ISF Institute of Research and Education (IIRE)

IIRE JOURNAL of MARITIME RESEARCH and DEVELOPMENT (IJMRD)

Volume 5 Issue 1

April 2021

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ISSN: 2456-7035

Published by:

ISF INSTITUTE OF RESEARCH AND EDUCATION (IIRE)
410, Gemstar Commercial Complex, Ramchandra Lane Ext, Kachpada,
Off Link Road, Malad West, Mumbai 400 064, India.
Website: www.iire.in, www.inner-search.org, www.isfgroup.in

Link of Publication: - https://ojsiire.com/index.php/IJMRD
Place of Publication: - Mumbai

IIRE Journal of Maritime Research and Development

Maritime sector has always been influencing the global economy. Shipping facilitates the bulk transportation of raw material, oil and gas products, food and manufactured goods across international borders. Shipping is truly global in nature and it can easily be said that without shipping, the intercontinental trade of commodities would come to a standstill.

Recognizing the importance of research in various aspects of maritime and logistic sector, IIRE through its Journal of Maritime Research and Development (IJMRD) encourages research work and provides a platform for publication of articles, manuscripts, technical notes, papers, *etc.* on a wide range of relevant topics listed below:

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Editorial Board

From the Editor's Desk…

The shipping industry is driven by compliance culture alone is a foregone conclusion, IMO is experimenting with some enriched model of regulatory compliance beyond the pure deterrence model of severity of sanctions as key determinants of compliance. Integrating economic theory with theories from psychology and sociology to account for both tangible and intangible motivations influencing individuals' decisions whether to comply with a given set of regulations is one such model. Specifically, the model accounts for moral obligation and social influence in addition to the conventional costs and revenues associated with illegal behavior, particularly given the awareness in the subjects of environment and safety today.

This issue of the journal largely dedicates to various facets of regulatory compliance. The paper 'Debunking Safety Myths' highlights the limitations of coercive enforcement and points out that what appears a matter of absolutes on the surface is in fact imperfect, convoluted, interpretive, and open to abuse.

Then there is the empirical study on the impact of new regulations on the seafarer who fear increased inspections, administrative burdens and sanctions and concludes that suitable awareness and training strategies are required to handle the change and prepare seafarers to cope with the anxiety and stress due to new regulations.

The role and design of systems that ensure environmental regulatory compliance in light of society's demand for policies that target a high level of environmental protection, public awareness and participation, and economic growth, is expressed in the paper on Ship Re-cycling industry in India that exudes the sincere implementation of Hong Kong Convention.

The proof of the pudding is encompassed in the paper on Light craft construction that details the concept design, fabrication and successful commissioning of cruise vessel designed to be operated in the backwaters of Kerala with much lighter design, higher payload capacity and economy of operations.

At the very core of the shipping industry lies the seafarer, who ensures the regulatory compliance. A very apt study on the supply and demand scenario of the seafarers themselves, in context to the global trade, forms the contents of the final well researched paper of this issue of the journal.

Dr. (Capt.) S. Bhardwaj

IIRE Journal of Maritime Research and Development

(IJMRD)

Volume 5 Issue 1, April 2021

NEW REGULATIONS – IMPACT OF IMPLEMENTATION OF SULPHUR 2020 REGULATION ON SEAFARERS

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Abstract

International Maritime Organization (IMO), through regulation 14.1.3 of MARPOL Annex VI, developed a standard with a cap of 0.5% m/m Sulphur content of fuel oil for use on board ships with an effective implementation date of 01 Jan 2020 to significantly strengthen the emission limit of Sulphur oxides. IMO developed guidelines for the consistent implementation to assist authorities, ship owners and operators. However, the actual implementation onboard ships would face multiple challenges due to additions of equipment, modifications to machinery, new procedures, and changes to existing practices. The study aimed to explore the nature of the problems foreseen by the seafarers prior to the implementation of the Sulphur 2020 regulation and to list out the problems that emerged post implementation. Detailed aspects of the regulation were discussed with industry experts. Seafarers were asked to rate the concerns due to foreseen problems prior implementation. Actual problems encountered post implementation were also listed and analyzed. It was found that Inspections, workload, paperwork, penalization, technical challenges like pipeline work, compatibility of fuel, fuel change over process and the necessary training were considered important concerns of the implementation. Department and seniority did not significantly cause any difference in the moderate to high level of concerns that the seafarers faced. Suitable awareness and training strategies are suggested to handle the change and prepare seafarers to cope with the anxiety and stress due to new regulations.

Keywords: Psychological factors; Seafarers; IMO; MARPOL; Sulphur Cap; Sulphur 2020; Seafarer's problems.

1. BACKGROUND:

International Maritime Organization (IMO), under the objective to control the harmful impact of shipping on the environment, develops regulations and guidelines to reduce pollution from ships through "International Convention for Prevention of Marine Pollution from Ships (MARPOL)". After a series of studies and discussions, MARPOL Annex VI, which limits the main air pollutants contained in the ships exhaust gas, was modified through regulation, 14.1.3, reducing the limit of Sulphur oxide emissions from ships. This new regulation, hereinafter called "Sulphur 2020", sets a limit of Sulphur content in the fuel not to exceed 0.50% m/m. It was agreed that 01 Jan 2020 as the effective date of implementation.

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There have been continuous changes in the regulations limiting the Sulphur content (Sulphur Cap) in the fuel. Sulphur cap is 0.1% m/m when the ships are trading near the coasts of European Union and United States of America, commonly known as Sulphur Emission Control Areas and 0.5% m/m in coastal waters of China including Hong Kong. Sulphur cap was however set at 3.5% globally, in rest of the areas. The new regulation brought down the Sulphur cap to 0.5% m/m globally from 01 Jan 2020. As a results ships had to make necessary modifications or changes to comply with the regulation. The three most common approaches to the compliance have been (1) cleaning all the fuel tanks and commence using of compliant fuel with Sulphur level below 0.5% m/m (VLSFO or LSMGO), or (2) installation of exhaust gas cleaning systems, commonly known as "scrubbers" that would clean the exhaust gas and reduce the Sulphur emission to within the stipulated level or (3) usage of alternate fuel system such as LNG to comply with the emission requirement.

When such new regulations are implemented, even though the procedures and the guidelines are well defined, the seafarers would have to undergo a process that is different from their routine and would need to integrate themselves to new procedure. They may have doubts about challenges faced during implementation and subsequent consequences of non-compliance. This situation would likely create uncertainties leading to anxiety and stress.

2. INTRODUCTION:

Increased environmental awareness is one of the social trending that forces to stimulate changes by means of new regulations. (Robins, SP, Judge T.A, Vohra N, Organizational Behavior, 2012,). In order to effectively implement the change, extensive guidelines were developed by International Environmental Protection Committee (IEPC) of IMO, Flag States, and other industry bodies such as Classification Societies, OCIMF, INTERTANKO, etc. for the consistent shipboard implementation plans. (MEPC.1/Cir 878, IMO, Guidance on the Development of Ship Implementation Plan for the Consistent Implementation of 0.5% Sulphur Limit under MARPOL Annex VI, 2018)

The said guidelines covered various factors including risk assessment, mitigation plan, modifications of tanks and cleaning of tanks, segregation capability, procurement of compliant fuel, change over plan, impact on the machinery system, related

documentation, and reporting. However, varied levels of difficulties were foreseen prior to the implementation such as possible challenges in availability of compliant fuel, uncertainty about the effectiveness of available scrubber models, lack availability of shipyards to carry out the modification as necessary and the possible fines by authorities for non-compliance.

Any societal and technological change is one of the extra organizational stressors for the people of an organization. (Luthens, 2011). Uncertainty about the possible future threat disturbs the ability to cope and results in anxiety. (Grupe & Nitschke 2013). Whenever there is an external or internal demand, there is an internal stress due to uncertainties in the situation (Huffman, 2004). To cope with this stress, it is essential for the seafarer to become well adapted to the expectations.

The earlier new regulations such as Maritime Labour Conventions, (2006), and lifeboat design modifications had brought similar stresses amongst the seafarers. In order to upgrade the safety of the vessels where open lifeboats were used, IMO, through SOLAS (International convention of Safety of Life at Sea), implemented regulations to have fully enclosed lifeboats and arrangements of hooks that could facilitate the boats being released with all ship complement inside the boat without any external assistance. However, the hook mechanism caused many accidents, and it has been widely believed that lifeboats that were meant to save lives have killed many. Even though many modifications were brought in for safety, there are still cases where the seafarers get injured or killed due to the failure of the hook mechanism. (Mora T, et all, 2010)

While in a larger perspective, every individual is appreciative of the new regulation (Sulphur 2020) and the importance of environmental impact, the overall implementation models did not adequately identify stressors encountered by the seafarers who are at the sharp end of the implementation.

3. NEED OF THE STUDY:

The implementation of the Sulphur 2020 has brought about many unique challenges. Several administrations announced severe fines and punishments for non-compliance with the new regulation. Imprisonment for 2 years and heavy fines for captains and ship owners who do not comply with the requirement was announced by Singapore

Government. Many countries have not agreed to use of open loop scrubbers within their coastal waters. All these collectively could create extra stress and anxiety amongst the seafarers, managers, operators, and ship owners.

However, irrespective of the actual reason for the non-compliance, the brunt is borne by the seafarers. Therefore, studies are needed to understand the concerns of the seafarers so that the industry stakeholders can develop appropriate designs to mitigate such stresses and formulate suitable awareness and training strategies.

4. AIM AND OBJECTIVE OF THE STUDY:

The aim of the study is to explore the nature of the problems foreseen by the seafarers prior to the implementation of the Sulphur 2020 regulation and to list out the problems that emerged post implementation.

Objective of the study is to

1) List out potential concerns that are perceived by the seafarers while complying with this new Sulphur 2020 regulation,
2) Identify areas of potential concerns as perceived by the seafarers across their rank and department.
3) Evaluate the problems encountered practically after implementation of Sulphur 2020 regulation.
4) Analyze the discrepancies and suggest possible solutions.

5. RESEARCH DESIGN:

This is an exploratory survey as “Sulphur 2020” is a new regulation and therefore the problems perceived and encountered would be novel in nature.

6. METHOD OF INVESTIGATION:

The research was conducted in three stages. First, a focused group interview was conducted with experts which was followed by a survey with the seafarers. Finally, a compilation of issues experienced by the seafarers, post implementation of Sulphur 2020 regulation was undertaken. The following measures were undertaken.

1) Research Scholar studied the relevant regulations and guidelines published by the IMO, attended workshops conducted by the scrubber manufacturers & industry bodies and consulted experts in the relevant area.
2) Focused group discussions with experts. Based on the discussion, the research scholar developed a questionnaire for the survey listing out the anticipated concerns the seafarers due to the new regulation.
3) The survey was conducted on the seafarers who were on leave and were about to join a ship within next few months.
4) Researcher collected the details of the incidents that happened in relation to the Sulphur 2020 after implementation (1st January 2020) till 15 November 2020.
5) Data were analyzed statistically, and the findings were interpreted.

7. SAMPLES:

The sample consists of seafarers, sailing on cargo ships that trade worldwide. The main categories of seafarers on a ship are Navigating (Deck) officers, Engineering officers, deck ratings, engine ratings, and catering ratings. For the present study, the personnel affected would be only Engineering officers and Navigating officers. Hence, they are included for the study. The sample consists of 148 seafarers. Mean age of the sample was 35 years with average sailing experience of 12 years. The distribution is explained in table 1.

Table 1- Sample distribution

Details	**Engine Officers**	**Navigation / Deck Officers**	**Total**
Senior Officers	42	39	81
Junior Officers	25	42	67
Total	67	81	148

8. TOOLS USED FOR THE STUDY:

1. Sulphur 2020 – Concern of Seafarers Survey questionnaire

A focus group interview was carried out with ten senior office superintendents who are well versed with the regulations, experts in fuels, engines, installation of machineries, and understanding practical aspects in the implementation of new regulations including pros and cons of that system.

This information was sought by simple direct questions which were made as the part of the interview. While there are multiple ways to implement the regulation, there are only two popular models, either installing a scrubber onboard which would clean the exhaust gas to reduce the emission or, alternately using compliant fuels such as Very Low Sulphur Fuel oil or Low Sulphur Marine Gas oil. This study is addressing only above two models.

The interview with superintendent consisted of one close-ended question and an open-ended question.

1) Considering a ten-year-old vessel, which is the best method for implementing the new regulation – Scrubber installation or using compliant fuel?
2) What are the major challenges you fore see in both above approaches?

These interviews revealed potential concerns that may be perceived by the seafarers due to new regulation "Sulphur 2020".

The following were identified that have the potential to cause anxiety and stress to seafarers.

1) Extra Workload.
2) Physical and mental fatigue.
3) Work related incidents.
4) Penalization / Criminalization due to non-compliance.
5) Additional procedures and paperwork.
6) Neglect of other machinery.
7) Approach by various Port State control authorities.
8) Level of training provided by the companies.

Additionally, following were considered as the conditions having potential to cause anxiety and stress when using new scrubber installations for compliance,

1) Hazard inside Engine Room due to additional sea water pipes.
2) Hazard due to passing of scrubbed water pipelines in Engine Room.
3) Machinery related problem within scrubber operations.

Following were considered as additional conditions having potential to cause anxiety and stress when compliance fuel usage is considered for compliance.

1) Increase in machinery issues due to compliant fuel.
2) Fear of punishment when using compliant fuel (especially if fuel was found to be higher in Sulphur content).
3) Compatibility issue of the fuel.
4) Additional challenges during fuel change over procedures.

A questionnaire was formulated using the inputs from the focused group interview. It consisted of a brief introduction of the regulation followed by relevant demographic details. Eleven statements of concerns were raised under scrubber installation as the mode of compliance. Twelve statements under the usage of compliant fuel as the mode of compliance. The statements were to be answered using a Likert scale ranging from 1-10 where 1 being the low and 10 being the high.

Additionally, to understand how the seafarers are prepared to handle the stress and anxiety, seven more questions were asked, which were as follows.

1) Do you think you are fully prepared to handle the new regulation without any issue? – (Yes/No)
2) Please advise your anxiety level due to new regulation (rate a number 1-10, both inclusive, 1 being the lowest)
3) Please advise your stress you are undergoing due to new regulation (rate a number 1-10, both inclusive 1 being the lowest)
4) How do intend to handle the additional pressure due to new regulation
    a. Gain More knowledge by attending seminar.
    b. Read more materials.
    c. Avoid joining vessel until the situation is settled.
    d. Face the challenge as it is without any preparation.
5) Any other feedback – an open-ended question
6) Willingness to share contact details.
7) If yes, then details of e mail and telephone number.

Content validity was established for the final form after showing to experts.

2. Data collected post implementation of the Sulphur 2020 Regulation.

Post implementation data was collected from a fleet of 221 vessels belonging to four companies. A list of issues faced was obtained following the implementation of Sulphur 2020 for a period from 01 Jan 2020 to 15 November 2020. This was analyzed and reviewed against the results obtained prior to the implementation.

9. PROCEDURES:

Final questionnaire was given as a hard copy to the seafarers who were visiting the organizations for training programs. The filled in forms were transferred to a digital code using Microsoft excel. The data was statistically analyzed.

10. ANALYSIS OF DATA:

The data was analyzed using SPSS version 26. Descriptive and inferential statistical analysis were carried out and inferred. Percentages, Means, and Standard Deviations were calculated for the responses, the "t" test values of the groups were calculated to see the differences based on their seniority and department.

11. RESULTS:

Results based on the statistical analysis are presented as follows:

Table 2: Overall Mean Scores of scrubber related and compliant fuel related problems perceived

S. No	Item	Mean (SD)	Skewness	Kurtosis
1	Overall Scrubber (N=148)	6.43 (1.61)	-0.717	0.024
2	Overall Compliant Fuel (N=148)	5.15 (1.91)	-0.174	-0.928

The table number 2 shows the descriptive statistical values. The mean score for overall scrubber related problems is 6.43 which falls in the second quartile. It means that the seafarers experience moderate amount of stress.

The overall mean score of compliant fuel related problems is 5.15 which falls in the 2nd quartile. It means that the seafarers experience moderate amount stress. The skewness and kurtosis scores for both fall within the normally distributed range indicating the homogeneity of the data.

Table 3: Item wise mean scores and comparisons of sub-groups for scrubber related questions

S. No	Statement – Scrubber related	Overall	Department			Seniority		
		(N=148)	Engine (n=67)	Deck (n=81)	t-score	Seniors (n=81)	Juniors (n=67)	t-score
		Mean (SD)	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
1	Extra workload for ship staff	6.84 (1.96)	6.76 (1.95)	6.90 (1.97)	0.43	7.00 (2.03)	6.64 (1.86)	1.11
2	Fatigue related problems	6.10 (2.21)	5.78 (2.07)	6.41 (2.29)	1.17	6.21 (2.32)	6.01 (2.09)	0.53
3	Work related incidents	6.19 (2.20)	6.21 (2.02)	6.17 (2.35)	0.10	6.42 (2.24)	5.91 (2.13)	1.41
4	Additional Paperwork	6.87 (2.00)	6.52 (1.96)	7.16 (1.99)	1.95	6.93 (2.08)	6.81 (1.90)	0.36
5	Penalization / Criminalization	6.51 (2.59)	6.67 (2.29)	6.37 (2.83)	0.72	6.78 (2.56)	6.18 (2.62)	1.40
6	Neglect of other machinery issues	5.86 (2.41)	5.64 (2.38)	6.05 (2.44)	1.02	6.17 (2.46)	5.49 (2.32)	1.71
7	Additional Hazard due to Pipeline Passing through Engine Room	6.34 (2.27)	6.33 (2.46)	6.36 (2.12)	0.08	6.89 (2.20)	5.69 (2.20)	3.31 *
8	Additional hazard due to scrubbed water pass through Engine Room	6.28 (2.18)	6.33 (2.46)	6.24 (2.13)	0.26	6.64 (2.20)	5.84 (2.09)	2.27 *
9	Machinery problems in scrubber operations	6.41 (1.99)	6.28 (2.17)	6.51 (1.84)	0.68	6.73 (2.02)	6.01 (1.89)	2.20 *
10	Anxiety due to PSC approach	7.14 (2.09)	6.88 (2.09)	7.35 (2.08)	1.35	7.27 (2.09)	6.97 (2.10)	0.87

11	Level of training provided as of now	6.22 (2.18)	6.10 (2.24)	6.32 (2.13)	0.60	5.72 (2.34)	6.84 (1.80)	3.21*
	Overall mean score	**6.43 (1.61)**	**6.31 (1.62)**	**6.53 (1.60)**	**0.79**	**6.13 (1.65)**	**6.22 (1.54)**	**0.72**

*p<0.05, significant at 95% confidence interval

Table 4: Item wise mean scores and comparisons of sub-groups for compliant fuel related questions

S. No	**Statement – Compliant Fuel Related**	**Overall**	**Department**			**Seniority**		
		(N=148)	Engine (n=67)	Deck (n=81)	t-score	Seniors (n=81)	Juniors (n=67)	t-score
		Mean (SD)	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
1	Extra workload for ship staff	4.98 (2.43)	4.76 (2.39)	5.16 (2.45)	1.00	4.98 (2.35)	4.99 (2.54)	0.02
2	Fatigue related problems	4.50 (2.35)	4.34 (2.35)	4.63 (2.37)	0.74	4.49 (2.26)	4.51 (2.48)	0.04
3	Work related incidents	4.44 (2.19)	4.39 (2.19)	4.48(2.19)	0.26	4.41 (2.15)	4.48 (2.25)	0.19
4	Additional Paperwork	5.28 (2.33)	5.13 (2.30)	5.40 (2.36)	0.67	5.04 (2.42)	5.57 (2.21)	1.38
5	Penalization / Criminalization	5.07 (2.72)	5.06 (2.68)	5.07 (2.76)	0.03	5.14 (2.85)	4.99 (2.57)	0.34
6	Neglect of other machinery issues	4.01 (2.31)	3.85 (2.26)	4.14 (2.36)	0.75	3.85 (2.53)	4.19 (2.38)	0.90
7	Machinery problems due to new fuel	4.86 (2.47)	5.48 (2.64)	4.36 (2.20)	2.81*	5.02 (2.52)	4.67 (2.40)	0.87
8	Fear of punishment while complying compliant fuel	5.56 (2.76)	5.16 (2.67)	5.89 (2.80)	1.60	5.43 (2.83)	5.72 (2.68)	0.62
9	Anxiety due to PSC approach	5.72 (2.60)	5.51 (2.51)	5.89 (2.67)	0.89	5.57 (2.81)	5.90 (2.33)	0.76
10	Compatibility issues	5.79 (2.37)	5.66 (2.45)	5.90 (2.32)	0.62	5.89 (2.52)	5.67 (2.18)	0.55
11	Fuel change over procedures	5.68 (2.42)	5.25 (2.46)	6.04 (2.35)	1.98*	5.61 (2.60)	5.76 (2.22)	0.36
12	Level of training provided as of now	5.93 (2.35)	5.51 (2.46)	6.27 (2.22)	1.99*	5.42 (2.36)	6.54 (2.22)	2.95*

	Overall mean score	**5.15 (1.91)**	**5.01 (1.97)**	**5.27 (1.87)**	**0.49**	**5.07 (1.98)**	**5.25 (1.84)**	**0.56**

*p<0.05, significant at 95% confidence interval

The concerns foreseen by the seafarers for methods of implementation, viz, usage of scrubber or compliant fuel are listed in Table 3 and Table 4 respectively along with means scores and SD. The tables also contain the mean, SD, and t values for department and seniority comparisons. Since a 10-point scale was used for the study, score of around 5 indicate a moderate level of concern.

