollution. Anti-fouling is achieved through micro current, in which boat act as cathode and the conductive paint act as anode. Though, Anti-fouling production is eco- friendly and can be carried out for 6 to 9 months but failed in complying with environmental component.[19]

d) Marine Anti-Fouling Coatings: aquatic species like, seaweed, shellfish, dolphin, whales have natural anti-fouling abilities. It is found that biological extracts of such organisms could be used as anti-fouling coatings. Few experimenters drew out 4 types of open loop steroid compounds from coral, which can be used as potent anti-fouling agent. From 2004 to mid-2009, various compounds were developed from diverse

[17] Chen Liu, Development of Anti-fouling Coating Using in Marine Environment, International Journal of Environmental Monitoring and Analysis; 3(5), 373,373-376, 2015.
[18] *Ibid, pg no:374*
[19] *Supra- 16, pg no:374*

organisms. Even though they are environmentally friendly, yet they do not possess long-term effect and these anti-fouling paints were cost effective.[20]

5.1.2. RECENT TIME INITITATIVE ON PREVENTION OF COVENTIONAL COVERING:

a) Silicate Anti-fouling Coating: this coating may create a potential alkaline zone between marine area and hull surface. this operation results in the ion exchange of silicate with H+ from saltwater and sets free an antifouling agent and accomplishes the anti-fouling purpose. These coating are not only affordable and eco- friendly but also has the ability to stand by climate change and marine environment. It can with stand more than two years and deliver efficient performance.
b) Capsaicin Anti-Fouling Agent: capsaicin is extracted from pepper fruit. Nelson determined its structure in 1919 but, Thresh gave it its name in 1876. The goal of anti-fouling paint containing capsaicin is accomplished via driving effect. Through release control technology, the beneficial components might be gradually released to provide a safe and long-lasting anti-fouling effect. It also serves as an antimicrobial and may stop marine creatures from growing. Researchers from both local and international universities have conducted extensive research on spicy natural anti-fouling agents thus far. For 186 days it was plunge in the water, with unbound marine life. The outcome shown that it could stop marine creatures from adhering.
c) Isothiazolinone Anti-fouling Coatings: isothiazolone anti-fouling derivatives are popularly known for their eco-friendly nature. The American business Rohm & Haas successfully developed and marketed 4,5-Dichloro-2-octyl-isothiazolone in the 1990s. This outcome was recognised in 1996 with the Presidential Green Chemistry Challenge award and in 1997 with the Chemical Environment Prize. It breaks down quickly in seawater, does not biologically accumulate in the marine environment, and has no negative effects on the environment or public health. However, the water solubility of these compounds is low, therefore production is difficult. As a result, more effort is required to enhance the performance, which is appropriate in all circumstances.
d) Nano Anti-fouling Coatings: A type of water-soluble resin material is used in microencapsulation technology, an effective nanotechnology for anti-fouling. In real-world applications, the anti-fouling chemical is released gradually and effectively

[20] *Supra- 16, pg no:375*

to create a stable environment, and the microcapsules may gradually disintegrate in sea water. inhibiting fouling. The anti-fouling agent that is microencapsulated exhibits superior anti-fouling efficacy over an extended period and has the potential to mitigate environmental damage. The one key path of improvement for paint is the addition of nanoparticles, which might enhance the rheology, coating adhesion, coating hardness, smoothness, and anti-aging qualities. development of anti-fouling agents.[21]

