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Energy Saving in Ship Operation Case Study

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ABSTRACT

Shipping is the world's only really reliable, global, cost-effective and energy-efficient mass transportation method for energy, materials, foods and products, maritime transport is central to sustainable development. In addition, the maritime transportation system itself must, therefore, ensure that its development is also sustainable. The concept of a sustainable maritime transportation system aims to identify some broad areas that need to be addressed if sustainability is to be achieved. These include safety, environmental protection, efficient operation, security and resource conservation. Energy-efficiency measures are, therefore, part of this concept, as they also address the reduction of CO2 emissions from international shipping which can be reduced by lowering fuel consumption; a key factor in ensuring international shipping contributes to efforts to mitigate climate change. Ships are important and strategic engineering structures. the ever increasing demands of efficiency, clean environment are pushing the size and complexity of ships upwards. Many Areas are taken in consideration to reduce fuel consumption and reduce air,water and noise pollution .one way to achieve better fuel saving is timely maintenance of machinery and regular interval hull cleaning. There are many reasons to look for Energy efficient Ship. Here’s a few:-As stated from (Fathom Ship Efficiency: The Guide, 2011). Reduce fuel consumption - SAVE MONEY, extra power and fuel consumption are needed to maintain ship service speed. Energy Efficient Ship will consume less fuel.

Keywords : SHIP, Hull cleaning , Energy Saving, Fuel Reducation, Marine Pollution, Mass Transportation, EEDI, LNG

I. INTRODUCTION

Two important aspects should need to be taken into consideration: Efficiency measures differ according to the type and the operational profile of the vessel; Measures for increasing efficiency are generally not cumulative. This highlights the important role of a ship designer who has to choose and integrates different possible technological solutions for the best overall performance of a ship. Promising areas of the research that can assist to meet the strategic goals could address:

Hull: Developments of Computer Fluid-Dynamics tools for eco-efficient design in order to innovate and optimize hull forms for multi-mission operational profiles; new molecules for hull treatment reducing resistance and combining anti-fouling properties; viscous resistance reduction identifying new laminar hulls concepts; wave-ship motion optimization; advanced hull designs for inland / shallow water navigation; and next generation propulsors.

This addresses issues related to the basic hull form design including selecting proper proportions, reducing resistance by optimizing the hull form and appendage design, and assessing the impact on resistance of waves and wind. There is also a discussion of how the IMO Energy Efficiency Design Index (EEDI) influences ship design and efficiency (J. Larkin et. al.-Influence of Design Parameters on the Energy Efficiency Design Index (EEDI),SNAME

Symposium on Climate Change and Ships, February 2010).

Energy-saving Devices This section covers devices used to correct or improve the efficiency of propellers as well as developing technologies aimed at reducing the hull frictional resistance or using renewable energy sources (such as solar and wind energy).

Materials: Breakthroughs are expected regarding the use of lightweight / higher strength composite materials (e.g. metal foamed sandwich) and the relevant joining techniques.

Engine: Combustion optimization of marine engines (injection timing, compression ratio, fuel spray geometry, etc.); alternative fuels (LNG, methanol, ethanol, DME, biodiesel and biogas); renewable energy propulsion (wind, sea and solar power); fuel cells running on hydrogen as auxiliary propulsion power; and in a longer term vision a diverse fuel mix adoption, with LNG, biogas, batteries and hydrogen produced from renewable sources. This section looks at the efficiency gains that are possible in the design and operation of the ship's machinery and systems. It covers main and auxiliary diesel engines, waste heat recovery and other auxiliary equipment

Fuel Efficiency of Ships in Service The final section addresses operational measures that can reduce fuel consumption. These include voyage performance management, hull and propeller condition management, optimum ship systems operation and overall energy efficiency management.

Overall ship operation and energy management: innovative solutions are expected for the monitoring, control and automation suitable to optimize the energy use on board permitting cost efficient operations in different vessel conditions. (IMO 2012 Resolution for Guidelines for Ship Efficiency Management Plan Marine Environment Protection Committee).