The overall mean score for scrubber related concerns is 6.44 which is above the moderate level. Mean scores for individual concerns range from 5.86 to 7.14 for scrubber related issues. This indicates that a moderate to high level of concern was foreseen. When the scores were compared department wise, there was no significant difference in the individual item or in the overall mean scores. However, when the scores were compared based on seniority, significant differences were observed for three concerns. Seniors perceived higher concerns for the additional hazard due to pipeline passing through engine rooms (t=3.31), additional hazard due to scrubbed water passing through engine room (t= 2.27), and machinery problems in scrubber operations (t = 2.20). The juniors felt more concerns regarding the level of training provided (t=3.21). This can be attributed to the higher level of knowledge, exposure, and experience of the seniors, whereas juniors are yet to get the necessary competency and training.

The overall mean score for compliant fuel related concerns is 5.15 which is at a moderate level. Mean scores for individual concerns range from 4.01 to 5.93. This shows that a below-average to average level of concern was foreseen. When compared department wise, there were three concerns which differed significantly. Deck department perceived higher level of concerns for the fuel change over procedures (t=1.98) and the level of training provided (1.99). Engineers foresaw more concerns than the deck department due to the machinery problems arising due to usage of complaint fuel(t=2.83). The contradicting finding where the deck department experiences high concerns could be due to the fear of unknown or anticipatory stress. Seniority wise juniors felt more concerned about the level of the training being provided (t=2.95). This again could be due to the knowledge gap between the seniors and juniors.

Concerns foreseen due to scrubber related issues are more than the concerns foreseen by the usage of compliant fuel.

The concerns foreseen by the seafarers in descending order due scrubber related issues are Anxiety due to approach taken by PSC authorities (7.14), Additional paperwork (6.87), Extra workload for the ship staff (6.84), Penalization / criminalization (6.51), Machinery problems in scrubber operations (6.41), Additional hazard due to pipelines passing through (6.34), Additional training due to scrubbed water pipe line passing through (6.28), Level of training provided as of then (6.22), work related incidents (6.19), Fatigue related problems (6.10) and neglect of other machinery issues (5.86).

The concerns foreseen by the seafarers in descending order due to compliant related issues are level of training provided (5.92), Compatibility issues of the fuel (5.79), Anxiety due to PSC approach (5.72), Fuel change over procedures (5.68), Fear of punishment (5.56), Penalization and criminalization (5.07), Extra workload (4.98), Fatigue related problems (4.50), Work related incidents (4.44), Neglect of other machinery issues (4.01)

Department and seniority did not significantly influence contribute to the order of concerns.

Table 5: Mean and SD for the responses on the items of self-reported level of anxiety and stress perceived

S. No	**Additional questions (AQ2) on Self perceived Anxiety**	**Overall**	**Department**			**Seniority**		
		(N=139)	Engine (n=60)	Deck (n=79)		Seniors (n=77)	Juniors (n=62)	
		Mean (SD)	Mean (SD)	Mean (SD)	t-score	Mean (SD)	Mean (SD)	t-score
1	Self-perceived Anxiety due to new regulations	5.87 (2.05)	5.72 (2.08)	5.99 (2.03	0.77	5.77 (2.26)	6.00 (1.76)	0.66
2	Self-perceived Stress due to new regulations	5.36 (2.16)	5.15 (2.11)	5.53 (2.2)	1.01	5.45 (2.20)	5.25 (2.12)	0.56

Review of subjective rating and findings based on the responses of preparedness to handle the new regulation, perceived anxiety & stress because of new regulations and suggested management methods. Of the 138 participants who chose to answer, 89 participants replied in affirmative for their preparedness to handle the new regulation.

A total of 139 responses were received for self- reported anxiety and stress which was on a scale of 1 to 10. The self-perceived anxiety scale was marked at a mean value of 5.87 and self-reported stress perceived at 5.36. It was also noted that both departments experienced stress and anxiety at similar levels. The scores did not differ significantly at seniority levels too.

When probed into methods to manage the perceived anxiety and stress, of the 135 who chose to answer, 133 participants indicated to follow either or more of the proposed methods of attending seminar, reading related materials, and gaining knowledge. Only one candidate preferred to directly face the challenge as it as and another candidate chose to not to join the ship until the new regulation issues settle.

12. REVIEW OF INCIDENTS THAT HAPPENED POST IMPLEMENTATION ONBOARD THE SHIPS:

After implementation of the regulation in 01 Jan 2020, the incidents that happened were followed in four organizations which were managing about 221 vessels. Out of the 221 vessels, 59 were fitted with scrubber installation to comply with the regulation. Remaining 162 vessels carried out fuel change over procedures and started using compliant fuel.

From 01 Jan 2020, until 15 November 2020, there were about 45 issues reported in relation to the new regulation. Of these, 34 issues were related to scrubber and 11 were related to use of compliant fuel.

Of the 59 vessels where scrubber was fitted as the means of compliance, 34 issues were reported. This can be categorized as follows:

1) Malfunction of scrubber equipment – 21
2) Leakage from the scrubbed water system – 6
3) Leakage from the seawater pipelines for scrubber – 4
4) Possible penalization due to potential non-compliance – 1 and
5) Work related incidents related to scrubber fittings – 2.

Issues reported on the scrubber usage was reviewed against the initial risk assessment to identify the gaps. In one of the vessels, there was a minor fire incident while the installation of scrubber was in progress without any injury to the personnel.

Of the 162 vessels where, compliant fuel was used as the mode of compliance to the regulation, 11 incidents were reported. The categories as follows:

1) Fuel compatibility issues – 3
2) Issues on machinery due to compliant fuel – 6
3) Work related incidents – 2.

These incidents were also reviewed against the risk assessment that was prepared prior to the implementation. This was to identify the gaps in identification of hazard, estimated risk and effectiveness of the control measure against the conditions at which incidents occurred at the later stage. For those ships where supply of compliant fuel was planned, management of cleaning of tanks with high Sulphur fuel posed big challenge. The ship crew were not familiar and not having enough equipment and machinery onboard to manage the large volume of sludge from the old fuel which had to be landed ashore. In one of the ships, while landing the sludge using containment boxes, an incident occurred during crane handling, causing minor spill on the jetty which resulted in fine.

13. FINDINGS AND DISCUSSION:

The mean scores of the responses indicated that certain conditions caused more anxiety and stress than others.

Scrubber installation as the means of compliance had higher concerns as compared to the usage compliant fuel. Scrubber installation on the board the ships for cleaning the exhaust gas is a major project involving high cost. The scrubber installation would need large volume of space in the engine room and funnel deck areas. There would be pipelines carrying sea water from sea chest and pumped up to the upper most deck on the ships. Additionally, the water that scrubbed the exhaust gas would be acidic. The treated water would pass down from higher decks to bottom part of engine room through pipelines. Leakages from these pipes could cause flooding and injury to the seafarer working in the vicinity.

The usage of Compliant fuel, on the other hand, does not require major modification or installation of machinery. It requires extensive cleaning of fuel oil tanks that presently carry high Sulphur. The ships are built mostly with machinery designed for running in high Sulphur fuel. Whereas compliant fuel would have varied lubricity and different composition compared to the regular high Sulphur Fuel. Machinery manufacturers and experts suggested adding of chemicals to the compliant fuel, changes to the operational setting of the machinery and modifications to the regular maintenance schedule to address the potential issues in the usage of such fuel.

The highest concern expressed was the anxiousness created due to the **approach by port authorities** who would verify the compliance. The regulations are verified for compliance by flag state authorities and classification societies prior issue of certificates and during periodical inspections. The port State Authorities of the country where the vessel calls, carry out inspections of the vessels, issue findings and may impose fines and / or detain the vessels for serious non-compliances. These inspection findings have commercial implications and are widely used as benchmarking amongst ship managers. It is a continuous stress for the seafarers to perform consistently well in port State inspections. In April 2019, Singapore government announced a punishment up to 2 years of imprisonment and fine for the masters and ship owners of the vessels who do not comply with Sulphur 2020 regulations. Such announcements, history of earlier punishments, and experience of own-self or their colleagues on similar issues can cause serious concerns for the seafarers.

Workload and paperwork increase with every new regulation. Implementation of Sulphur 2020 too has many addition workloads without being effectively compensated with additional resource.

Level of training provided was the highest concern in the compliant fuel related issues, as there were many publications and circulars being released by different manufacturers of the machinery. Failure to understand or interpret these properly might result in breakdown of machineries when using the compliant fuel.

Fatigue related problems and Neglect of other machineries were the least expressed cause of concerns among the listed concerns. This could be due to availability of adequate policies and procedures available for managing the same.

14. CONCLUSION:

1) Seafarers were able to foresee the problems that might arise from the implementation of new regulations causing anxiety and stress.
2) Inspections, extra workload, paperwork, penalization, were the major causes of concerns expressed.
3) Technical challenges like pipeline work, compatibility, fuel change over process, and necessary training were considered important concerns of the implementation.
4) Fatigues and neglect were rated least of the concerns.
5) All seafarers experienced moderate to high level of concerns due to the Sulphur 2020 regulations.
6) Seafarers did not differ much in their level of concerns due to department or seniority. All of them experienced similar level of stress due to the implementation.
7) Seafarers felt prepared to handle the effect of the new implementation and felt more training, reading and seminars which would assist them to handle the same, as necessary.
8) Scrubber malfunction and fuel compatibility issues were the frequent problems post implementation.

15. IMPLICATIONS OF THE STUDY AND FUTURE DIRECTIONS:

This study was done only with Indian nationals working in four organizations. Hence the generalization of the findings is limited to those population only. Larger sample with more nationalities and from more companies would be a well-represented sample. However, as seafarers have a common work culture, these findings would help in understanding their problems. These findings can help relevant stakeholders to address

and design interventions to cope with the stress and anxiety arising out of any subsequent new regulations.

The studies also imply that organizations and industry bodies must evolve more possible scenarios which would result in non-compliance with the regulation and develop robust solutions to mitigate the same. These may include but are not limited to making efficient models of scrubber, alternate means for reducing emission levels, technological solutions to machineries when using compliant fuels etc. Suitable and effective training programmes and orientation to prepare seafarers to deal with circumstances need to be developed.

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DEBUNKING SAFETY MYTHS

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Abstract

This paper analyses the Hoegh Osaka incident in the light of Safety Management systems and the practices evolved in managing safety. These evolved practices had created myths about managing safety through compliance to procedures and checklists generated in typical work-as-imagined scenario which ended up regarding the frontline seafarers as solely responsible for incidents. The paper attempts to debunk these common myths and presents a new view on Safety Management that looks at organizational environment affecting the frontline seafarer's performance.

Keywords: Safety Management, Hoegh Osaka, Safety myths, Compliance to procedures.

1. INTRODUCTION:

In January 2015, the pure car and truck carrier (PCTC) Hoegh Osaka developed a severe list on departing from Southampton and was left stranded outside the port for more than 19 days. The official investigation revealed how decision making became the victim of production pressures. The vessel sailed from port without determining accurately the stability conditions upon completion of cargo. It was a routine practice to leave this task to be carried out once the vessel was out at sea; a practice that appears to be common within the PCTC industry. The weights of the cargoes declared at the time of loading were significantly different from the actual weights; a practice that extends even beyond the PCTC industry. The port captain never felt the need to involve the chief officer in the preparation of the stowage plan. The chief officer, on the other hand, did not feel he had the authority to question the pre-stowage plan.

The preventive actions that followed from the accident should not surprise anyone. A volley of plans, presentations and questionnaires were sent off to the entire fleet reinforcing the importance of compliance with procedures and checklists and warning the crew against being influenced by perceived commercial pressure. But will these actions actually do anything to improve safety?

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2. SAFETY MANAGEMENT SYSTEM:

During the 1980s a number of very serious accidents including the Herald of Free Enterprise led to the introduction of the International Safety Management (ISM) Code, based on the principles of the ISO standards, and taking a structured, systematic and documented approach to the management of safety and quality. A key requirement of the Code was for every organisation to formally adopt a safety management system (SMS).

And what exactly is the purpose of the SMS? It can be illustrated using the 'Swiss Cheese' model of accident prevention, where several slices of cheese are lined up against each other. The cheese slices represent organisational barriers to prevent accidents. These typically include crew competence and training, emergency preparedness, maintenance of safety equipment, analysis and reporting of accidents, documentation control, effective control and monitoring from the shore side etc.

The holes in the cheese represent noncompliance – instances where rules, regulations and procedures were not followed. These are referred to as noncompliances. When an accident happens, the conventional explanation is that there was a hole in the barrier because rules and procedures were not followed. The purpose of the SMS is to ensure the systematic identification, detection and follow up of noncompliances so that the organisation is better prepared to manage safety risks.

If the capsize of the Herald of Free Enterprise led to the introduction of the safety management system, the stranding of the Hoegh Osaka has surely reaffirmed that we need more of it. More rules, procedures and checklists to plug those holes! But the existing approach to safety management has proven deeply flawed and dangerously misleading. For the rest of this paper I will illustrate some myths about safety management systems, and then debunk these myths by offering a new view about safety management systems.

3. SAFETY MYTHS:

Light bulbs and the myth of compliance

Light bulbs either light up or they do not. There is no middle way to determine whether they work or not. The underlying philosophy of a safety management system is similar to the working of light bulbs - bimodal and absolute (yes and no), with the sole aim of establishing whether rules, regulations and industry standards have been complied with or not.

But if we apply this bimodal approach to the Hoegh Osaka, there are not many instances of noncompliance. The vessel complied with all the statutory requirements and was manned by competent crew who were adequately rested at the time of the accident. The loading computer program was 'approved' and would have worked accurately if the correct cargo weights had been fed into the computer. The remote gauges for tank sounding were not operational at the time of the accident – but this was not necessarily a noncompliance, as long as tank soundings could be obtained manually. It appears that in the absence of compliance risks, the company regarded rectifying the fault in the remote gauges as a low priority. The official accident report stated that: 'In light of the low priority given by the company to repairing the gauges, a similar low priority was assumed by Hoegh Osaka's chief officer, who resorted to estimating ballast tank quantities.' A defective ballast sounding system that was otherwise compliant with regulations was encouraging 'unsafe practices' onboard.

4. CROSSING THE RED LINE:

At a maritime symposium on 'safety culture', the importance of following the rules and procedures came up, as one would expect. An elderly gentleman stood up and said, 'Ladies and gentlemen, we are in the business of transporting flammables, remember you must never cross the red line'. What he meant was that the workers should under no circumstances dare to breach rules and procedures. The crew on board the Hoegh Osaka had crossed the red line on numerous occasions. The Master did not hold a pre-load meeting with the deck crew and officers. The chief officer underestimated the importance of accurately calculating the stability condition before departure. Instructions on the use of loading computer were not part of the chief officer's familiarisation checks. The heavy lift cargoes were not secured in accordance with the CSS Code 2011, IMO Resolution A.489 (XII), IMO Resolution A.533 (13), IMO Resolution A.581 (14), IMO Resolution A.581 (14), as amended by MSC.1/Circ.1355,

MCA publication Roll-on/Roll-off Ships: Stowage and Securing of Vehicles Code of Practice (and add to this a raft of regulations, circulars and industry standards that even the experts specialising in cargo securing plans may be unaware of).All of this would have played its part in the accident. But pick a routine cargo operation on any PCTC and chances are that you may find an even more comprehensive list of rule violations. A seafarer with whom I recently discussed this issue stated: 'If you go to this level of detail, you will find problems in everything I do'. A dozen experts analysing split second decisions influenced by intense production pressures will no doubt establish numerous instances where rules were violated, and procedures were not followed. But is this approach really effective in managing safety?

5. THE PROCEDURALISATION OF EVERYTHING:

The accident investigation report into the Hoegh Osaka found that there were a total of 213 checks to be completed by the chief officer for cargo operations alone. This exemplifies a 'rotten onion' style of management; one where multiple layers of procedures and checklists can cover up the core issues. These procedures (referred to as 'objective evidences' in the language of SMS) make it extremely difficult for an outsider (ie regulator) to gain insight into the core practices and culture of an organisation. I am reminded of a fire damper that was found fully corroded and inoperable during a survey, despite maintenance management plans indicating fully operational fireFigurehting systems in 'excellent condition'. No amount of processes, procedures and checklists can solve core problems of this nature. If anything, they only make core issues more inaccessible.