5.1.3. PREVENTIVE MEASURES USED ON SHIPS:

a) Electrolytic System: In order to stop or lessen the settling and breeding of marine creatures, electrolytic antifouling works primarily by producing copper ions in extremely small quantities. The mussels and larvae float through the cooling water system to the discharge point without injury, sticking to the surface of strainers, pipework, box cooler tubes or seachests. The dosage of Cu is adjusted based on exposure and location. Applying a minimum 2 ppb (2µg/L) Cu content is recommended for seawater systems of moderate size. It breaks down quickly in seawater, does not biologically accumulate in the marine environment, and has no negative effects on the environment or public health. However, the water solubility of these compounds is low, therefore production is difficult. As a result, more effort is required to enhance the performance, which is appropriate in all circumstances.[22]

b) Chemical Dosing: Another popular technique for controlling marine growth in pipe networks is chemical dosing. Ferrous chloride, an anti-fouling compound, is utilised. to fill seawater boxes with dosage, to stop corrosion, the chemical applies a protective ferrous layer on the pipes. By creating a layer on the surface, ferrous chloride also aids in preventing corrosion in the piping.[23] Emissions from the chemical dosing approach pose a concern to the environment, as does any chemical antifouling material.

c) Ultrasonic System: Another technique for preventing marine growth in pipe systems is the use of high frequency waves. This approach claims an 80%

[21] *Supra- 16, pg no:375*
[22] Electrolytic antifouling explained, Last updated: 14.06.2023 https://cathwell.com/electrolytic-antifouling-principles/
[23] Capt. Ahmed Saad Hassan Noufal and Capt. Mohamed Hussein Nassar Hassan, The Impact of Implementing the International Convention on the Control of Harmful Anti-fouling Systems in Ships (AFS Convention) on the Marine Environment, Journal of Shipping and Ocean Engineering 6, 61, 57-63, 2016.

reduction in biofouling. A wave generator creates and transmits high-frequency electrical impulses in the ultrasonic manner. This system's primary benefit is that it is non-invasive and has no parts that come into touch with saltwater. Furthermore, no harmful compounds are created.[24] The foundation of ultrasonic antifouling is eliminating microfouling at the cellular level. The system's goal is to break through the organisms' cell walls and stop the fundamental components of fouling from adhering to the hull. In essence, the device causes gas bubbles to appear in the water. Marine growth is prevented by the local pressure when the bubbles burst.[25]

d) Electro- Chlorination: According to the electrolysis of seawater principle, some of the salt in the water is transformed into sodium hypochlorite, which is then used to disinfect the organic material in the water that the onboard pumps are sucking up. The technique is environmentally beneficial despite using a chemical treatment approach with an active ingredient (chlorine) because of the entirely reversible reaction that produces the chlorine. Upon being released overboard, sodium hypochlorite reverts to salt and water, eliminating any traces of the chemical from the surrounding environment. Simple, adaptable, and appropriate for any application, EcoFonp inhibits the growth of fouling in a variety of environmental settings, including places where fouling can be particularly aggressive.[26] By producing sodium hypochlorite through electro-chlorination, chlorine can be produced and used as a fouling preventive. 10% chlorine in seawater. One PPM (parts per million) will stop fouling, but a rapid death of all marine life is possible. The board can be used to test this. Note that fresh water should not be used with this device; it is intended for use only with sea water.[27]

CHAPTER IV

[24] *Ibis-22, pg no:62*
[25] Ultrasonic antifouling, https://cathwell.com/industries/ships/ultrasonic/
[26] ELECTROCHLORINATION ANTIFOULING, https://polipodio.com/en/antifouling-systems/electrochlorination/
[27] *Ibis-22, pg no:62*