Benefits are as Follows

- To Reduce vibration in running gear
- To Prevent engine overheating (blocked intakes)
- To Reduce re-antifouling cost
- To Increase speed of your boat.
- To Early detection of any issues like Hull damages corrosion can be identified

II. METHODS AND MATERIAL

Theory

Methods for using a ship's propeller as a power absorption dynamometer employ the propeller as a measuring instrument to estimate either water speed or shaft power. The resulting propeller model can be used to detect hull fouling while comparing ship performance against a standard "clean-hull" baseline.Introduction Ship operators realize that hull fouling causes drag-related speed loss and increases fuel consumption when additional power is required to maintain service speeds. The wasted energy due fouling-related losses can be substantial but have historically been difficult to quantify, sinc changing ship and environmental conditions cause high variability in performance data. This is a method of separating out these effects and using a ship's propeller as a tool for early detection of hull fouling (Using a Ship's Propeller to Detect Hull Fouling – Logan)

The Power to Overcome Total Resistance is defined as

Equation 1

$P=C\ R_t\ V$

P = Power

C = Constant

Rt= Total Resistance

V = Speed Through water.

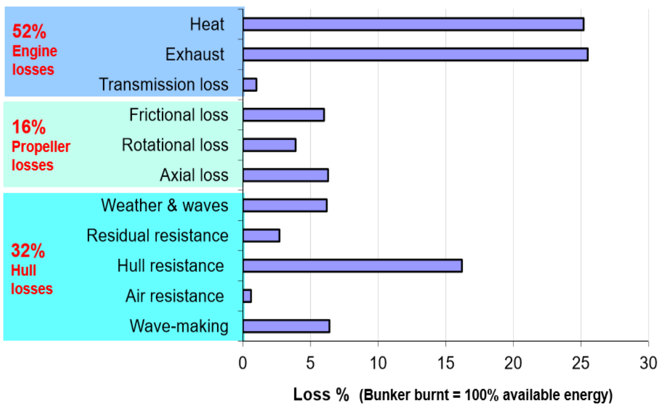

Figure 1. Typical Distribution of Energy Loss in Ships.

A ship's resistance To move a ship, it is first necessary to overcome resistance, i.e. the force working against its propulsion. The calculation of this resistance R plays a significant role in the selection of the correct propeller and in the subsequent choice of main engine (Logan -Using a Ship's Propeller to Detect Hull Fouling)

General A ship's resistance is particularly influenced by its speed, displacement, and hull form. The total resistance RT, consists of many source-resistances

Which can be divided into three main groups, viz.:

1) Frictional resistance 2) Residual resistance 3) Air resistance

The influence of frictional and residual resistances depends on how much of the hull is below the waterline, while the influence of air resistance depends on how much of the ship is above the waterline. In view of this, air resistance will have a certain effect on container ships which carry a large number of containers on the deck.

Ship performance monitoring traditionally has been a complex subject, requiring knowledge of naval architecture, marine engineering, mathematics, statistics, and more recently, computer science.. With the modern automation systems installed on today's vessels, these constraints have become less restrictive. High speed data acquisition, low-cost computers, and advanced database technology are now at the practitioner's disposal to eliminate past barriers to accurately measuring hull and propeller performance.

Methods for using a ship's propeller as a speed or power measuring device were established at least eighty years ago, but were not highly publicized. The unique characteristics of these methods are their simplicity, high accuracy, and their use of actual ship performance data, instead of scale models. The propeller model can be used to track speed loss and power /fuel increase over time using metrics that are easily understood by both ship crews and their management counterparts. Beyond this, propeller power absorption techniques can also be employed for optimizing other aspects of ship operational efficiency, such as quantifying draft, trim, and weather effects on fuel economy. In conclusion, rising fuel costs, hull maintenance expenses, and mounting environmental regulations make hull condition monitoring a cost-effective tool for prudent ship operators to eliminate energy waste due to hull fouling, reduce carbon emissions, eliminate the carriage of invasive species between ports, and impartially assess hull coating effectiveness.(Ship Design and Performance for master and mates –Dr C.B Barrass)

What is Hull Fouling /Bio – FOULING?

The Accumulation of Marine Growth on underside and sides of ships. Their types depends upon temperature and water quality .these are of types Shell, weed, Slime.

Shell Species such as barnacles and Mussels .weed such as seaweed and Brown weed. Slime caused by Accumulation of Algae.

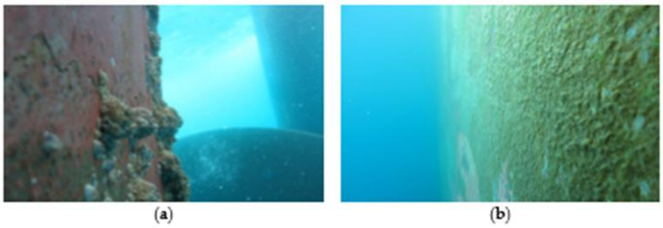

Figure 2. Bio Fouling on Ship Hull- in spite of fouling control coating under water hull cleaning is still required

Schultz, M.P.; Bendick, J.A.; Holm, E.R.; Hertel, W.M. Economic Impact of Biofouling on a Naval Surface Ship. Biofouling)

HOW DOES FOULING OCCUR?