To a large extent the problem lies in how safety audits are conducted. The auditor finds a few non-conformances and the company addresses them by adding a set of procedures and half a dozen checks to the SMS. The quest for paperwork to prove safety generates even more paperwork for managing safety. Everything from starting the main engines to switching the kettle on is 'proceduralised' and 'risk assessed' and the SMS eventually becomes a monster. There is very little foresight and thinking in this mundane 'check-do' process.

The Hoegh Osaka's two hundred or so checks for cargo operations alone are a true reflection of this contagion. While the company was busy creating the checks, the chief officer was busy ticking the boxes on the checks, the Master was too busy to verify the checks, the regulator was kept busy assessing the checks, the investigator was busy counting the checks – and with these multiple layers of protection, the safety management system was drifting into failure beneath all these checks. The imaginary world of procedures and checks had drifted too far away from the real world of practice.

6. 'NO BLAME' MYTH:

Most accident investigations' reports and safety audits start by stating that the purpose of the exercise is not to apportion blame or find faults with individuals. In practise, this is far from achievable with our current approach to managing safety. Within the 83 page Hoegh Osaka incident report, the term 'chief officer' appears 132 times, and Master 89 times. By contrast, the organisation responsible for the safety management system appears in the report only on 60 occasions. Of the two dozen conclusions drawn from the report, 16 are centred on the vessel and the crew on board. It is obvious that the focus of the report remains on the behaviour and actions of those proximally closer to the scene of accident. Research in accident studies views this tendency of focusing excessively on the actions of those physically closer to the accident as 'proximity bias'.

It is interesting to see how a highly ambiguous and uncertain situation is captured and presented as a structured and systematic report. In an attempt to present an official narrative, the report illustrates a one-sided construct of the entire ordeal. The report suggests the problem begins with an erroneous stability condition and ends with an extremely tender vessel that capsizes just after departing from the port. There is no mention in the report of the last safety audit, management onboard visit, charterer's inspection, or QHSE plans and reports. How could so many entities have missed so many unsafe practices that were so common on board? The voices from the control room and wheelhouse are lacking. The inability to calculate final stability conditions prior to departure is considered a 'drift from fundamental principles of seamanship'. But it should be noted that there is not much rigour in such statements. Under these circumstances, how can we preach the mantras of 'no blame', 'just culture' and 'safety first' to anyone involved in an accident?

7. A NEW VIEW OF SAFETY MANAGEMENT:

Having summed up the four popular myths of SMS, there are several questions to be answered.

- First, we place so much faith in compliance with regulations in managing safety – but is compliance really as straightforward (yes and no) as it appears on its face? And if not, can we still make effective use of compliance in managing safety?
- Second, can we think beyond the punitive language of 'rule violations' in managing safety?
- Third, can we ever manage safety genuinely without shaming and blaming our workers?
- And finally, if excessive procedures and checklists are taking us away from our core problems, what can we do to bridge this gap?

The answers will offer an alternative approach to the safety management system (and hopefully debunk some myths).

8. PURPOSEFUL COMPLIANCE:

Technology moves far faster than our ability to control and regulate it. When compliance with 'rigid' regulations conflicts with operations, owners may seek 'alternative compliance' through risk assessments, waivers, and exemptions and even threatening to transfer their vessels to 'business friendly' flag states. What appears a matter of absolutes on the surface is in fact imperfect, convoluted, interpretive, and open to abuse. Many high-risk industries have realised the limitations of compliance with rules and regulations and resorted to requiring a duty of care and responsibility from the operators even if this requires undertaking measures beyond compliance. (Of course, this approach is not without its own problems.)

In the case of the Hoegh Osaka, it surely made sense to use all available Codes, Circulars and IMO Resolutions to verify compliance with cargo securing when compiling the accident report – except that this was undertaken in hindsight and with ample time (the official report took more than a year to publish). The knowledge surely existed when the vessel was being loaded, but could it ever be applied as a means of preventing accidents, rather than just identifying noncompliances in the wake of an accident? This is an important question that we need to ask in designing and

implementing our SMS. Compliance must have a meaning and purpose, not be something demanded for its own sake.

9. APPROXIMATE ADJUSTMENTS:

In many societies, even the thought of breaching the rules can be intimidating (just as in other societies it is a way of life). After all, rules and procedures are there to assist us. It is unthinkable for many of us to imagine that a vessel could ever sail from port without obtaining final stability calculations. And how could the chief officer tick off checks that were never really carried out? Why, despite clear instructions in the SMS, were tank soundings not obtained on a daily basis? Is this really a case of unreliable seafarers 'falsifying records' and crossing red lines?

Far from unsafe practices and a drift away from seamanship, this is exactly how work is performed. If the chief officer had diligently followed the rules and performed all the two hundred or so checks, the vessel may not have departed from the port in time. In many countries, working to rule is a deliberate form of protest.

When the chief officer was selective in following the checklist, it could well be that he was indeed applying seamanship (using his professional judgment, prioritising and making adjustments when faced with time constraints) rather than 'drifting away' from it. What we consider as 'red lines crossed' are approximate adjustments required to succeed at all levels within the organisation. These adjustments are approximate because we cannot write precise rules and procedures for every single task; because those procedures demand resources that may not always be available (for example ample time, competencies); because procedures are underspecified, involving terms such as 'apply good seamanship' that do not specify what is expected from the individual in a given situation. Approximate adjustments have to be made to get the job done. This is how we succeed in everyday work despite demanding deadlines and budget constraints.

10. THE EQUIVALENCE OF SUCCESS AND FAILURE:

Do we always need someone to blame in the wake of an accident, or is there an alternative? Let us examine the fine details of the Hoegh Osaka accident: a last minute change that made Southampton the first call in the port rotation plan rather than the last; a historical trend of guessing ballast quantities rather than obtaining actual tank soundings; a routine practice of declaring less than the actual weights in cargo manifests; a metacentric height (GM) marginally short of the required stability standards; a mere 0.6 metres bow trim that led to a high rate of turn; and a righting moment that brought the vessel back upright when she developed a heel while turning at a speed of 10 knots, but which became insufficient at a mere two extra knots speed at the next turn in the channel. Note the dynamic nature of certain variables and how the routine practices and approximate adjustments came together. Where is the root cause of the accident? This shows how approximate adjustments and routine practices can sometimes emerge as disproportionate, non-linear outcomes.

Change any one of those variables and there is a good chance that the Hoegh Osaka would have safely exited the channel just as do most PCTCs and many merchant vessels each day. None of us would have noticed the ‘deep rooted’ problems so pervasive within the industry. On the contrary, the management would have rewarded the employees in their next performance review. Who would not wish for a workforce that could balance safety with quality so well? Is this not how competitive organisations are meant to operate in an aggressive market? It does not help to explain why we should blame people who exhibit a ‘can do’ attitude and are willing to go that ‘extra mile’. Granted, there are negligent behaviours and unsafe practices – but the boundaries between success and failure seem to have diminished.

11. BUSINESS IS SAFETY:

It does not make much sense to react to ‘unsafe practices’ by replacing a handful of seafarers and introducing more checks, controls and barriers. When something goes wrong, it has usually gone well many, many times before. That is why people do it! So, without understanding why it was done in this way and why it went well, we have no

hope of understanding why it went wrong. It pays to observe a successful routine operation with an open mind.

Recall the last-minute changes to the port schedule of Hoegh Osaka. This is a usual problem for many ships (it was also an issue in the case of the Herald of Free Enterprise). Therefore, we should begin by looking at the usual and normal actions in this case. How do crew members adjust to last minute changes to port schedules? When time is limited, how does the crew meet deadlines when getting their jobs done? How does the vessel still manage to depart from the port on time despite a late arrival in port? Pay close attention to whether crucial decisions are made based on incomplete, incomprehensible knowledge and poorly written procedures. Observe how work is performed when not all crew members are adequately experienced in handling key operations.

Find out how shortcomings in apparently certified equipment are compensated for in everyday work. It is here that we start to appreciate human performance. It is here that we realise the need to remove the unnecessary checks and barriers that impede rather than facilitate decision making. It is also here that we start to realise that we cannot write procedures and checks for every conceivable situation. And it is here that procedures and checklists start to mesh with the messy world of operations. Here lies an opportunity to genuinely promote a ‘no blame’ culture and reduce the administrative burdens that are helping neither safety nor businesses.

After more than two decades of futile attempts to implement a ‘structured, systematic and documented approach’ in managing safety, it should be clear that it does not exist. The case discussed here was chosen not because it was unique or one-off. It only serves as a recent example available in the public domain to expose the fatal fallacy that we call safety management system. Perhaps the time has come to leave behind the light bulbs, red lines and rotten onions and embrace a new view of safety management system. Safety is not a crime against business. Business is safety.

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LIGHT CRAFT CONSTRUCTION USING SANDWICH DESIGN WITH VACUUM INFUSION

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Abstract

This paper is based on the concept design, fabrication and successful commissioning of a functionally compact, economically powered, aesthetically and ergonomically designed round bilge, round transom, low air-draught day and week-end cruiser vessel primarily for backwaters. Though not geographically constrained this development is a model for promotion of heritage tourism in the Kerala coast and primarily in the heritage Muziris tourism circuit. The vessel features several firsts, primary among which is the lightweight construction adopting sandwich construction using polyurea PVC core light density, high strength core material and glass fibre fabric in the form of bi-axial and quadraxial fibre with highly economic rapid vacuum infusion process. The combination of an optimized hull form favouring highly streamlined flow adopted and improved through towing tank tests, provision of generous beam for space and comfort, low centre of gravity through hull form design and the weight saving features of the vacuum infusion sandwich core construction makes the design unique for adoption on large scale manufacture. The vessel is also the largest of its kind to be built in India using vacuum infusion process. This paper highlights the details of the design and the technical manufacturing process and its challenges

Key words: Fibre glass hull, sandwich construction, vacuum infusion, quadraxial fibre, light craft

1. INTRODUCTION:

The success of marine crafts especially pleasure boats and lightweight high speed crafts, depends on successfully maximizing their performance with reduced weight, cost and environmental impact [Reference 1:www.diabgroup.com].The development of weight saving designs of vessels directly bring economic advantage because of lesser fuel consumption and bring environmental benefits. Vessels constructed using composites with core sandwich material provide the benefits of higher speed, longer range, greater payload capacity, reduced power demand besides reduced environmental impact.

This paper presents the rationale behind composite sandwich construction and describes the design features of a marine pleasure craft with inherent advantages, based on the first-hand experience of actual vacuum infusion in the production of the marine pleasure craft. The sandwich construction consists of PVC (poly vinyl chloride) foam

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as core material with binding layers of glass fibre on either side. The glass fibre is in the form of biaxial or quadraxial woven/ stitched glass fibre and impregnated with resin in situ with the core material using the vacuum infusion process. Though the composite boat building industry has been in existence for almost 50 years in India, it is only in the last decade or so, that the advanced technology of construction using vacuum infusion and PVC foam core material has become a practical industry process. The technology was popularized through adoption for the large size wind-mill blade manufacture. Although the marine pleasure craft industry is still a growing industry in India, the present maritime policy of the government and incentives for the industry provide very encouraging environment for the adoption of this technology for better boat building. The design and construction presented here represents the largest marine pleasure craft in India to date, using sandwich construction for the entire hull, deck, bulkheads and superstructure using the vacuum infusion process.

2. ADVANTAGES OF SANDWICH CONSTRUCTION:

Core sandwich materials offer the highest strength per weight ratio for all marine applications. The core material provides excellent fatigue and slamming properties in sandwich structures, which makes them particularly ideal for rescue crafts, coast guard vessels and other special crafts that often operate in high-sea conditions. It is a fact that construction cost may be higher in the case of sandwich core composite material, however this has to be balanced with the life cycle cost which would also consider the operational cost over the lifetime of the vessel. Studies related to a specific type of vessel have shown that the single skin versions may be heavier by 70% and material and production cost may be higher by 17% in relation to the sandwich equivalents. [Reference 2: Djurberg, 2012].

A total cost evaluation should include material, production and operational cost and obtain the break-even period. On such considerations, studies have shown that glass fibre based sandwich construction of marine crafts can be a beneficial choice.

3. SANDWICH THEORY:

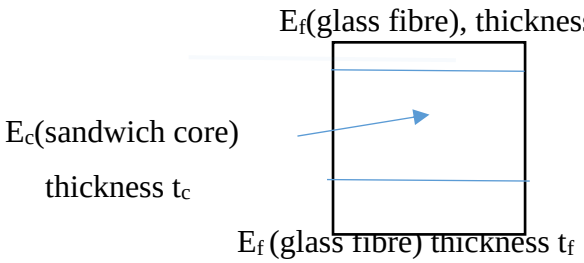
The stress distribution in the sandwich is understood on the basis of the sandwich theory. Flexural rigidity denoted as D describes the strength of the sandwich

construction and it is the product of the elastic modulus E and the moment of inertia I of the cross section. Figure 1 depicts the typical cross section of a sandwich construction using glass fibre reinforcement in resin matrix on the upper and lower sides and foam core separating the two.

Since the modulus of elasticity E is not constant over the cross section for sandwich material with different materials such as glass fibre and sandwich foam, It is obtained by integration as follows:

Figure1 Typical cross section of sandwich construction

$$D = EI = \int Ez^2\, dz \tag{1}$$



For the symmetric cross section depicted in Figure1, the flexural rigidity by integration becomes

$$D = E_f t_f^3/6 + E_f t_f d^2/2 + E_c t_c^3/12 \tag{2}$$

$$= 2D_f + D_o + D_c \tag{3}$$

where Ef is the modulus of elasticity of the glass fibre laminate,
Ec is the modulus of elasticity of the foam core material,
tf , tc the thickness respectively of glass fibre layer and core material.

As an approximation, the first term Df is small because tf the thickness of glass fibre is much smaller than the thickness of the core material, and Ec is much smaller than Ef ie., the modulus of elasticity of the core material is much smaller than that of the glass fibre laminate. Therefore, only the middle term remains, in other words, D = Do and this gives a simplified expression for the modulus of rigidity of the sandwich material. The stresses due to bending are carried by the bottom and upper layers,

$$\sigma_f = M_x/(t_f\, d) \tag{4}$$

and the uniform shear stress is given by

$$\tau_c = T_x/d \tag{5}$$

The above consideration establishes that the flexural rigidity increases by virtue of the thickness of the core material.

4. CORE MATERIAL:

As earlier mentioned, the objective of the core is to support shear forces and separate the faces for higher flexural rigidity or stiffness. The design incorporating core provides high stiffness to weight ratio because of the lightweight nature of the core material. Hence low-density core material is an important aspect of the design. When deflection is to be limited, weight saving with sandwich design is almost 90% compared with steel-based design. Sandwich construction also offers very important advantages by way of thermic insulation, acoustic dampening, reserve buoyancy, non-corrosiveness and increased impact resistance. The core material is a unique combination of cross linked almost equal parts of polyurea and PVC (Poly Vinyl Chloride) to give good mechanical performance with very low weight. The combination gives an Inter Penetrating Network (IPN).(Reference 3: Guideline to Core and Sandwich, DIAB)

5. CORE MATERIAL PROPERTIES:

The material (under the trade name Divinycell HM) is a high-performance structural core material for use in marine hulls. It is capable of absorbing high dynamic impacts and slamming loads. With good elongation property it gives lighter, yet stronger structure. The high compressive strength provides good resistance to denting and skin wrinkling of thin skins. The important properties are typically as follows: [Reference4:Technical data DIAB]

Compressive strength: 1.414 MPa [203psi]
Compressive modulus: 0.101 MPa [14.5psi]
Shear strength: 1.164 MPa [167 psi]
Shear modulus: 0.027 MPa [3.91psi]
Shear strain: 41%
Density: 80kg/m3 [5lbs/ft3]

6. HULL FORM DEVELOPMENT:

The philosophy of hull form development has been based on the objective of having spacious, low air-draught day and week-end cruiser at a modest speed of 8 knots for primarily backwater conditions with a limiting wave height of 0.5m, with a bedroom for two, and lounge and deck seating for 10 persons as day passengers, a kitchenette, toilet and segregated engine room and steering gear compartment. Figure 1, 2 and 3 respectively show the final body geometry in the form of Lines Plan, towing tank test and the final General Arrangement for appreciation of the layout. Besides consideration for comfort and ergonomic layout, paramount consideration was given for environmental protection by providing inoculum digester-based bio-toilet and zero discharge into water.

Table 1: Main particulars of the vessel

Particulars	**Prototype**	**Model**
Scale	1	5.0
LOA	11.9m	2.38 m
LWL	11.51 m	2.30 m
Breadth MLD	3.5 m	0.616 m
Design Draft	0.80 m (final draft 0.65m)	0.160 m
Displacement	7.80 t	62.40 kg
Max. Speed	8.0 knots (0.38 Froude no.)	1.840 m/s

Figure 1: Line's plan showing the hull form evolved after consideration of towing tank test results. Stem rake was improved to reduce bow wave and beam was increased for better space comfort.

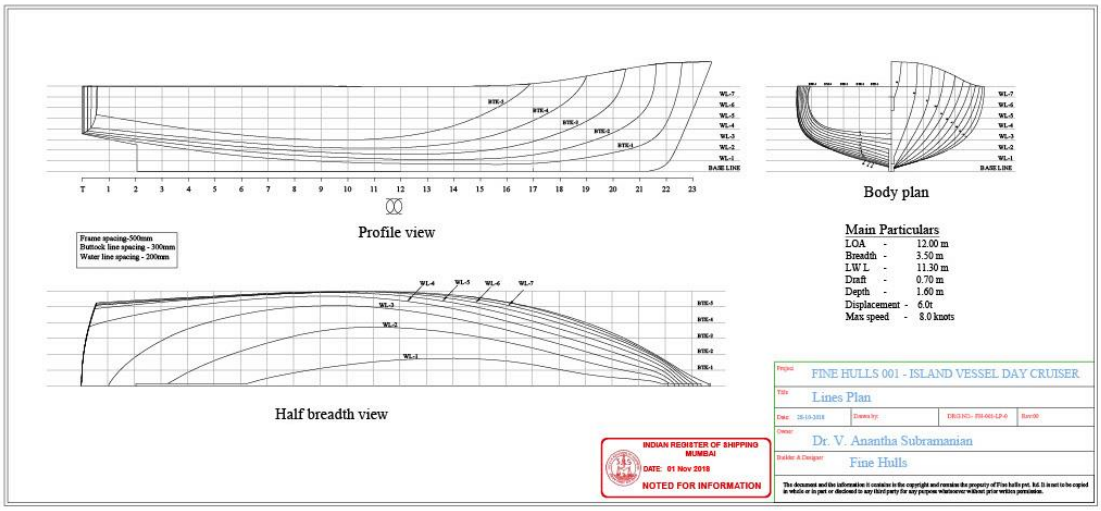


Figure 2: Towing tank test showing bow wave formation. The stem rake was improved based on the towing tests.