4.1. INTERNATIONAL FRAMEWORK ON PREVENTION OF ANTI-FOULING COATINGS ON SHIP:

At Rio Conference 1999, Chapter 17 of Agenda 21, developed on Environment and Development, measure to eliminate the pollution from organotin compounds in anti-fouling system on ships by states. In 1989, International Maritime Organization (IMO), acknowledged, adverse environmental effects by organotin compounds. IMO's Marine Environmental Protection Committee (MEPC) passed a resolution, on governments to take action to stop using TBT-containing anti-fouling paints on ships that aren't made of aluminium and to stop using anti-fouling paints that release more than four micrograms of TBT per day on non-aluminium hulled vessels shorter than 25 meters, in 1990. An Assembly resolution was passed by the IMO in November 1999, requesting that the MEPC create a legally enforceable worldwide instrument to address the detrimental impacts of anti-fouling systems on ships. The resolution stipulated that by January 1, 2003, there would be a worldwide ban on the use of organotin compounds as biocides in anti-fouling systems on ships, and by January 1, 2008, there would be an outright ban. The International Convention on the Control of Harmful Anti-fouling Systems on Ships was subsequently adopted based on this agreement, on October 5, 2001. The convention came into force on 17 September 2008.[28] ANNEX 17, RESOLUTION MEPX.378(80), 2023 GUIDELINES FOR THE CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING TO MINIMIZE THE TRANSFER OF INVASIVE AQUATIC SPECIES, adopted on 7 July 2023. Article 38 of the IMO convention with scope on control and prevention of marine pollutions from ships, the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, the objectives of the Convention on Biological Diversity, 1992, the 2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (Biofouling Guidelines), developed by the Sub-Committee on Bulk Liquids and Gases were recalled by the Marine Environment Protection Committee. Totally there are 14 rules and 4 appendixes. The main objectives of the rules are to minimize the transfer of invasive marine organisms through biofouling, to prevent, reduce and control pollution of the marine environment in obligation with Article 194,195 and 196 of United Nations Convention on the Law of the Sea (UNCLOS), To provide globally consistent approach to stakeholders on control and management of biofouling. [29]Appendix 1 to 4 deals with

[28] *Supra- 1*
[29] *SuprIa-6, rule 3*

Assessment of Biofouling Risk, Inspection and cleaning Reports, Example Form of Biofouling Management Plan and Example Form of Biofouling Record Book.[30]

4.2. INDIAN FRAMEWORK ON PREVENTION OF ANTI-FOULING COATINGS ON SHIP:

Accordance with PART XIB Control of Harmful Anti-fouling Systems of Ships, section 356Y of the Merchant shipping Act 1958, "Power to make rules. *(1) The Central Government may, having regard to the provisions of the Convention, make rules to carry out the provisions of this Part. (2) In particular and without prejudice to the generality of the provisions of sub-section (1), such rules may provide for all or any of the following matters, namely:— (a) appropriate measures for operation of ships under the proviso to sub-section (2) of section 356P; (b) the standards, requirements and measures to ensure compliance under section 356R; (c) procedure and conditions and the fees which may be levied for inspection and issuance of international Anti-Fouling Systems Certificate under section 356S; (d) procedure and the fees which may be levied for issuance of Anti-Fouling Systems Certificate for foreign ships in India and Indian ships in foreign countries under section 356T; (e) procedure for collection, handling and disposal of wastes under section 356U; (f) the format of record of Anti-Fouling Systems, the manner in which such record shall be maintained under section 356V; (g) any other matter which is required to be or may be prescribed."*[31] Section 356P deals with Application, 356Q with Definitions, 356R. Control of anti-fouling systems.3568. Issuance of International Anti-Fouling System Certificate.356T. Issue of Anti-Fouling System Certificate for foreign ships in India and Indian ships in foreign countries,356U, Controls of waste materials.356V. Record of anti-fouling systems,356W. Inspection and control of all ships above 400 gross tonnage.356X. Information regarding contravention of the provisions of Convention.[32]

The Ministry of Shipping Notification, 19th January 2016, exercised the powers conferred by section 356Y of the Merchant Shipping Act, 1958 Act, the following rules, namely: the Merchant Shipping (Control of Anti-fouling System) Rules, 2016. Totally there are 11 rules and 4 schedules. Rule 3 deals with control on anti-fouling systems, rule 4 with procedure for

[30] 2023 GUIDELINES FOR THE CONTROL AND MANAGEMENT OF SHIPS' BIOFOULING TO MINIMIZE THE TRANSFER OF INVASIVE AQUATIC SPECIES, ANNEX 17 RESOLUTION MEPC.378(80), 7, adopted on 7 July 2023.