- ✓ A natural phenomenon and occupational hazard to which all ships are susceptible but particularly in circumstances where ships remain idle/static in warm/tropical waters.
- ✓ The start of fouling is very dependent upon local conditions and fouling intensity variations over time.

- ✓ The combination of warm and shallow water is the most challenging and will generally cause fouling to attach sooner and grow faster.
- ✓ For stationary exposure when fouling normally is the biggest problem, periods of more than 10-14 days give a large increase in the risk of fouling.((Townsin, - "Estimating the Influence of Weather on Ship Performance)

WHY IS FOULING A PROBLEM?

- ✓ Fouling can affect a ship's hull, rudder, chests and propeller.
- ✓ Increases under water resistance to propulsion.
- ✓ Blocks main engine cooling intakes.
- ✓ Loss of speed by up to 10% as a result of reduced engine revolutions and high propeller slip.
- ✓ Increase in fuel consumption by up to 40%.
- ✓ Dry docking necessary to remove fouling, cleaning costs and loss of time.
- ✓ Consequential losses, for example during the ship's next employment.(M.P. Shultz, "Economic Impact of Biofouling on Naval Surface Ships," December 2010)

Summary & Conclusions Hull fouling can impact ship schedule, fuel expense, and, in severe cases, overload propulsion engines and increase their maintenance cost. A growing number of international environmental regulations have come into effect relating to greenhouse gas emissions and the carriage of aquatic invasive species on fouled ship hulls. More regulations are likely to come in the future.

All ship owners are aware of these factors. However; ship performance losses due to hull and propeller fouling are difficult to quantify as inputs to techno-economic models of optimal ship operations. Changing ship and environmental conditions cause performance variations that make the separation of hull and propeller effects a difficult task. From a business standpoint, prevention of marine growth through the use of an effective anti-fouling paint is an obvious choice, but selecting the best paint for a given ship's operating profile is not so obvious. Almost all paint companies promote similar fuel savings with their products.

III. RESEARCH METHODOLOGY

Hull cleaning machines :

There are different cleaning machine with different size and capacity, some general used cleaning machine specification is as below

Equipment used are Surface Supplied Diving Equipment with CCTV Hydraulic grinders and brush. Hydraulic Power pack .Digital Camera.The hull cleaning system is proven and used worldwide for several years.

The stable and proven system has been modified with the technology that is used today as as environmental protective hull cleaning of shipsThe cleaning machine releases the fouling from the ship hull so that the cleaned fouling is collected in a very simple and safe processThe cleaned material is transported from the cleaning machine through a very unique filter system, specially developed to filter the cleaned fouling, so the entire hull cleaning process will be conducted completely environmentally neutral As the hull cleaning system is very simple and the diver has physical contact with the machine, the reliability and cleaning speed are very high.

Hydraulic Power Pack
Basic model:
This machine can be used for all our standard brushes. The machine has a maximum cleaning width of 85 cm. and a cleaning speed of 20 m² per minute.

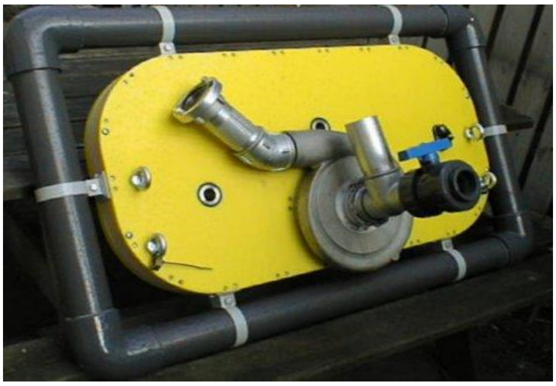

Figure 3. Hydraulic Power Pack Machine

Data:
Works at 10 bar water pressure. Can run with less pressure at slightly fouling. Optimum water flow of 1000 l/min.Weight above water: 40 kg. Weight in water: slightly positive. Length 110 cm. Width 70 cm. Couplings 2".
This machine works like a vacuum cleaner or hoover and collects all removed materials. It is used in ports for light and medium fouling.