Table 2: Towing tank test results showing resistance and projected installed power

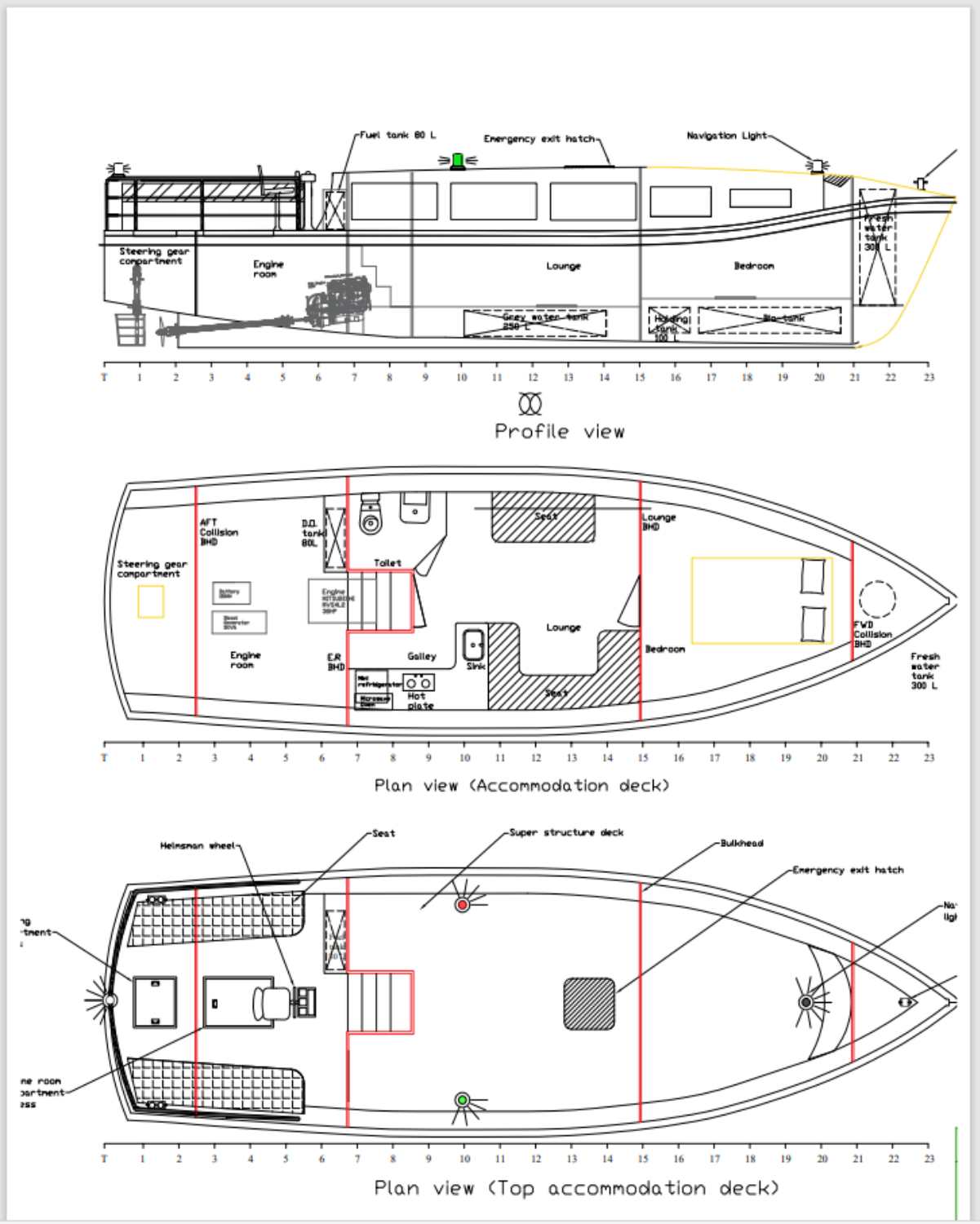
Sl. No.	Ship speed (knots)	Ship resistance (kN)	Effective power (kW)	Effective power (HP)	Installed power (HP)
1.	5.0	0.484	1.26	1.71	3.42
2.	6.0	0.815	2.51	3.41	6.82
3.	7.0	1.317	4.75	6.45	12.90
4.	8.0	2.149	8.85	12.03	24.06
5.	9.0	3.870	17.93	24.36	48.72

Based on the tank test results and with consideration for propeller performance efficiency, de-rating allowance and a margin of allowance, the final engine power was chosen as 38HP (Mitsubishi engine developing 38HP at 3000 rpm).

7. MANUFACTURING PROCESS:

The manufacturing process starts with the involved operation of plug manufacture, negative form or female die and finally the manufacturing of the hull form. The former two processes are not described here as they are fairly standard and routine though by no means lesser effort. Typically the female die is manufactured only when large scale manufacture is envisaged, however in this case as a pioneering effort, a full-fledged negative form in fibre-glass was manufactured. Absolute air leak prevention into the female die is the biggest challenge in the vacuum infusion process later.

Figure 3: General arrangement incorporating the design objectives



8. THE VACUUM INFUSION PROCESS:

Vacuum infusion is the most critical process in the entire manufacturing effort. It requires continuous vacuum pumps to operate and maintain total vacuum (0mm Hg) within the evacuated space between the polythene film cover and the female die for period typically stretching to 4 hours. The process is briefly described here. Refer to Figure 4 for the schematic set-up for vacuum infusion of a representative marine craft. Specific training is most essential since in a failed attempt huge quantity of resin can thermoset in an irreversible process leading to loss of raw materials and consumables. However, a planned approach can pre-empt any such eventualities. The most important components for vacuum infusion are 1. The finished die absolutely air-leak tight. For the moulding process, the die is prepared with a first gelcoat layer as in manual layup process. Afterwards the layers of glass fibre (in bi-axial or quadraxial stitched fibre form), the Divinycell HM foam (as per design) and top layer of glass fibre again are arranged on the die surface. The die (as shown in the schematic below) is covered and sealed with polythene sheet specially available in large wide rolls with sealing double side adhesive tape. Powerful vacuum pumps suck out the air in the gap between the die and the polythene sheet. Blank tests are a must to ensure that perfect vacuum is maintained in the space before starting the resin infusion process. The creation and maintenance of perfect vacuum (0 mm of mercury pressure indicated) is a fundamental necessity, and it is a demanding process as the tiniest of leaks (ie., atmospheric air from outside leaking into the die) can result in failure of vacuum infusion of resin later.

List of components used in the preparation:

1. Female die tested including all joints for absolute leak proof to prevent ingress of atmospheric air into the vacuum space
2. Gelcoated surface with layers of glass fibre fabric and core material
3. Vacuum bag with polythene film
4. Polythene tubing to vacuum pump
5. Resin reservoir with flow line outside bag with multiple injection points
6. Vacuum pump line and return line to catch-pot with pressure gauges to monitor vacuum condition
7. Polythene spiral wrap, peel ply, etc.
8. Vacuum bag sealant tape.

Figure 4: Schematic layout for vacuum infusion (Reference 5: http:www.frpbbs.com)

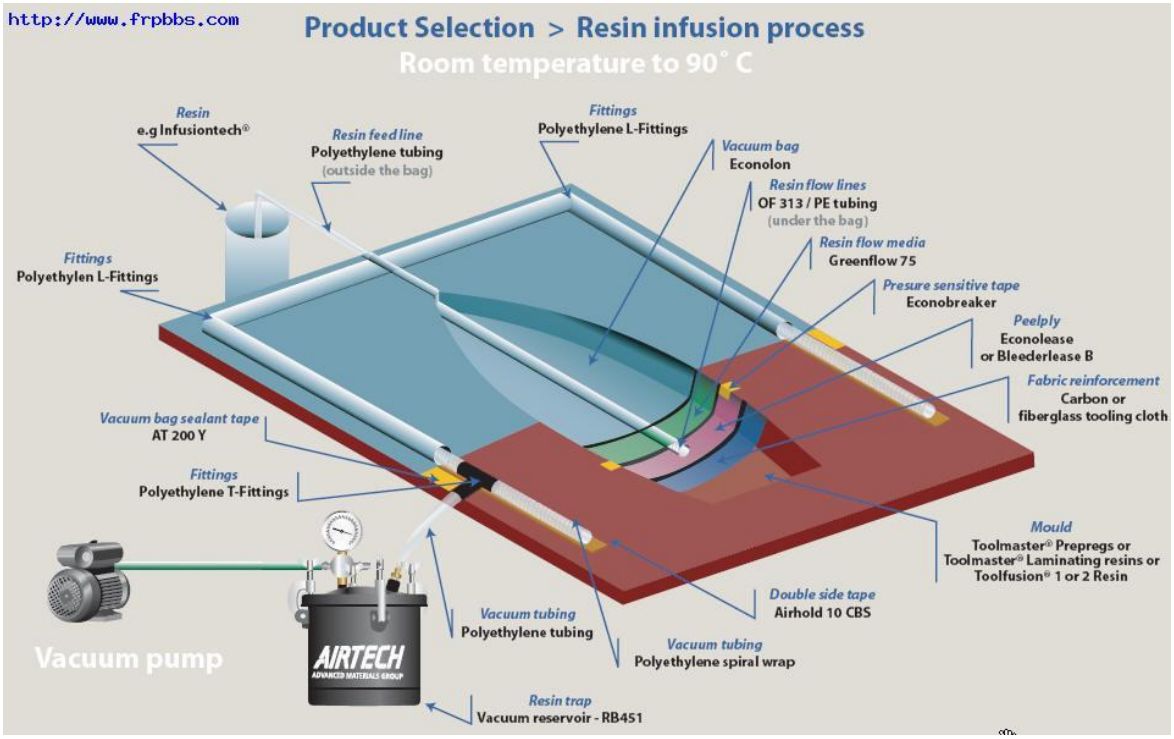


Figure 5: Typical hull bottom and side shell layup design

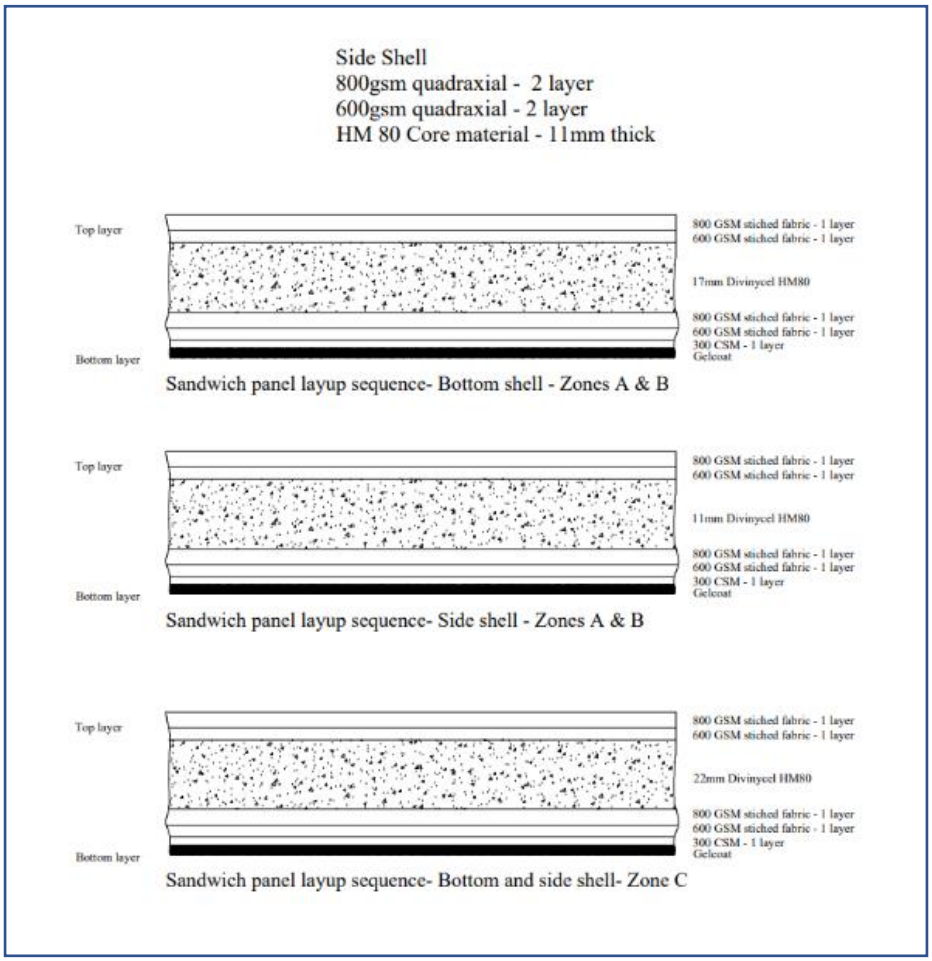


Figure 6: Midship section shape of hull and superstructure

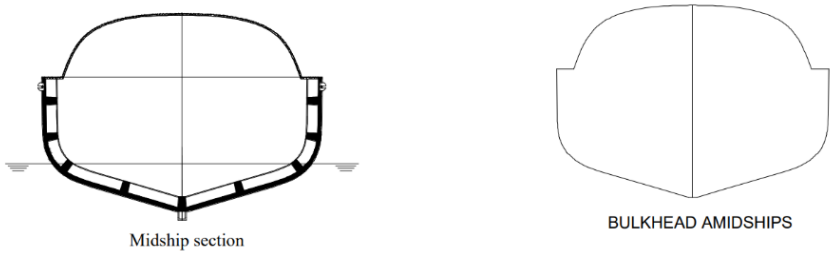


Figure 7: Surface of the female die prepared for layer layup

Figure 8: Quadraxial fibre layer in position in preparation for the vacuum infusion.

Figure 9: Peel ply, spiral tube in preparation for the vacuum infusion process

Figure 10: Maintenance of absolute zero pressure is a must

Figure 11: Quadraxial fibre layers, divinycell sandwich foam, inner quadraxial layers, peel plies, vacuum sealing

Figure 12: The catch-pot is an important component in the return line and should have absolutely no leaks

Figure 13: About 400kg of calibrated slow setting resin (setting time between 90 and 120 mins.) mixed in one batch and the entire hull moulded in a matter of few hours

Figure 14: A series of spiral flow tubes, injection hoses, vacuum return lines, ensure controlled exothermic setting is done in the next two hours

Figure 15: The ship and superstructure ready to be released from inside the die

9. CONCLUSION

This paper presents a state of the art construction process for lightweight fibre glass pleasure craft construction. In the process this paper describes the salient features of the design of a classic hydrodynamically efficient hull form with space, comfort, and ergonomic features both internal and external. The design incorporates the most favourable engineering features of a lightweight hull with high rigidity and shear strength for resisting hydrodynamic loads and economy of operational cost in the long run because of the lightweight hull form. In the final analysis the process has economic advantages since the initial higher cost due to the sandwich core is offset by lesser resin consumption in the moulding process, lighter design, higher payload capacity and economy of operation.

Table 1: Comparison of Tensile Strength

Specimen and test	**Tensile strength N/mm2**	**Youngs modulus kN/mm2**
Hand layup Tensile test	234	12.29
Infusion Tensile test	287	16.16

Table 2: Comparison of Flexural Strength

Specimen and test	**Flexural strength N/mm2**	**Flexural modulus kN/mm2**
Hand layup flexural test	320	6.65
Infusion flexural test	370	10.93

Table 3: Comparison of glass content

Specimen	Glass content in percentage
Hand layup	35%
Vacuum infusion	50 to 60%

The above results are based on laboratory tests conducted at the Composites Laboratory IIT Madras, drawn from actual manufactured samples.

Figure 16: The final hull emerges from the die, below stern view

Figure17: The day/ weekend cruiser rolls out for final transportation to destination

Figure 18: The vessel is berthed at its destination, a comfortable backwater cruiser.

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A PERSPECTIVE STUDY OF SHIP BREAKING IN INDIA AND THE IMPACT OF INTERNATIONAL CONVENTIONS AND REGULATION

Gopikrishna Chockalingam[7]
Dr. K. Sivasamy[8]

Abstract

Recycling is the most efficient and sustainable way of disposal towards the end of useful life of a ship. However, presently it is not carried out in a safe, environmental friendly manner in the beaching method of ship breaking carried out in the beaches of South Asian Countries such as Bangladesh, India and Pakistan causing frequent accidents, loss of life and environmental degradation. To address the above issues, International conventions such as Hong Kong Convention, EU Ship Recycling, regulations and guidelines have been adopted. This paper analyses the ship breaking in global and Indian perspective, the existing legal framework, the issues in the Indian ship breaking yards and the impact of the International conventions and regulations in Ship breaking in India with a conclusion towards the necessity for implementation of the above conventions.

Keywords: Hongkong Convention, IMO, EU Ship Recycling Regulation, Ship breaking, Sustainable ship recycling, Training.

1. INTRODUCTION

Maritime transport is the cheapest mode of transport and remains the backbone of the globalized trade and the manufacturing supply chain which constitutes about more than four fifths of world merchandise trade by volume which is carried by sea. The entry into force of the several global environmental mandatory instruments and the voluntary standards being adopted in the shipping sector is having a huge impact on the ship building yards and ship owners due to the fact that they are mostly responsible for incorporating the new standards into the design features and construction of new ships adhering to the existing rules and regulations. In addition, there is enormous pressure from the global shipping regulators on the ship owners and shipping industry towards usage of cleaner fuels and energy efficient vessels towards addressing the issues related to the global warming and climate change. This scenario has resulted in huge expenditures and consequently lower profits to the shipping companies resulting in many of the ships being prematurely sent for demolition to the ship breaking industry to end their life. This scenario has a huge impact both in the shipping industry as well as in the ship recycling industry. On one hand, demolition of old ships helps the renewal

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of the global fleet of ships, balance the demand and supply of ships in the freight market; on the other hand, it recycles millions of tons of scrap material and contributes to non-depletion of the existing resources and thereby the sustainability of the resources for the future. It is estimated that scrapping of less fuel-efficient vessels in the form of older ships is on an increase, with an estimated projection of 26 million dwt equivalent in 2019 and 44 million dwt equivalent in 2020, thereby reducing the growth in the world fleet by 0.8 per cent in 2020, notably 1.1 per cent across the bulker fleet, 0.8 per cent across the tanker fleet, and 0.7 per cent across the container ship fleet .