[31] The Merchant Shipping Act, 1958, section 356Y, (44 of 1958)

[32] *ibid*

survey and certification, Rule 5. Issue or endorsement of an International Anti-Fouling System Certificate or Indian Anti-Fouling System Certificate, certificates and records drawn as per Schedule 1 International Anti-fouling System Certificate and Schedule 2 Indian Anti-fouling System Certificate, rule 6. Issue or Endorsement of an International Anti-Fouling System Certificate by Director General or another country which is party to Convention, rule 7. Validity of an International Anti-Fouling System Certificate or Indian Anti-Fouling System Certificate, Rule 8. Declaration on anti-fouling system, declaration drawn from, Schedule 3 model from of declaration on anti-fouling system while engaged in international voyage declaration on anti-fouling system, rule 9. Procedure for control of waste anti-fouling material, in accordance with Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, rule 10. Fees.: The fees which may be levied for survey, inspection and certification under these rules shall be as specified in the Schedule 4, from gross tonnage of ships up to 500 tons of Rs. 10,000 to Insurance of Endorsement 2,000. rule 11. Penalty: Whoever contravenes any provisions of these rules shall be punished in accordance with the provisions contained under sub section (2) of section 458 of the Act.[33] "*Section 458(2) In making a rule or regulation under this Act, the Central Government may direct that a breach thereof shall be punishable—(a) in the case of a rule made under 3[section 331 or section 344-I] with imprisonment which may extend to two years, or with fine which may extend to ten thousand rupees, or with both;(b) in the case of any other rule or regulation made under any other provision of this Act, with fine which may extend to one thousand rupees; and in either case if the breach is a continuing one, with further fine which may extend to fifty rupees for every day after the first during which the breach continues."*[34]

CHAPTER VI

CONCLUSION AND SUGGESTION: "Misson-mode" was started by IMO, to reduce greenhouse gas emissions from international shipping, less than half by 2050, due to the unnerve, sixth assessment report of Inter- governmental Panel on Climate Change. A biofouling coating of slime as thin as 0.5 mm, covering up to 50% of an underwater hull surface, may cause a 25–30% increase in greenhouse gas emissions, depending on the vessel's features, speed, and other external factors. The MEPC passed an amendment in 2021 adding restrictions on the biocide "cybutryne." The amendment stipulated that ships must not

[33] the Merchant Shipping (Control of Anti-fouling System) Rules, 2016.
[34] *Supra-30, section 458(2).*

use or reapply anti-fouling solutions using this material starting on January 1, 2023. An analysis, which focused on the underwater hull protection techniques used in major shipyards of India, was conducted by National Maritime Foundation (NMF). On comparing anti-fouling paints, AIRCOAT and Silverstream System. Silverstream System possess compactible among the three, it stands with additional cargo space, reduction in noise pollution, active anti-fouling property, eco-friendly, commercially available but cost effective than anti-fouling coatings. One possible first step towards decarbonisation is the commercially available Active Air Lubrication Technology, it is mandatory to Boost research and development initiatives in Indian labs and universities to identify superior substitutes for environmentally friendly underwater hull protection techniques.[35] Government should take necessary steps to provide labs for experimenting eco- friendly substitutes coating in affordable prices , in concern with Indian markets, necessary safety equipment should be provided to harbour workers and ship cleaners, waste water management and filters system must be enhanced to treat waste water from cleaning anti-fouling paints on ships, setting up adequate monitoring systems in each ports to monitor the safety mechanisms.

[35] Ayushi Srivastava and Commodore Debesh Lahiri, TOWARDS A SUSTAINABLE BLUE ECONOMY: INCORPORATING GREEN NORMS IN SHIPS' UNDERWATER HULL PROTECTION PRACTICES IN INDIA, National Maritime Foundation, 13 April 2023, https://maritimeindia.org/towards-a-sustainable-blue-economy-incorporating-green-norms-in-ships-underwater-hull-protection-practices-in-india/