Figure 4. Medium Fouling Cleaning Machine

Data:
The machine has a maximum cleaning width of 85cm.Cleaning speed is 15 m² per minute. Best at 10 bar water pressure. Optimum water flow 1000 l / min Weight above water: 55 kg.Weight in water: Slightly positive .Length: 113 cm.Width: 97 cm.Coupling 2 "

HighFouling:
This machine is built for very strong fouling. It can perform cleaning up to 15 cm. with extra sharp knife brushes.

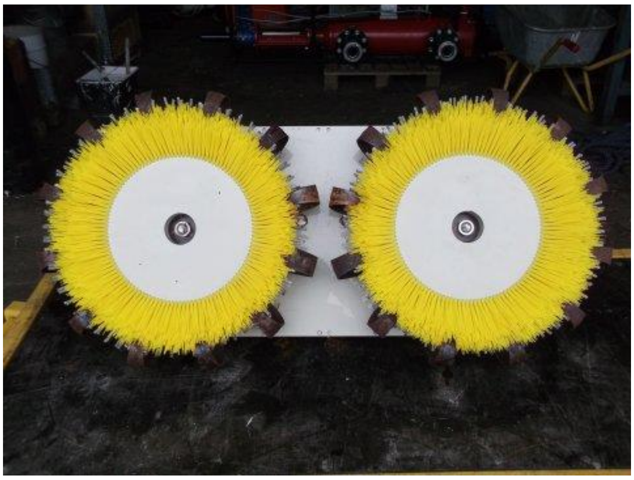

Figure 5. high Fouling Cleaning Brushes

Data: The cleaning speed is after the nature of the fouling. The Machine has a maximum cleaning width of 105 cm. Best at 10 to 12 bar water pressure. Optimum water flow 1000 to 1200 l/minWeight above water: 50 kg.Weight in water: Negative weight Length: 110 cm.Width: 70 cm. Coupling 2"

Filter System:

This filter system is unique due to the fact that it can be used for hull cleaning of all types of paint. The inserts of the filter are replaceable depending of the paint and the nature of the fouling. For the inserts of the filter quality and approval certificate are included.

IV. Case Study

Below is Result of Fuel Consumption in oil tanker Ship, Data was analyzed over long period and different voyages in Both Laden and Ballast condition .

Various Areas in observation before Hull Cleaning Operation.
As The propeller was moderately covered with approximately 70% slime and 90% calcium deposits.

After polishing to Rubert's scale Grade "A", the propeller was found in good general condition. The boss cap assembly was complete. No obvious hydrodynamic defects were observed.

Figure 6. Before and after Cleaning Photo of Propeller Boss Cap.

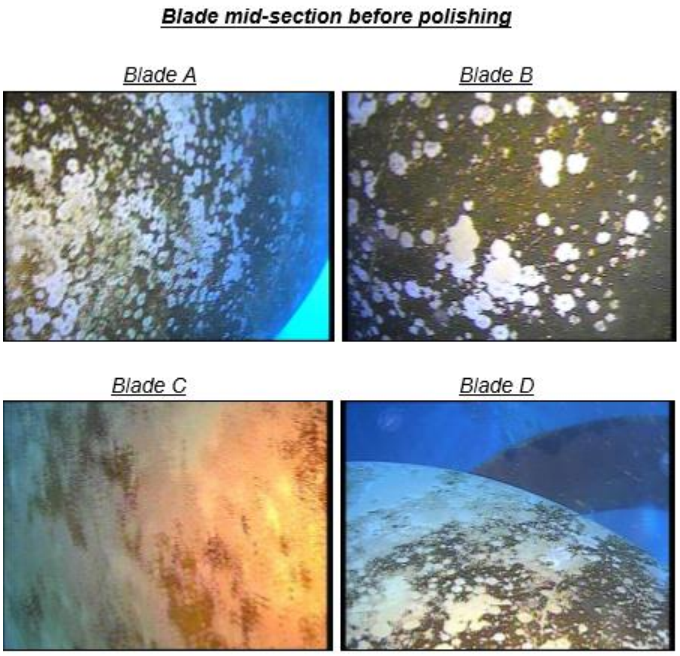

Figure 7. Before Cleaning Photo of Propeller Blades.