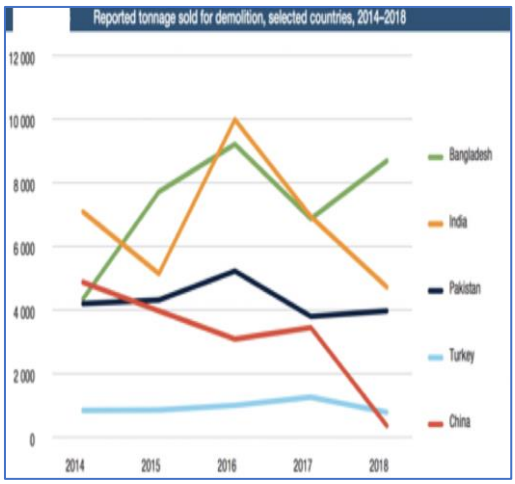
Ship recycling is considered as a best practice to reuse the components, recycle the material due to which a high proportion of utilization of steel is achieved from the recycled ships for the other domestic manufacturing sector which reduces the load on the steel manufacturing industry. However, the manner at which the work process in the ship recycling industry takes place is of a serious concern. The unsafe work practices, accident prone living and working conditions of the workers, loss of life, violation of labour rights, manual work process, poor downstream waste management, health hazard to the workers and the coastal community in the area and environmental degradation are the serious issues at present facing the ship recycling industry. The presence of hazardous material such as asbestos, polychlorinated biphenyls (PCBs), mercury, glass fibre, solid foam in the ship construction as well as the remnants of banned anti fouling substances, paints used in the hull coating and ship generated wastes such as waste oil and oily residues are also few factors towards the accidents as well as health hazard in this industry, considering the worker's lack of awareness and lack of training in handling the hazardous material. In the global arena, to address the above issues, the member nations of the BASEL Convention of the United Nations, the International Maritime Organization, International Labour Organization has jointly come out and adopted the Hongkong Convention. The European union has also enacted its own Ship recycling regulations which is much more stringent than the Hongkong Convention (HKC). The Hong Kong Convention is yet to come into force. This paper analyses the key issues of concern in the ship recycling and the relevance of early as well as strict implementation of Hong Kong Convention.

2. GLOBAL PERSPECTIVE

The shipbreaking industry has been around since ages, as long as the birth of the ships but over the past half-century it has gravitated to certain regions in the world where the ship breaking industry offers inexpensive land, cheap labour and where there is no or less stringent environmental regulations. Prior to World War II, the yards in Europe, USA and Japan handled the most shipbreaking, with the renowned Ward yards in the United Kingdom gaining public attention by breaking up some of Britain's well known ocean liners and naval vessels. After the end of the World war-II, Taiwan and Kaohsiung became a major destination for vessels at the end of their economic lifespans. In Europe, Spain and Turkey competed with Asian ship breakers, however mostly for the smaller ships. Pakistan's government noted the value of shipbreaking as an employment provider and by the late 1970s declared the activities as "legal" for importing purpose. Due to the high productivity, the shipbreaking business was at a high in the Kaohsiung yards in the 1980's. In the early 1980s, the mudflats of Pakistan, India and Bangladesh rose to prominence by offering cheaper labour as well as lax environmental regulations and low taxes. New yards for ship demolition were established in Pakistan, India, Bangladesh and China. The sands of Pakistan's Gadani beach rose to the prominence, followed closely by the yards established in 1983 at Alang in India, and in Chittagong in Bangladesh using the same beaching techniques. Today most shipbreaking continues to be handled in the South Asian countries such as, Bangladesh, India and Pakistan but the profits have declined due to the very reason that China has flooded the market with cheap steel. With Europe and the United States totally curtailing the environmentally harmful ship breaking has made the ship breaking growing in a faster rate in the yards of the South Asian countries besides Turkey. Ships were acquired on the world market through either independent brokers or by a purchasing cooperative formed by the ship breakers themselves. The price was largely determined by a vessel's light displacement tonnage, type and market demand, paperwork, import duties, business licenses obtained and various harbour fees paid.

The decorative furnishings, the brass items and the operational equipment of the scrapped ships were sold just after dismantling. Most of the old steel used in the construction were melted down and re-cast into steel ingots. Similar to shipping and shipbuilding industry, ship recycling industry is also driven by industry cycles.

Figure 1



Source: UNCTAD, Review of Maritime Transport,based on data from Clarkson's Research.

As shown in the Figure 1, the recent trend in the period from 2014 to 2018 indicates that the demolition rate is in a steep increase in Bangladesh, marginal increase in Pakistan whereas the other countries in the top league (of five leading countries) have shown a drop in the demolition tonnage. This is due to the very fact that India is presently in the process of promoting a safe ship recycling industry by way of acceding to Hong Kong Convention and also due to the fact that China has imposed a ban on the entry of foreign ships to their yards for recycling as one of the wide range of measures aimed at controlling the environmental pollution in their country.

Figure 2

Reported tonnage sold for demolition by major vessel type and country of demolition, 2018
(Thousand gross tons)

	Bangladesh	India	Pakistan	Turkey	China	World total	Percentage
Oil tankers	5 989	1 946	2 824	66	14	10 884	59.5
Bulk carriers	1 115	465	829	18	53	2 495	13.6
General cargo ships	127	149	57	65	5	405	2.2
Container ships	620	402	38	54	152	1 284	7.0
Gas carriers	347	455	48	3	97	951	5.2
Chemical tankers	43	167	28	28	2	268	1.5
Offshore vessels	181	581	72	143	30	1 156	6.3
Ferries and passenger ships	..	171	..	14	..	185	1.0
Other	210	353	47	29	5	673	3.7
Total	8 632	4 690	3 943	418	359	18 300.9	100.0
Percentage	47.2	25.6	21.5	2.3	2.0	100	

Source : Clarkson's Research-2019

As shown in Figure 2, Bangladesh has emerged clearly as a leader as per the reported tonnage sold for demolition by major vessel type. Accidents and pollution issues continue to increase in the shipbreaking industry where in the beaching method of ship breaking is involved. Presently about 50,000 ships are in the World fleet, with a carrying capacity of 2 billion tonnes DWT and about 1000 ships are sent for scrapping every year to the Ship recycling industry of which, as per the statistics of 2018, 92 percent of the ship scrapping is carried out only between Bangladesh, India and Pakistan.

3. LEGAL FRAMEWORK

As legal framework towards the safe ship recycling, the following are the major international conventions, regulations and treaties that are in place.

Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal of 1989

The International Labour Organization (ILO) guidelines of 2003, Safety and health in Ship breaking, Guidelines for Asian countries and Turkey.

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009

The EU Ship Recycling regulations enacted in 2013

The Hong Kong Convention (HKC) with guidelines for safe and environmental friendly recycling is yet to enter in to force. It adapts a “Cradle to Grave” approach. The provisions for entry into force of the convention are that the convention will come in to force, 24 months after fulfilling the following three conditions: (i) Ratification by at least 15 member states (ii) The combined merchant fleets of the States that have already signed the convention should represent at least 40% or more of the gross tonnage of the global merchant shipping volume and (iii) The combined maximum annual ship-recycling volume of the States that have already signed the Convention should constitute at least 3% or more of the gross tonnage of the combined merchant shipping of the same States during the preceding 10 years.

Presently, with ratification of India, a major ship recycling state, the first condition has already been met, while the second and third conditions are yet to be complied.

Compliance to the second condition is very close, however, the third condition requires a ratification from any one of the top five ship recycling nations other than India and Turkey who have already ratified the convention. It means any one of the following countries such as

Bangladesh with a present capacity of 9.9 million GT

Pakistan with a present capacity of 5.7 million GT

China with a present capacity of 8.2 million GT.

It is worthwhile to note that the rest of the world barring these top five league ship recycling nations contributes only a meagre 0.6 million GT altogether. This shows the magnitude of the concentration of the ship recycling activities happening in the South Asian countries. The modern industries responsible for dismantling of ships for recycling are required to adhere to the principles of recycling as per the Hong Kong International convention. The Hong Kong Convention establishes control and enforcement instruments related to ship recycling, determining the control rights of Port States and the obligations of Flag States, Parties and recycling facilities under its jurisdiction. The Convention also controls the communication and exchange of information procedures, establishes a reporting system to be used upon the completion of recycling, and outlines an auditing system for detecting the violations.

Meanwhile, the European Union has enacted its own Ship Recycling Regulations at the end of 2013. The EU Ship recycling regulations (EUSRR) 1257/2013, do not agree with the beaching method of recycling which is carried out in high tide zones in the muddy flats of the South Asian countries. Unlike the HKC regulations, the EU Ship Recycling Regulations (EU SRR) controls the downstream waste management to control the waste generated during the Ship recycling. The EU SRR seeks to regulate not only the EU flagged ships and EU recycling facilities but also the ships sailing other flags through the control of inventory of hazardous materials (IHM) and facilities outside the EU through the declaration of EU list of approved facilities. The EU SRR also mandates that European flagged ships must be recycled only in yards that are in the European List of approved yards. The EU regulation on ship recycling also mandates all EU/EEA Flag vessels above 500 GT and other flag vessels visiting EU/EEA ports and anchorages must carry an inventory of hazardous materials as of 31st December 2020. The new build vessels built after 31st December 2018 must be in compliance to the above

requirement. On board examination and verification towards compliance to the above requirement is expected to commence from the year 2021. Both HKC as well as EU SR regulations mandate that the inventory of hazardous material must be carried throughout the life of the vessel and the same are to be updated whenever there is any subsequent modification of the ship or any addition of material. The IHM will facilitate the ship recycling yards to plan for appropriate handling of hazardous materials which is one of the main reasons for the accident and hazardous occurrence.

The cost of ship recycling at European ship recycling yards are more expensive and therefore presently not an ideal destination for the EU Ship owners. Many of the ship owners from EU countries circumvent the EU regulations by changing the ownership, flag and name of the vessel before the end of life of the vessel, prior heading off to the ship demolition and thereafter reaches the ship breaking yards of the South Asian Countries for the final demolition through the cash buyers. It is to be noted that the most popular end-of- life flags exclusively used by cash buyers at the end of life of a vessel towards scrapping are Panama, Comoros, St Kitts and Nevis, Palau, Liberia and Togo. Presently the EU is planning to start a recycling incentive to compensate the EU ship owners who operate the vessels in EU flag and opts to recycle the vessels as per EU SRR in EU approved list of ship breaking yards. With growing movement and stepping up of the pressure on shipowners to disclose their approaches to ship recycling, this incentive, will motivate more ship owners and shipping companies to opt an environmental friendly ship recycling in EU approved ship breaking yards without circumventing the EU regulations. Presently about 43 yards including 34 facilities located in 12 EU Member States and in Norway, 8 facilities in Turkey and 1 facility in the United States of America are in the European list of approved yards. This recycling capacity will not suffice the requirement of the current ship breaking need. Therefore, it is required to add more capacity by adding more ship breaking yards to the existing list of EU approved yards.

Most countries around the globe are presently, actively engaged with ship breakers to improve the workers safety and decrease yard pollution however without adequate academics. The expanded adherence to the Hong Kong Convention and EUSRR may bring about a more responsible ship breaking industry with more concern for worker’s safety and clean environment.

4. INDIAN PERSPECTIVE

In India, Ship breaking industry started officially in the early of the 19th century in 1910 in Mumbai and Kolkata port, however Indian ship breaking yards became an international destination only in the early 1980's. Presently, ship breaking is being carried out in India at various locations such as Alang Soshiya belt and Sachana in Gujarat, Dharukhana near Mumbai, Tadri and Maipe in Karnataka, Baypore in Kerala, Vishakhapatnam in Andhra Pradesh and Valinokkam in Tamil Nadu.

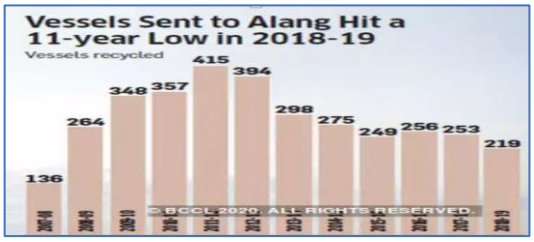
The world's largest ship breaking yard is presently in Alang in Gujarat, India located on the Gulf of Khambat, started in the year 1982-83 with a meagre 5 ships and 0.24lakh LDT, presently has a mammoth capacity to break at least 450 ships annually. In the year 2011-12, the industry dismantled a record highest 415 ships and 3.85 MLDT handled. Presently about 153 plots developed on 10 kms long coast, oversees the ship dismantling of almost 50% of the world's different types and sizes of vessels, provides employment of about 35000 to 40,000 employees directly and about 4,00,000 workers employed indirectly with an annual turnover of about 6000 crores. It is reported that over 6,900 vessels have been dismantled in these yards during the last three decades.

The Ship breaking Code -2013 was adopted in 07th March 2013 and in effect in pursuance of the Supreme Court of India order dated 06th September 2007 which is very comprehensive and in line with many of the requirement of HKC regulations. The responsibilities of the various Government authorities, Ship recycling facilities, Ships, and other related stake holders are clearly defined in the ship breaking code. The requirement for the accommodation, sanitary facilities, health care, Insurance, primary amenities such as community centers and labour welfare centers for the workers and other training requirements towards hazardous material and waste handling are also defined. However, due to lack of implementation and enforcement of the code requirements, as reported, still there is a practice of carrying out work without impermeable work surfaces, poor downstream waste management, poor working conditions, low per day wages of the labour in comparison with other labour wages in other industries. The ship breaking facilities in Alang Soshiya belt do not have adequate accommodation and sanitary facilities for the workers employed. Adding to the poor working and living conditions, there are less health and insurance facilities available

for the workers. Occupational diseases to the workers such as respiratory diseases, cancer and other skin diseases are not appropriately recorded. Adequate training on safety and hazardous material handling are not provided; safe working practices are not strictly followed. Accidents are very common, remains a serious matter of concern and during the period from 1983 to 2013 spanning a period of 30 years around 470 workers have lost their life in various accidents in the Alang Ship breaking yards. The frequency of accidents are high owing to the hazardous nature of activities and due to the fact that the labour employed are mostly unskilled, uneducated and untrained. In the last two years, about 16 workers have lost their life. This includes two separate incidents where in two workers have lost their lives in two different yards who have applied for EU Certification.

Ship recycling volume from 1996 to 2003 remained in the range of 600 ships a year and varied between 18 million DWT to 30 million DWT. The period from the year 2004 to 2008 witnessed a low activity in the ship recycling sector due to the robust economy and buoyant freight rate in the global market and therefore less ships got recycled. Majority of the ships that were recycled in India are cargo ships. This has been evident that the number of ships recycled in India has a higher share compared to DWT. India continues to maintain more than 30% share of the global ship recycling volume by dead weight (DWT) and more than 40% share by numbers. In terms of DWT, India recycled 33% ships in 2012, followed by Bangladesh's 24%, China's 20%, Pakistan's 16% and others 7%. By number of ships, India's share was 40%, followed by China's 18%, Bangladesh's 17% and others 17%. India recycled ships equivalent to 18 million DWT corresponding to close to 500 ships.

Figure 3



Source: Gujarat Maritime Board,Care Ratings

However, as shown in the Figure 3, in the year 2018-19, vessels recycled or sent to Alang ship recycling yard hit a very low in the 11-year period. Going forward, there is

a need to restrict the falling market share and increase the dominance of the Indian ship recycling industry and to gain a larger share. In order to recapture the losing market share in the global ship recycling sector, India needs to review the Ship recycling industry and have to upgrade its work process. India has already enacted a wide range of regulatory instruments. Nearly about 50 central and state statutes directly or indirectly exists for the protection and improvement of the working and living conditions of workers in the hazardous industries. However, it is reported that the same has not been strictly adhered in case of the ship recycling industries. Lack of coordination between different enforcement agencies has been reported as one of the major lacunae in the effective implementation of labour and environment laws.

Presently, India has acceded to Hong Kong International Convention for Safe and Environmentally Sound Recycling of Ships, 2009 on 28th November 2019. The Recycling of Ships Bill, 2019 has become an act after receiving the ascent of the President of India on 13th December 2019. The Government has decided to bring this Act to provide regulation of recycling of ships by setting certain international standards by laying down the statutory mechanism for enforcement of such standards. It is expected that the enactment of the ship recycling act, 2019 and compliance will bring more business to the Indian ship recycling yards. As a major step, on 15th October 2020, the Government of India, has notified the Directorate General of Shipping (DGS) as National Authority for Recycling of Ships under the section 3 of the Recycling of Ships Act, 2019 and also has authorized DGS as an apex body, to administer, supervise and monitor all activities relating to Ship Recycling. Accordingly, DGS will look after the sustainable development of the Ship Recycling industry, monitoring the compliance to environment-friendly norms, safety and health measures for the stakeholders working in the ship recycling industry and will be the final authority for the various approvals required by the Ship-Recycling yard owners and the State Governments.

Presently few IACS classification societies are issuing Statement of Compliance to several ship recycling yards in Alang for compliance to Hong Kong Convention and are also making recommendations to EU as an ‘Independent Verifier’ in accordance with the requirements of European Union Ship Recycling Regulation. With the Basel Ban Amendment, adopted by the Parties to the Basel Convention on the Control of the Transboundary Movement of Hazardous and Their Disposal in 1995, coming as

international law on December 5, 2019, the mounting pressure from NGOs and the financial institutions showing keen interest for the responsible approach of Ship recycling by the EU Ship owners, there is a need for the demonstration by the EU ship owners who own about 40 percent of the World fleet.

With HKC not coming in to force immediately, this could end up in a chance for the acceptance of EU Ship recycling regulations by the EU ship owners and recycling in the EU list of yards, which may severely impact the Indian ship recycling industry in a big way unless they are included in the EU list of approved Ship recycling yards considering a jaw-dropping 84% of all European end-of-life ships in 2017 ended up in South Asian countries in either India, Pakistan or Bangladesh and therefore a huge loss of business opportunity for Indian Ship recycling industry.

5. CONCLUSION

It is very necessary that the Hongkong international convention comes early into force towards a safe, sustainable and environmental friendly global ship recycling. Presently, without the ratification from anyone of the major three ship recycling countries such as Bangladesh, China and Pakistan, the Hong Kong convention cannot enter into force unless a diplomatic conference is convened by IMO to agree for a different entry criterion through a Protocol.

As far as India is concerned, India has ratified the Hong Kong Convention, the age-old unregulated ship breaking units are on the preparation to come under the regulations of Hong Kong Convention. The Government of India intends to improve the living and working conditions of the workers in the Ship breaking yards in association with the Industry. In order to improve the conditions, it is paramount to have appropriate formal education and training prior to employment for the employees in the ship breaking and recycling industry as most of the accident occurrence that has taken place is either due to unsafe work practices, not wearing appropriate PPE and poor knowledge of the hazardous material involved in ship building. Presently training is being imparted in the Ship recycling yards by few of the IACS class members. However, still there is no uniform formal training or academics for the employees across the Ship recycling industry. The yards are also to be modernized and mechanized to avoid hard manual labour. Presently almost half of the recycling yards in Alang have invested in

infrastructural and procedural improvements and have obtained a “Hong-Kong Convention Statement of Compliance” from IACS Classification Societies. However, the NGOs in the sector have raised serious concern that there is no adequate transparency in the certification process. An effective adherence to HKC regulations will set a safe working atmosphere free from occupational health hazards as well as safeguard the environment. A change in the face of ship recycling industry as a safe workplace will invite/facilitate the entry of more and more investment as well as youngsters with adequate qualification in the field which will also assist ease up the unemployment issues in the country. It is very much essential that the gap between the regulations in the Hongkong convention and the European Union Ship recycling regulations are to be identified and must be bridged towards wider acceptance. Options must also be explored towards the possibility for an upgradation or shift in the beaching method of recycling to other environmental friendly methods of recycling such as the use of dry dock, jetty/pier ship breaking.

Considering the above, there is a need for the related Governmental organizations and agencies to combine with the other stake holders in the ship recycling industry, academia towards more research activities and development in the area to formulate the training needs, improvement of the Ship recycling facilities and strict implementation of the same. The above measures will not only facilitate the implementation of safety in the ship breaking yards towards reducing accident occurrences but also prevent the environmental degradation and thereby help effectively implement the HKC regulations in ship breaking industry in India. This in turn will also enable to keep high the prospects of India as a true market leader in Ship recycling and as a sustainable, safe and environmental friendly ship recycling industry as envisaged by the Government of India.

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WORLD SEABORNE TRADE AND SEAFARING HUMAN RESOURCES - A STUDY

Poonam Kapoor[9]
Pawan Kapoor[10]

Abstract

Global trade is largely driven by the human needs and other geopolitical factors which are dynamic in nature. In the recent past some of the geopolitical issues include continuing conflict between USA and China impacting exports from China, turmoil in Venezuela affecting their exports, and European containerised imports looking likely to be stuck with demand growth of no more than 2% for years to come. The last year has seen unprecedented changes with the onset of COVID-19 its impact on the vessels calling ports during the year 2020.

A major portion of global trade is carried by ships across the oceans and thus the manpower that drives the ships plays an especially important role.

This paper analyses the demand and supply situation of the seafaring human resources in the context of the global trade. It analyses the change in the global trade of different commodities/cargoes, availability of suitable vessels to carry the cargo and the need and availability of human resources to man those vessels.

Keywords: Seaborne-Trade, Seafaring Human Resource, Manpower, Seafarers

1. INTRODUCTION:

The shipping industry is highly globalized in nature and is strongly linked with the world economy and trade. The time since February 2020 has been phenomenally unprecedented for the entire world, as it is grappling to come to terms with the ongoing Pandemic situation.

While the second and somewhere third wave of COVID-19 pandemic is sweeping across all countries, the global maritime community strives to ensure that the global trade continues.

Shipping facilitates more than ninety percent of world trade. The paper examines the growth of world seaborne trade in terms of cargo loaded, the number of vessels and available carrying capacity of vessels for the period of 2012 to 2022.

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The paper also analyses the change in global situation due to Covid 19 and demand and supply of seafarers. The paper covers analysis of data from the key seafarer providing nations from Asia, and some from European Union, Eastern Europe, Russia, UK, Spain, and Other CIS Countries.

2. METHODOLOGY:

The paper is based on secondary data from various UNCTAD and IIRE reports.

Growth of seaborne trade on various parameters, and analysis of demand and supply situation of human resource is carried out based on various statistical tools such as YoY and avg. YoY growth, mean, linear trends. The following statistical tools are used are in the paper:

2.1 Year on Year (YoY) GROWTH:

The calculation is based on the straight-line growth rates method. The formula used for Straight line growth rate calculation is:

$X = (1/N) * (E - B)/B$

Where,

B = wages in previous year.

E = wages in following year.

N = number of years between beginning and ending year, which in the present study is 1.

2.2 AVERAGE YEAR ON YEAR GROWTH:

This average is calculated for the YoY growth Figures between the years 2009 and 2014 to get an understanding of the rate at which the wages have risen or fallen during the last 6 years.

2.3 FORECASTING BY LINEAR REGRESSION METHOD:

Regression is a statistical tool to examine the relationship of two variables. Linear regression uses one independent variable to explain the outcome of the dependent variable.

Forecasting by Linear Regression:

$Y = A + bX + u$

Where,

Y is Dependent variable,

X is Independent variable,

A is the intercept,

b is the slope and

u is the regression residual

2.4 COMPOUND ANNUAL GROWTH RATE:

Compound annual growth rate (CAGR) is a specific term for the geometric progression ratio that provides a constant rate over a period. CAGR is not an accounting term, but it is often used to describe some element of the business, for example revenue, trade volumes, units delivered, registered users, etc.

CAGR dampens the effect of volatility of periodic returns that can render arithmetic means irrelevant. CAGR is equivalent to the more generic exponential growth rate when the exponential growth interval is one year.

3. SEABORNE TRADE:

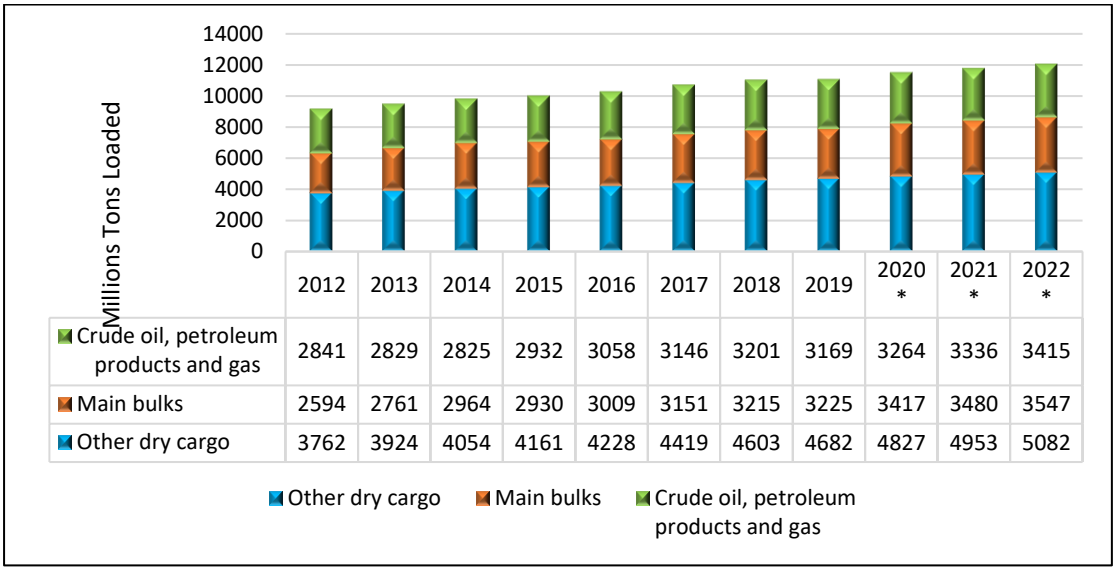
The main driver for requirement of skilled seafaring human resources remains the seaborne trade. Analysis of decade long data reveals an overall growth in the international seaborne trade since 2012. In 2012 the overall loaded cargo was 9197 Million Tons, which at the current rate of growth is expected to reach 12045 Million Tons in 2022 (Figure 1). The data for 2020 to 2022 are forecasted values by regression method.

The flow of seaborne trade comprises various cargo bifurcated as:

- crude oil, petroleum products and gas.
- main bulks (includes iron ore, grain and coal only), and
- other dry cargo (includes bauxite/ alumina and phosphate, and containers).

Figure 1: Growth of World seaborne trade (2012 to 2022)

(Millions of tons loaded)



	2012	2013	2014	2015	2016	2017	2018	2019	2020 *	2021 *	2022 *
Crude oil, petroleum products and gas	2841	2829	2825	2932	3058	3146	3201	3169	3264	3336	3415
Main bulks	2594	2761	2964	2930	3009	3151	3215	3225	3417	3480	3547
Other dry cargo	3762	3924	4054	4161	4228	4419	4603	4682	4827	4953	5082

Source: Review of Maritime Transport (UNCTAD) 2020

**Forecasted numbers*

The reported loading for the crude oil, petroleum products and gas in 2012 was 2841 MT (31 per cent share) and is predicted to be 3415 MT by 2022 (28 per cent share). Main Bulks which were 2594 MT in 2012 (28 per cent share) and expected to be 3547 MT by 2022 (retaining the 30 per cent share).

The other dry cargo and containers which were 3762 MT in 2012 are predicted to be 5082 MT by 2022. The per cent share remains around 41 per cent of the total cargo. Observation of data of various cargoes shows that the Compound Annual Growth Rate (CAGR) for the crude oil, petroleum products and gas is 2.60 per cent between 2012 and 2022. On the other hand, the Main bulks registered growth of 5.78 per cent CAGR; other dry cargo and containers, and total cargo have registered CAGR of 4.75 per cent and 4.36 per cent respectively for the same period.

Consolidated data from above clearly reveals a sustained growth in seaborne trade for all the various categories of cargo since 2012 as displayed in the Table 1 (with last three years' data forecasted). This is a positive sign supporting a growth in shipping which is reflected in the Table 2 displaying the growth in number of vessels and their cargo carrying capacities (with last three years' data forecasted).

Table 1: Growth in Sea Borne Trade

Cargo Categories	MT Loaded in 2012	MT Load expected in 2022	CAGR
Crude Oil, Petroleum Products and Gas	2841	3415	2.60
Main Bulks	2594	3547	5.78
Dry Cargo and Containers	3762	5082	4.75
Total Cargo	9167	12045	4.36

Table 2: Growth in Carrying Capacity and Vessels

	Number of Vessels	DWT Capacities (Thousands of DWT)
2012	46901	1518109
2022	54175	2157214
CAGR	1.45	3.58

However, this growth prediction is expected to take a beating considering the recent geopolitical developments across the globe, and the impact of the pandemic.

4. GROWTH IN CARRYING CAPACITY AND NUMBERS:

With the growth in seaborne trade from 2012, there has been a corresponding growth in the overall DWT in capacity of vessels, and the number of vessels. Analysis of vessel capacity (DWT) is displayed in Figure 2, where left Y axis has thousands of tons while right Y axis has per cent growth. The X axis shows the years. The growth in number of vessels is displayed in Figure 3 where the left Y axis has numbers, and the right Y axis has per cent growth.

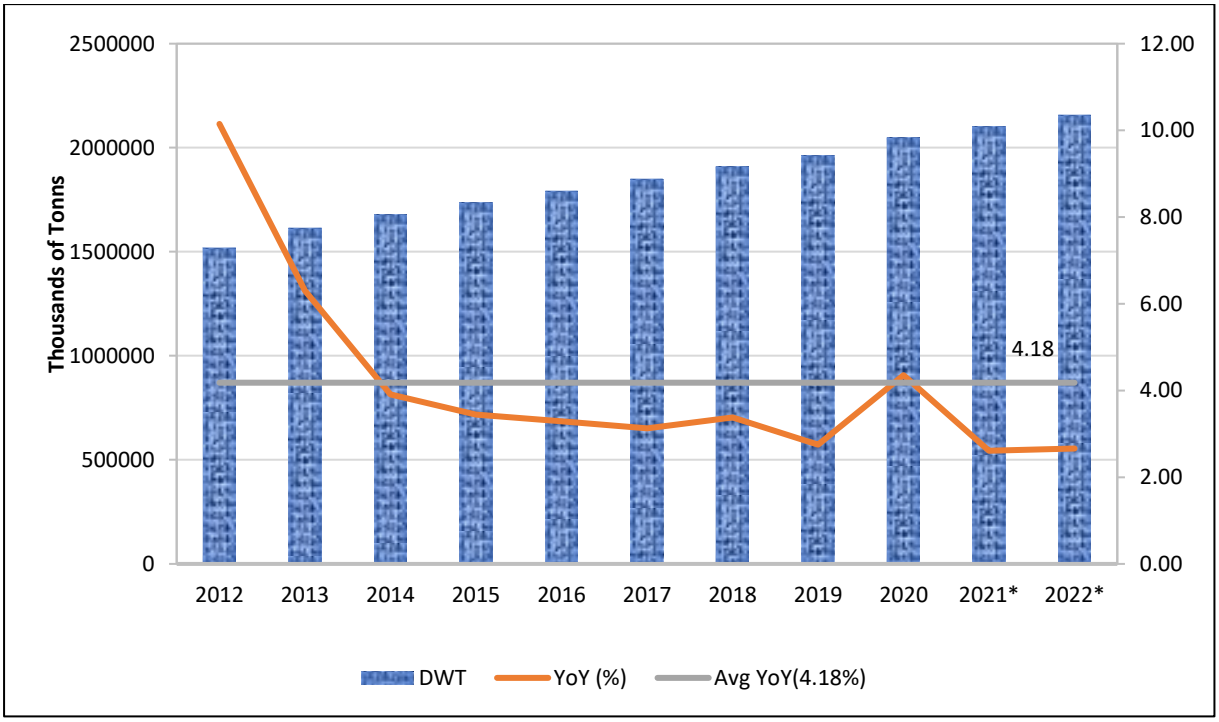
For analysis, only vessels of 1000 or more GRT have been considered. There were 46901 Ships and 1518109 (thousands of DWT) available to facilitate the seaborne trade in 2012. This is expected to grow to 54175 ships and 2157214 thousand DWT in 2022.

While the DWT has grown at the CAGR of 3.58 per cent from 2012 to 2022, the number of vessels has grown at a CAGR of 1.45 per cent during the same period. The data for 2021 and 2022 have been forecasted using regression analysis. Ever increasing size of vessels is one of the factors for a lower CAGR growth in number of vessels.

Shipping and seaborne trade has always been susceptible to various risks with ever changing global scenario. The cyclical recovery of global economy in 2017 after a decade long economic crises in 2008-2009 has positively impacted major growth indicators. However, in recent times the conflict between the USA and China, and in the other parts of the world, plus the impact of the pandemic seems to again impact the overall trade potential.

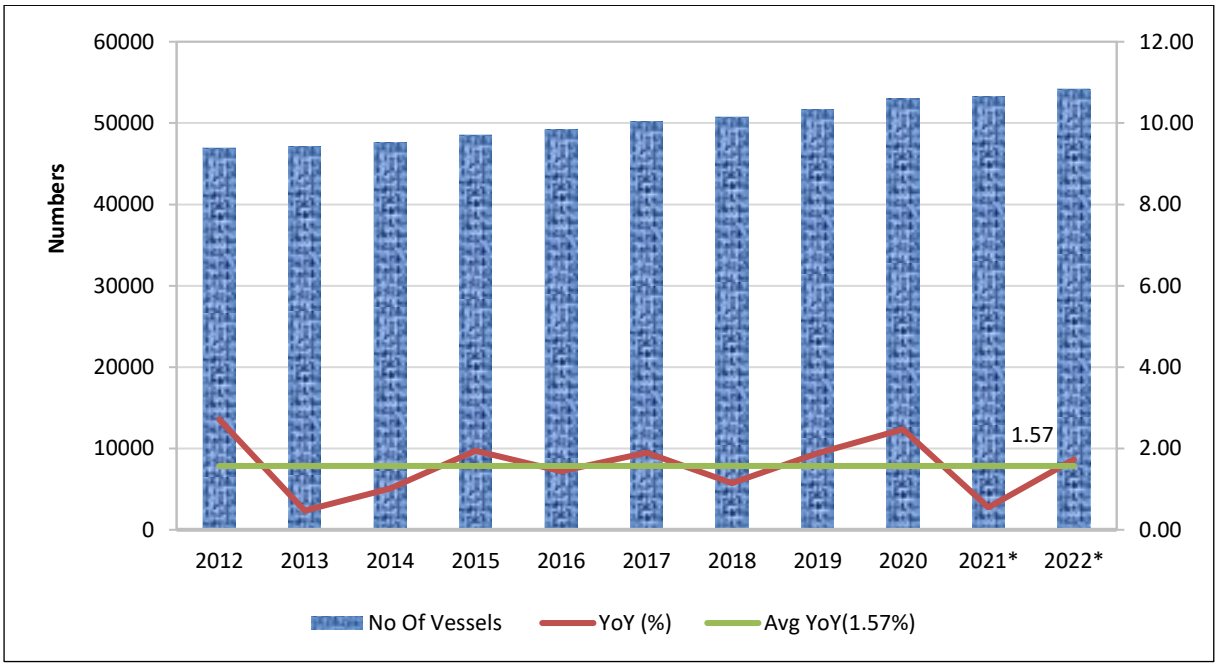
Figure 2: World Fleet Capacity Growth (2012 to 2022)

Dead-weight tonnage (thousands of tons)



Source: Review of Maritime Transport (UNCTAD) various issues

Figure 3: Growth in Numbers of Vessels (2012 to 2022)



Source: Review of Maritime Transport (UNCTAD) various issues

5. CHANGE IN GLOBAL SITUATION DUE TO COVID–1911:

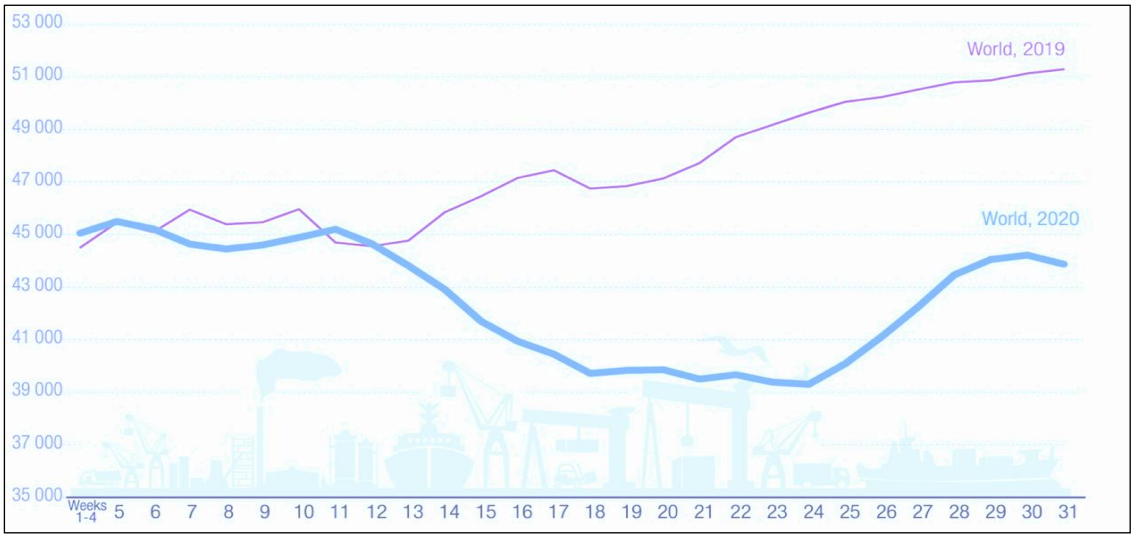
During 2020 the COVID-19 pandemic has severely impacted the port traffic (UNCTAD RMT 2019). In the first 31 weeks of 2020, the port calls by all ship types were down by more than 10 per cent on the same period in 2019. For the first 10 weeks of 2020, until about mid-March, port calls for 2019 and 2020 were almost identical. Afterwards, volumes for 2020 began to decline noticeably. By weeks 21 and 22, i.e. the second half of May 2020, global port calls had fallen to less than 80 per cent of calls for the same period during the previous year. A subsequent slight improvement showed signs of weakening again in the last week of July (week 31). These trends vary by ship type as well as by region.