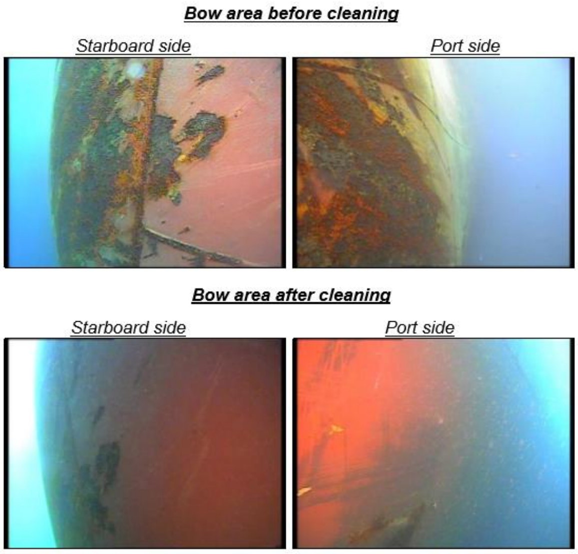

Figure 8. Port and Starboard Side before and after cleaning Photo.

Case study of Effect of Hull Cleaning on Fuel Consumption

Below table is Fuel Consumed by vessel at 13 Knots before Hull Cleaning

Table 1. Fuel Consumption before Hull Cleaning in Ballast and Laden Condition.

VOYAGE				SIGNIFICANT PERFORMANCE								
REF	PORT LIST	POOL SPD	ORD SPD	MILES	TIME	SPEED	CURRENT	GW SPD	ME	AUX	OTHER	ME
Ballast		**Kts**	**kts**	**nm**		**kts**	**kts**		**Total**	**Total**	**Total**	**Day**
35	ANTWERP-murmansk	13	13.0	1624	124.6	13.03	0.27	12.77	74.50	16.80	0.00	14.35
36	ANTWERP-FLUSHING	13	13.0									
36	FLUSHING-murmansk	13	12.4									
37	ROTTERDAM-SOUND	13	13.0	557	42.2	13.20	-0.21	13.41	27.80	5.10	0.00	15.81
37	SOUND-ST PETERSBURG	13	13.0	686	52.7	13.02	0.05	12.97	31.70	5.30	0.00	14.44
38	ANTWERP-ANTWERP	13										
38	ANTWERP-SOUND	13	13.0	584	46.1	12.67	0.08	12.59	30.10	5.10	0.00	15.67

38	SOUND-ST PETERSBURG	13	13.0	664	50.0	13.28	-0.06	13.34	36.60	5.50	0.00	17.57
Ballast		13		4115	315.6	13.04	0.09	12.95	200.70	37.80	0.00	**15.26**

Laden		**Kts**	**kts**	**nm**		**kts**	**kts**		**Total**	**Total**	**Total**	**Day**
34	PORT GENTIL-At Sea	13	13.0	1827	142.1	12.86	-0.17	13.03	100.80	18.00	0.00	17.02
34	At Sea-ROTTERDAM	13	13.0	1985	159.7	12.43	0.01	12.42	114.60	19.90	0.00	17.22
35	Murmansk-BORSELE	13	13.0	1703	132.9	12.81	-0.21	13.03	101.80	16.80	0.00	18.38
36	Murmansk-ROTTERDAM	13	13.0	1405	109.8	12.80	-0.09	12.89	86.00	12.20	0.00	18.80
37	ST PETERSBURG-GREAT BELT	13	13.0	690	52.7	13.09	-0.03	13.12	43.60	6.00	0.00	19.86
37	GREAT BELT-ANTWERP	13	13.0	599	46.6	12.85	-0.14	12.99	39.80	5.50	0.00	20.50
38	ST PETERSBURG-GREAT BELT	13	13.0	691	52.6	13.14	0.04	13.09	41.60	5.80	0.00	18.98
38	GREAT BELT-ROTTERDAM	13	13.0	585	45.4	12.89	0.03	12.85	37.00	5.10	0.00	19.56
39	GOTHENBURG-LAVRION	13	13.0	3169	246.5	12.86	0.24	12.62	168.00	28.30	0.00	16.36
40	TUAPSE-ODESSA	13	13.0	411	32.1	12.80	0.23	12.57	21.50	3.90	0.00	16.07
40	DARDANELLES STRAITS-MALTA	13	13.0	686	54.5	12.59	0.10	12.49	38.50	7.30	0.00	16.95
41	TARANTO-ALGECIRAS	13	13.0	1288	99.6	12.93	-0.02	12.95	66.80	14.60	0.00	16.10
Laden		13		15039	1174.5	12.81	0.00	12.80	860.00	143.40	0.00	17.57