The impact of COVID-19 has not been uniform across different shipping market segments. Some segments have been hit extremely hard, but the decline in ports calls is masked in the total Figures by container traffic, which has not been hit as hard as

[11] SOURCE: UNCTAD – Impact of COVID-19 Pandemic on trade and development

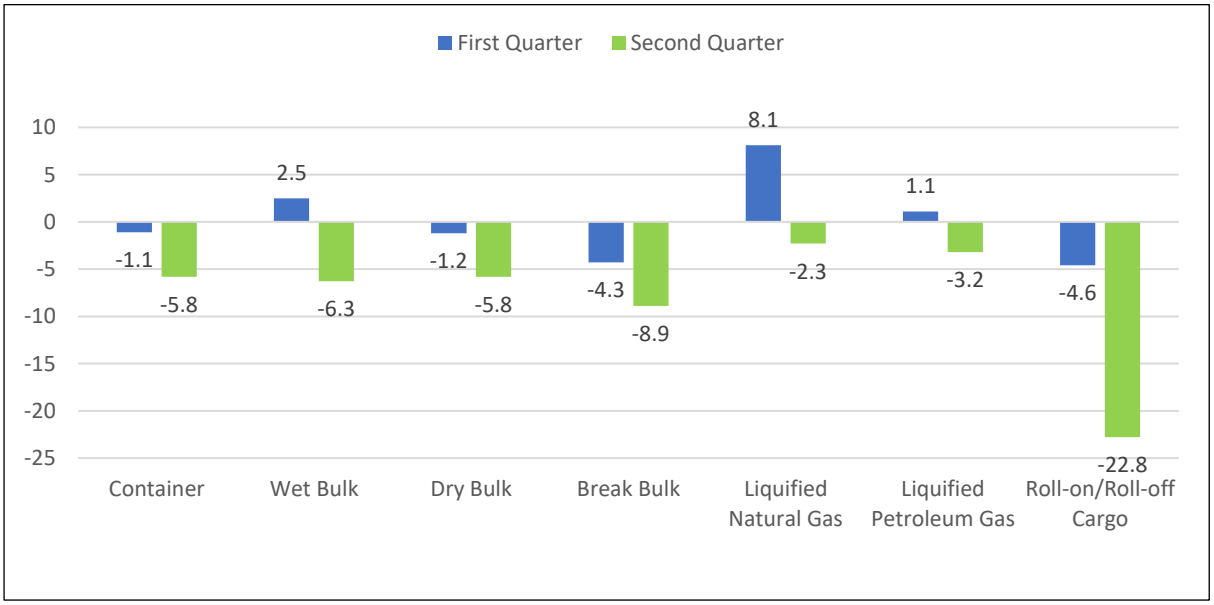
some other segments, as shown in Figure 4 below, and accounts for about 60 per cent of seaborne trade by value.

Figure 4: Impact of Pandemic due to COVID-19 on World port of calls in 2020



In the second quarter, breakbulk and roll-on/roll-off cargo ships, which include ferries and other vessels that carry passengers, suffered significant declines in port calls, at around -9 and -23 per cent, respectively.

Figure 5: Changes in port of calls in 2020 with 2019 due to COVID-19.



COVID–19 has indeed impacted shipping sector in many ways causing an overall slow-down. This will affect the projected growth to some extent.

6. DEMAND FOR SEAFARERS FOR MANNING WORLD FLEET:

The number of vessels available worldwide impacts the requirement of seafarers to man them. Vessels as small as 1000 GRT may have a total crew (officers and ratings) between 10-14 whereas larger vessels like VLCC, VLOC, etc. may have a complement of up to 30 seafarers on board. For the purpose of analysing seafarer demand, a safe manning scale of 22 seafarers per vessel is considered.

The breakup of various ranks is displayed in Table 3 below. The position of trainees i.e., Deck and Engine Cadets and Trainee Seamen have been excluded from this list.

Table 3: Standard Manning Scales

Sr. No.	Levels	Ranks	No. of seafarers
1	Management Level	Master	1
		Chief Engineer	1
		Chief Officer	1
		Second Engineer	1
2	Operational Level	Second Officer	1
		Third Engineer	1
		Electrical Officer	1
		Third Officer	1
		Fourth Engineer	1
3	Support Level	Pump man (only on tankers)	1
		Bosun	1
		Fitter	1
		Able-Bodied Seaman	3
		Motorman	2
		Ordinary Seaman	2
		Wiper	1
4	Catering Staff	Cook	1
		Messman	1
Total Seafarers			20 without Catering Staff 22 with Catering Staff

While the number of vessels in the world fleet of 1000 or more GRT, are 52961 in 2020 and estimated to cross 54175 in 2022, a Figure of 53000 vessels has been considered to evaluate the demand for seafarers at present. Table 3 displays the computation of seafarers' numbers in various categories. While the tenures of various seafarer positions on board for most nationalities are 3-4 months for Management Level Officers, 5-6 months for Operational Level Officers, and 8-9 months for the Ratings, some nationalities may have extended tenures. Thus, to compute the demand of seafarers, two scenarios have been worked out as follows:

- Scenario 1: Applying multiplying factors to arrive at 50% surplus for Officers and 25% surplus for Ratings over and above the onboard requirements.
- Scenario 2: Applying multiplying factors to arrive at 75% surplus for Officers and 50% surplus for Ratings over and above the onboard requirements.

It is estimated that while Officers needed to fulfil the requirement are between 715500 (Scenario 1) and 834750 (Scenario 2); the Ratings currently required are between 728750 (Scenario 1) and 874500 (Scenario 2). The Saloon ratings (Cook and Messman) and Trainees (Deck, Engine, ETO, and Ratings) have been excluded from this computation.

Table 4: Estimated Demand for Officers and Ratings in 2020 for 53000 Vessels of GRT 1000 and above

Seafarer Category	Average Numbers Per Vessel	Estimated by Number of vessels 1000 GRT and above in 2020 - 2021	Total Requirement on board	Total Demand at 50% surplus for Officers and 25% Ratings (Scenario 1)	Total Demand at 75% surplus for Officers and 50% for Ratings (Scenario 2)
Management Level Officers	4	53000	212000	318000	371000
Operational Level Officers	5	53000	265000	397500	463750
Total Officers	**9**		**477000**	**715500**	**834750**
Deck and Engine Ratings	11	53000	583000	728750	874500

Total Deck and Engine Ratings	**11**		**583000**	**728750**	**874500**
Total Officers and Ratings	**20**	**53000**	**1060000**	**1444250**	**1709250**

Note: Above computation does not include Saloon Staff on Merchant Vessels, as well as Trainees of any category.

7. SOURCES OF SEAFARERS SUPPLY:

Data obtained from 14 major ship owners and managers operating worldwide and having establishments located in various countries for sourcing seafarers, account for nearly 80% of the world seafarers. The countries include Asian countries: China, India, Myanmar, Indonesia, Philippines and Sri Lanka; and European and other countries: Ukraine, Romania, Croatia, Russia, Estonia, Latvia and Lithuania.

In the Officer category, India emerges on top with a supply of 144930, followed by China at 118566, and Philippines in third position with 95975 officers. With different shipboard service tenure durations followed for different nationalities, two possible scenarios have been considered as far as demand is concerned, at 715500 and at 834750 (table 4 in Section 2.4). The nationalities considered (of which data has been analysed) cater to between 85 (Scenario 1) to 77 (Scenario 2) per cent, the remaining is fulfilled by the Rest of the World.

Philippines emerges at top for supply of Ratings with 173107, holding a market share of between 20% to 25%, followed by China with 122120, and Indonesia in the third position with 92465. The projected demand of Ratings is between 728750 and 874500 (table 4 in Section 2.4) is fulfilled up to 92 (Scenario 1) to 77 (Scenario 2) per cent by the nationalities considered (of which data has been analysed), and balance by the Rest of the World.

The Population, Number of Seafarers, and potential of each country to supply seafarers in terms of percentage of the total demand has been computed for both the Scenarios for Officers, Ratings and Total Seafarers and presented in Figures 6 to 14.

Other countries spread across the globe which supply seafarers but could not be analysed due to non-availability of recent data, include Pakistan, Vietnam, Cambodia, etc. from Asia; UK, Poland, Italy, France, Sweden, Netherlands, Denmark, Norway, Spain, Portugal, Turkey, etc. from Europe; and Australia and New Zealand. These countries have been grouped as 'Rest of the World' in Figures 8 to 13.