Table 2. Fuel Consumption after Hull Cleaning in Ballast and Laden Condition

VOYAGE				SIGNIFICANT PERFORMANCE								
REF	PORT LIST	POOL SPD	ORD SPD	MILES	TIME	SPEED	CURRENT	GW SPD	ME	AUX	OTHER	ME
Ballast		**kts**	**kts**	**nm**		**kts**	**kts**		**Total**	**Total**	**Total**	**Day**
42	TANGER MED-HUELVA	13	13									
43	BARCELONA-LAVERA	13	12.4									
46	ROTTERDAM-SOUND	13	13	556	43.3	12.84	0.25	12.59	23.00	4.90	0.00	12.75
46	SOUND-UST-LUGA	13	13									
Ballast		13		556	43.3	12.84	0.25	12.59	23.00	4.90	0.00	12.75

Laden		**kts**	**kts**	**nm**		**kts**	**kts**		**Total**	**Total**	**Total**	**Day**
41	ALGECIRAS-TANGER MED	13	13									
42	HUELVA-BARCELONA	13	13	640	49.2	13.01	-0.03	13.04	31.20	7.00	0.00	15.22
43	LAVERA-ROTTERDAM	13	13.5	320	24.0	13.33	-0.11	13.44	16.90	3.00	0.00	16.90
46	UST-LUGA-GREAT BELT	13	13	672	52.5	12.80	0.01	12.79	34.10	6.40	0.00	15.59
46	GREAT BELT-IMMINGHAM	13	13									
Laden		13		1632	125.7	12.98	-0.03	13.01	82.20	16.40	0.00	15.69

Shows fuel consumption data Analyzed and study of Fuel consumption in before and After Hull cleaning both in Ballast and Laden Condition for vessel.

Table -SUMMARY The analysis for vessel shows. The average consumption of the class @normalized speed of 13.0 knots

There is significant amount of Drop in per Day Fuel Consumption in Main Engine

Table 3. Fuel Saving Before and After Hull Cleaning

	Ballast Condition – Ton per day	Laden Condition-Ton per day
Before Hull Cleaning	15.26	17.57
After Hull Cleaning	12.75	15.69

The results are substantial enough to suggest that taking continuous action to remedial hull and propeller issues across a full sailing cycle is more beneficial than allowing gradual deterioration to set in, only to be rectified at the end of that 4 to 5 year cycle.

Typically, the deterioration that occurs in hull and propeller performance between dry-dockings is mainly the result of biological fouling and mechanical damage. Regular hull cleaning and propeller polishing can assist in negating these effects between dry dockings.

As per Result Fuel Saving per Day after Hull Cleaning is around 1.88 Ton per Day. And Ship Fuel Cost which is known as Bunker is Calculated in Base Currency of USD and Various Prices Based on Port and Market. At Major Port Cost is Around 300 USD Per Ton of Bunker Port Includes (Rotterdam, Fujairah, Singapore) Thus Cost Saving Per Day is Around 600 Usd for Fuel Saving and Hull Cleaning Operation which also Depends on Port and Based Currency for Operation is in usd cost will be around 8000 usd . Thus Cost of operation will be recovered in first 15 days of fuel saving.

V. CONCLUSION

Hull cleaning intervals.The optimum interval between the periodic cleanings and inspections that comprise a preventive maintenance program will vary with the type of vessel, the location of the vessel, and its service profile (speed of operation, idle time, etc.). The type and condition of bottom coatings will also have an effect on the cleaning interval. Large vessels typically have several layers of coatings, up to 6 millimeters thick, and generally operate 4 to 6 months between hull cleanings. The location of the vessel also has a substantial influence on the rate of fouling since marine organisms flourish in warm tropical waters. The U.S. Navy has established geographic fouling zones, indicating the frequency with which the hull and unpainted surfaces (propellers, rudders, and sonar domes) should be cleaned for vessels operating within each geographic zone. Propeller cleaning is recommended up to six times a year and hull cleaning is recommended up to three times a year.

VI. REFERENCES

[1]. Fathom Ship Efficiency: The Guide, 2011.

[2]. SNAME Symposium on Climate Change and Ships.

[3]. IMO 2012 Resolution for Guidelines for Ship Efficiency Management Plan Marine Environment Protection Committee

[4]. Ship's Propeller to Detect Hull Fouling –Logan

[5]. Schultz, M.P.; Bendick, J.A.; Holm, E.R.; Hertel, W.M. Economic Impact of Biofouling on a Naval Surface Ship. Biofouling

[6]. Townsin, - "Estimating the Influence of Weather on Ship Performance.

[7]. M.P. Shultz, "Economic Impact of Biofouling on Naval Surface Ships," December 2010