Figure 6: Active Seafarers from Countries Analyzed

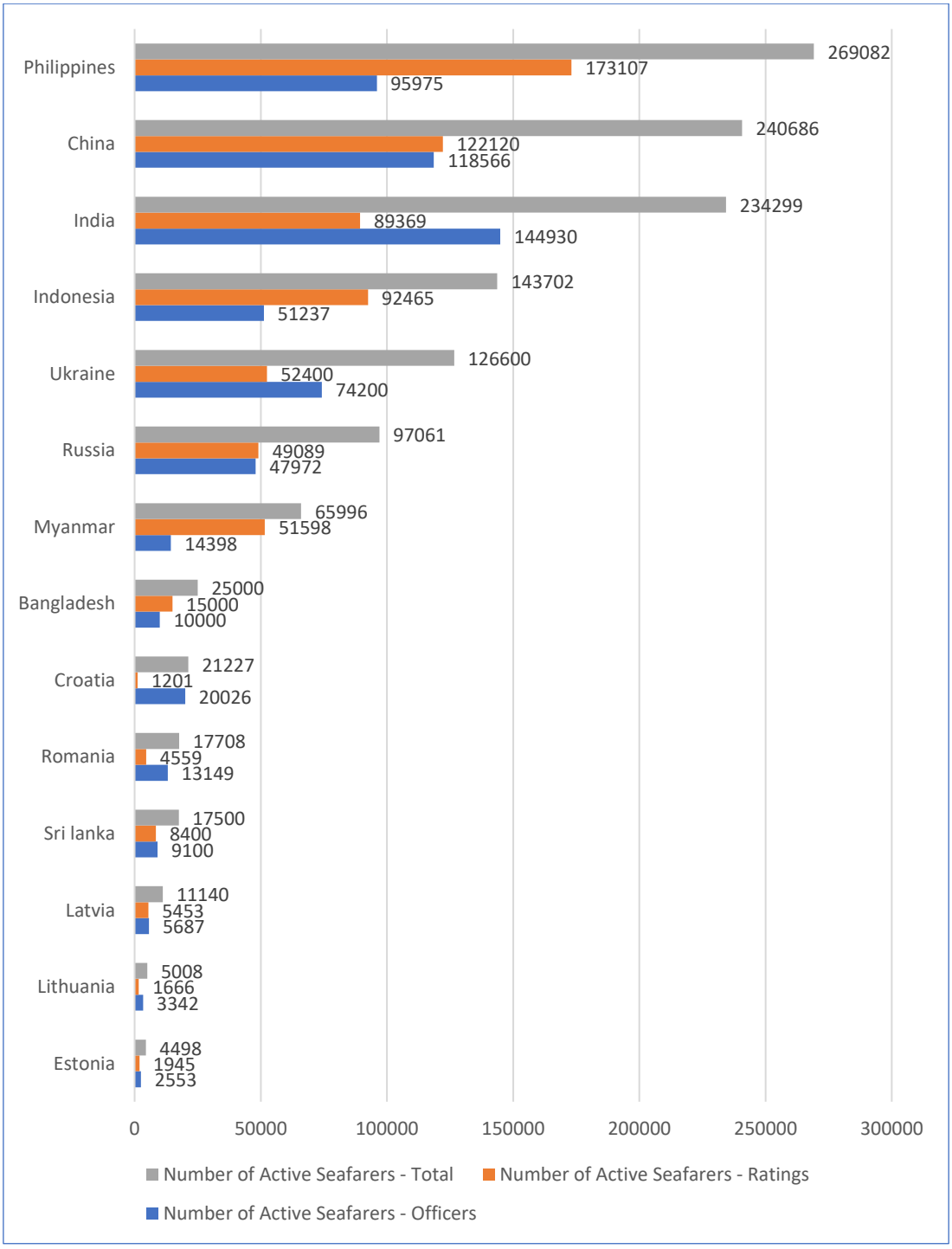


Figure 7: Number of Active Seafarers and Percentage of Population

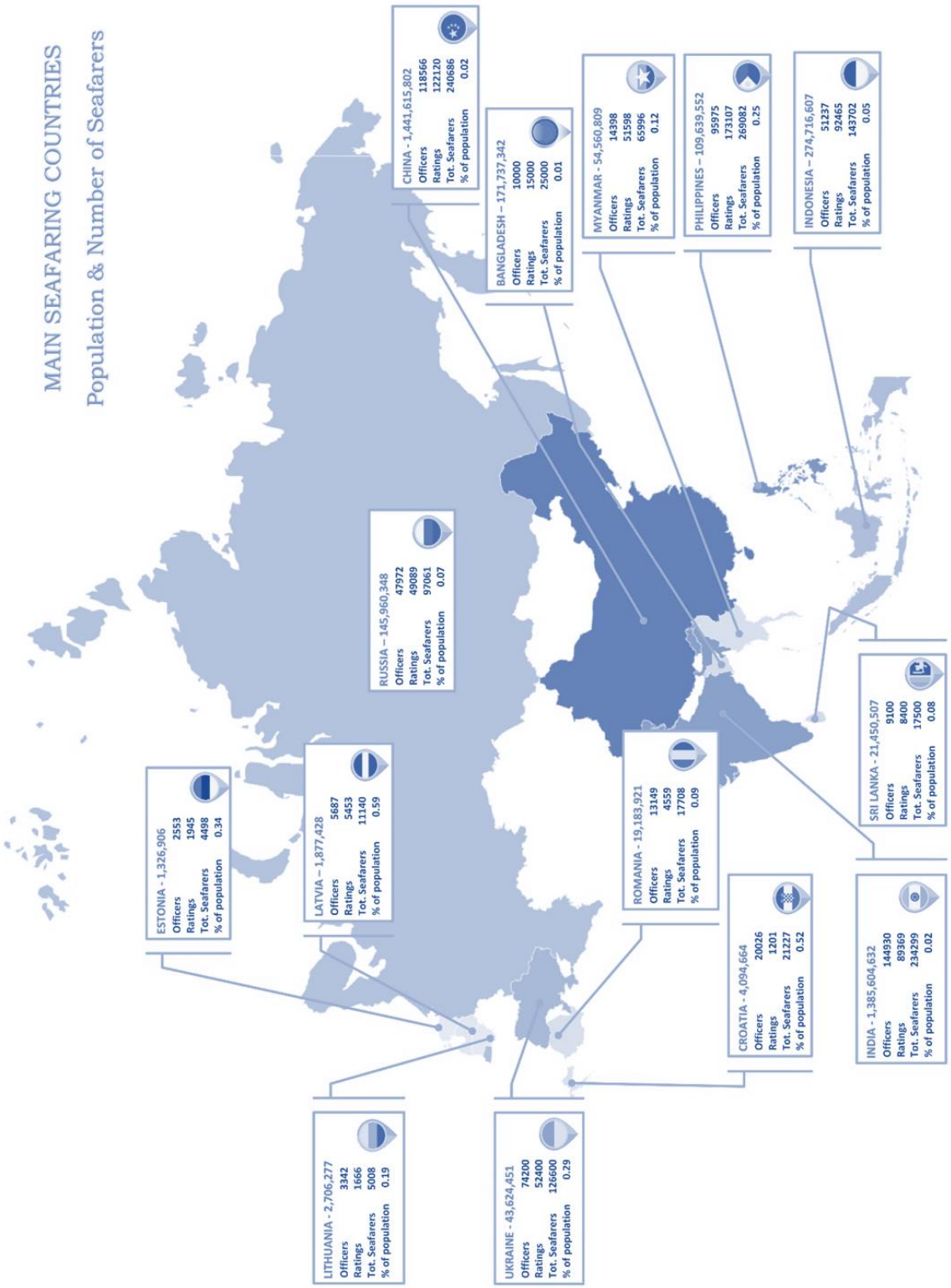


Figure 8: Supply Potential to meet Global Demand: Scenario 1- Officers

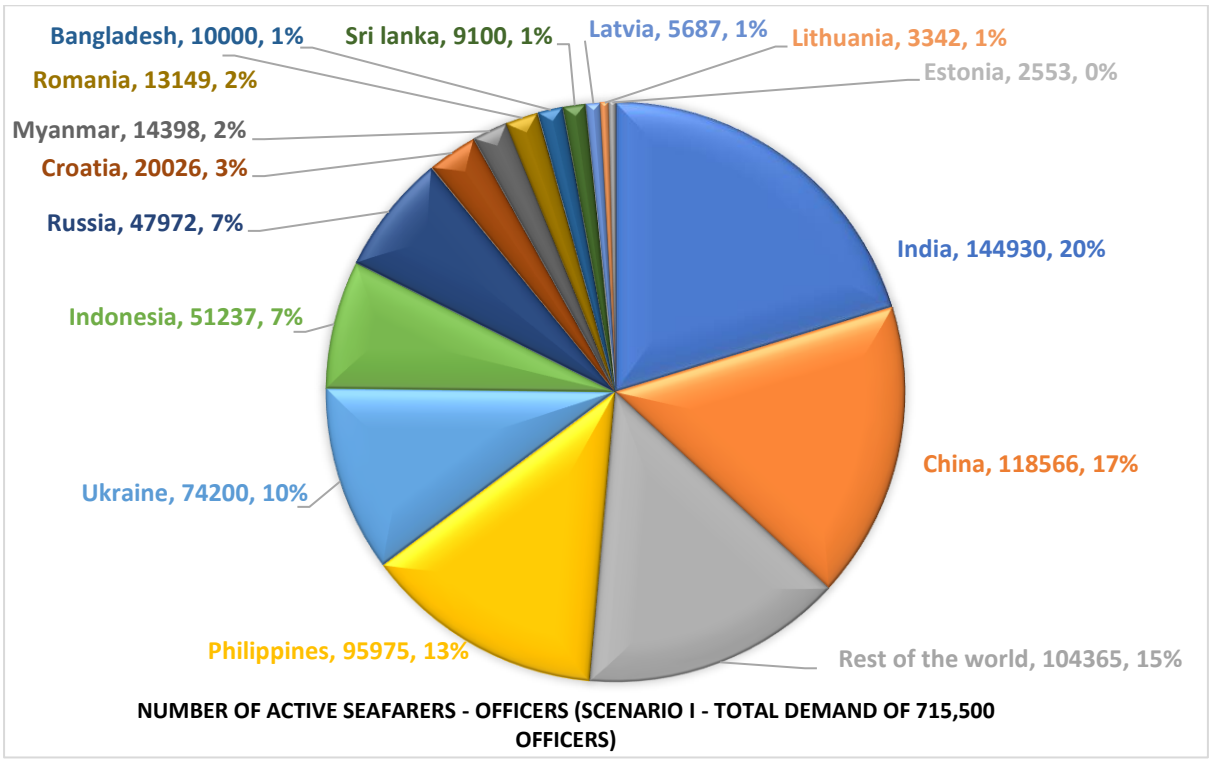


Figure 9: Supply Potential to meet Global Demand: Scenario 2- Officers

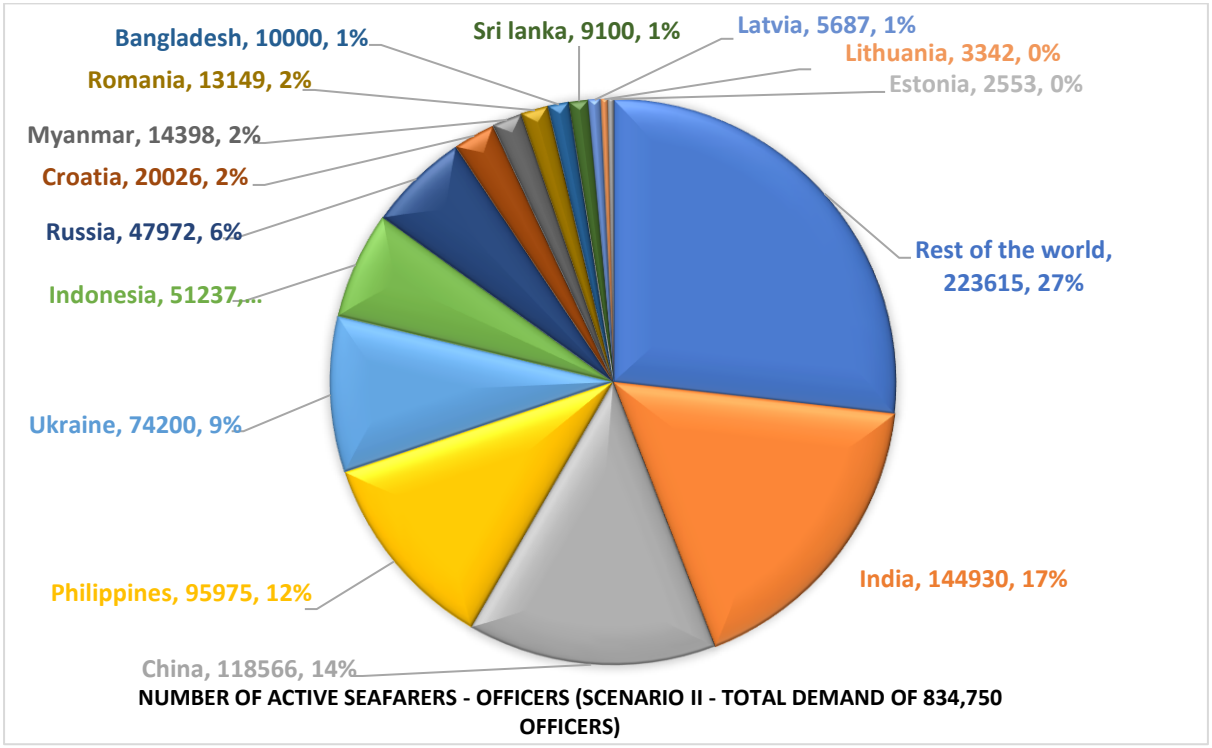


Figure 10: Supply Potential to meet Global Demand: Scenario 1- Ratings

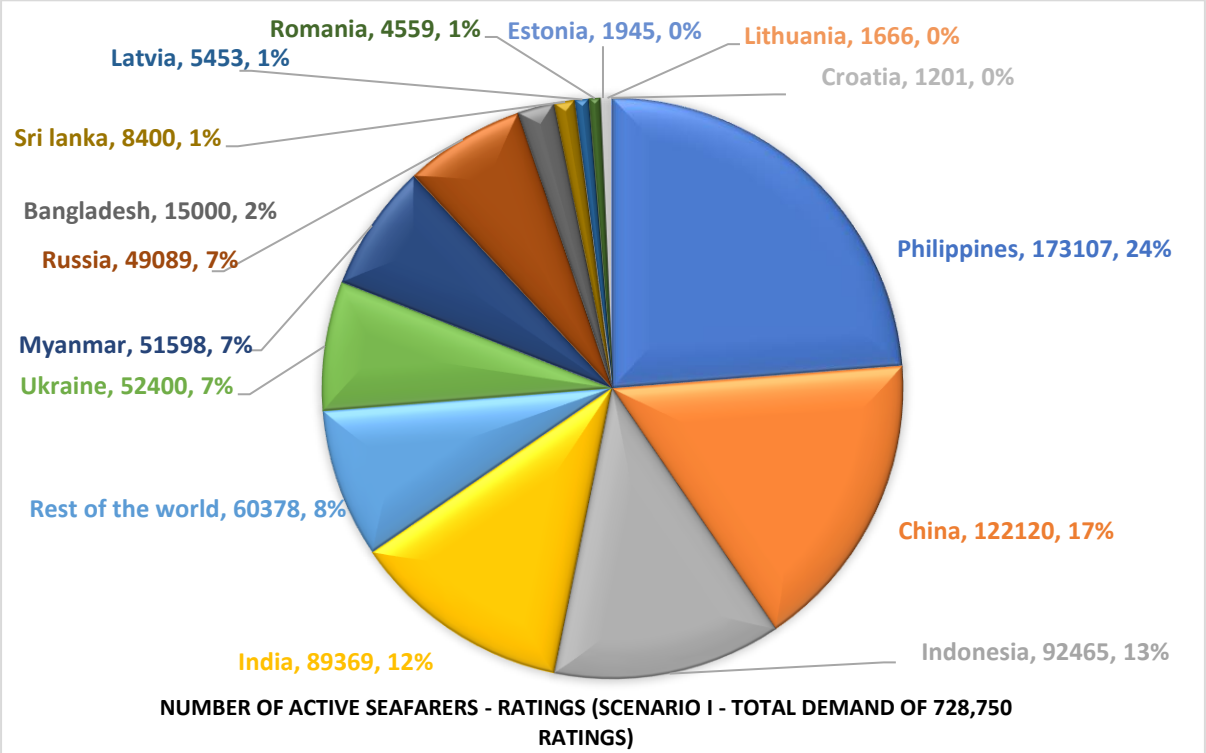


Figure 11: Supply Potential to meet Global Demand: Scenario 2- Ratings

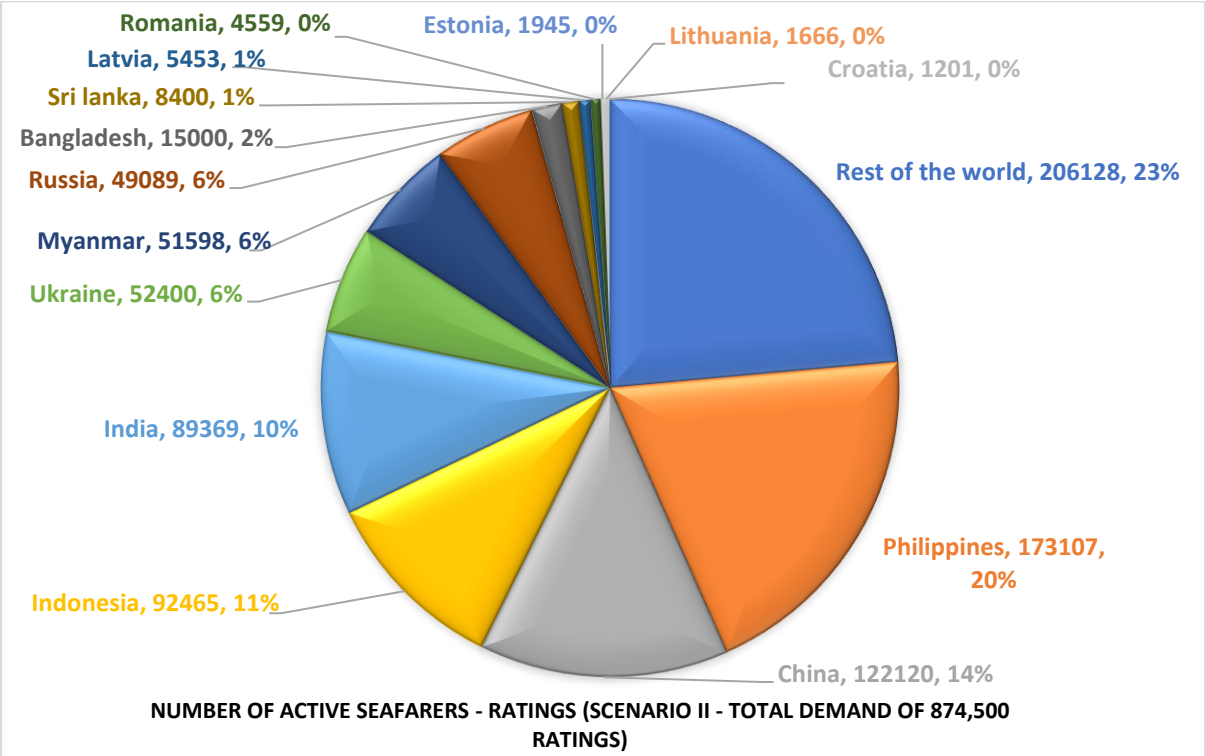


Figure 12: Supply Potential to meet Global Demand: Scenario 1- Total

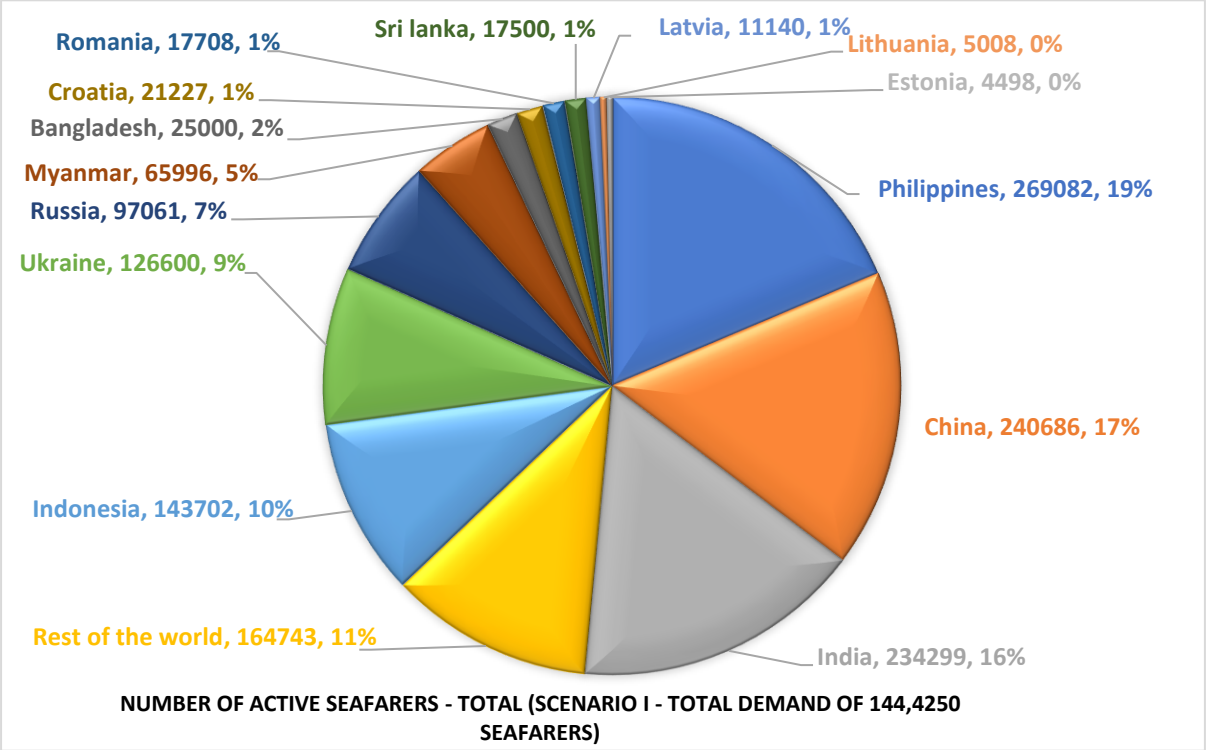
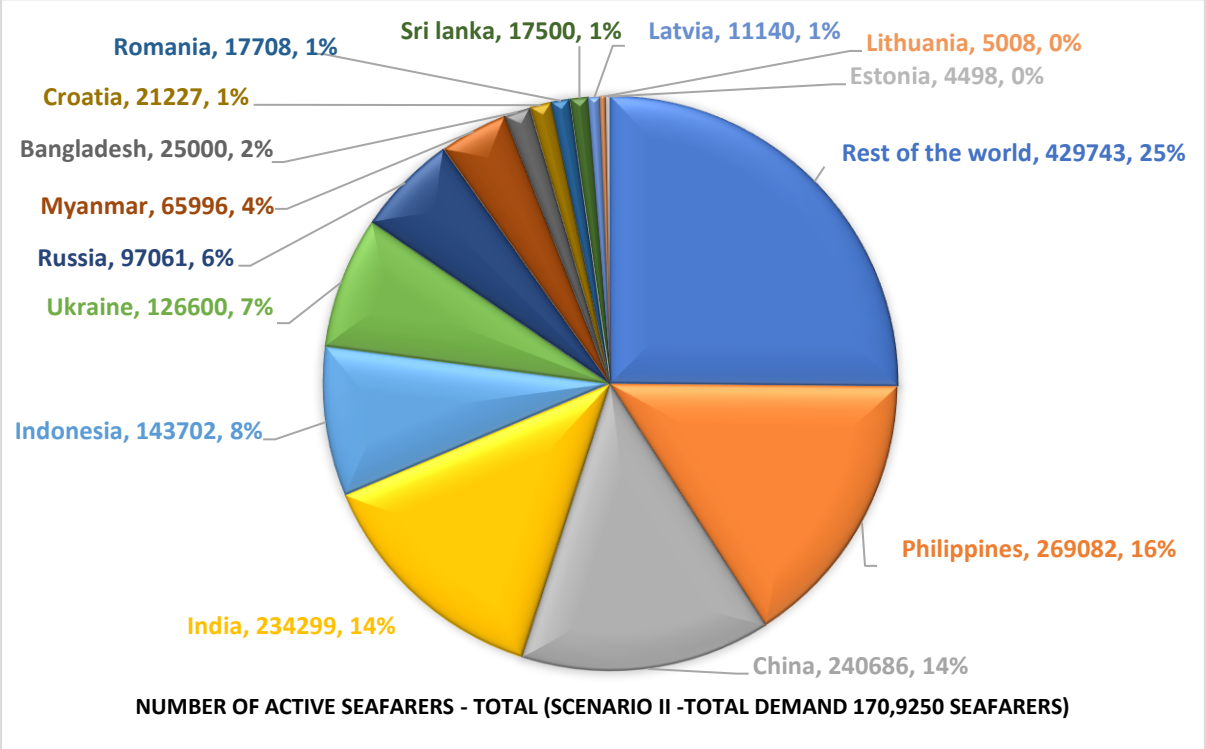
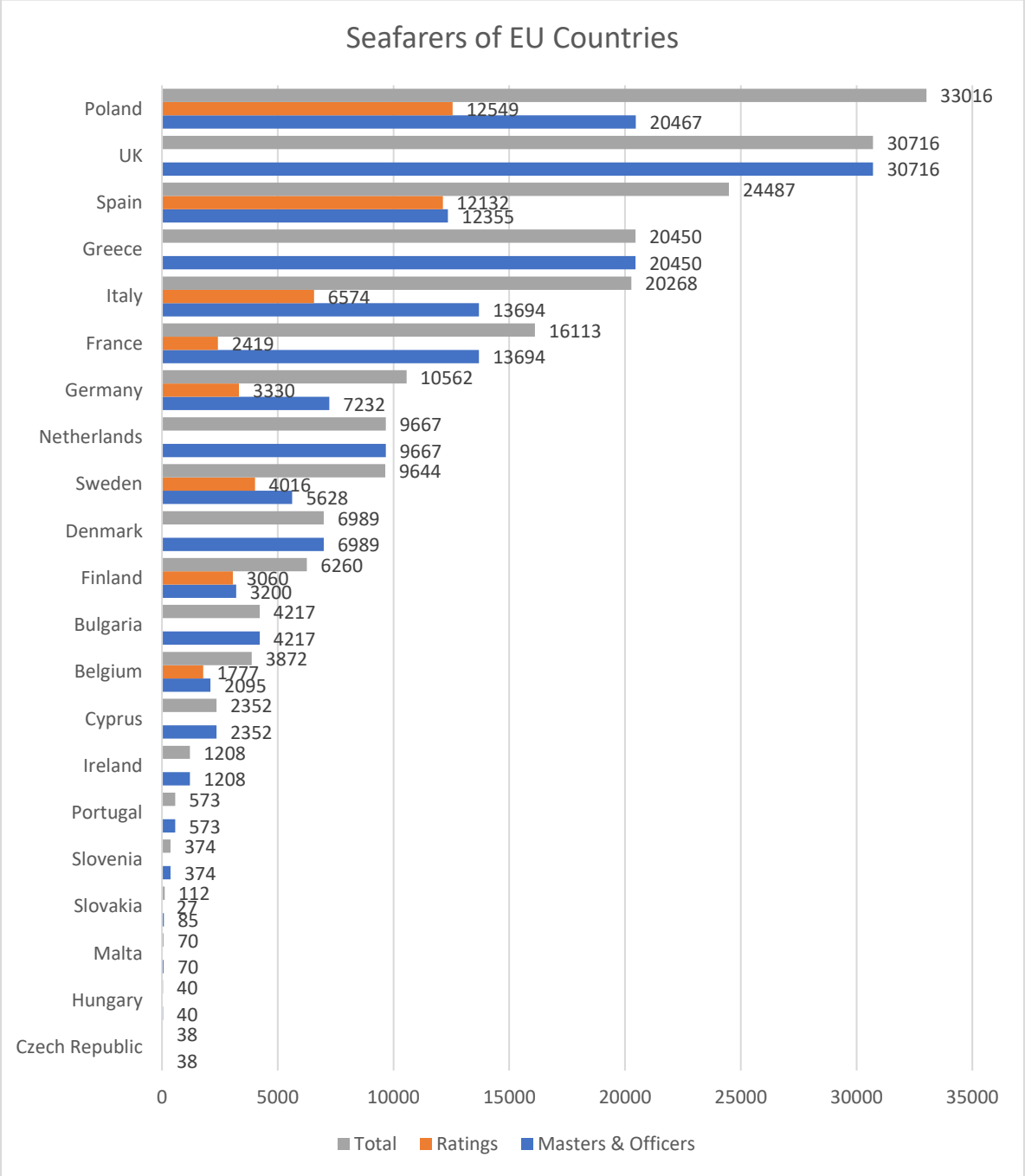


Figure 13: Supply Potential to meet Global Demand: Scenario 2- Total



While the current active seafarers' numbers for the Rest of the world are not known precisely due to non-availability of data, a report by EMSA (Seafarers Statistics in EU – 2018) details the numbers available in 2018 which have been compiled and presented below in Figure 14. The countries Ukraine, Romania, etc. have been excluded from the data computation and display below.

Figure 14: Supply Potential of Seafarers by EU Countries in 2018



8. CONCLUSION:

When we juxtapose the supply of seafarers over the computed demand, we find that with availability from known prominent nationalities (Figure 6) plus availability from European nations (Figure 14), we may be able to meet the demand in Scenario 1 (Table 4). For Scenario 2, we are certainly running short of numbers.

However, even this match with Scenario 1 requirements would fall short on account of the specialization needed for operating certain kind of vessels, availability of sufficient numbers for each rank, and some inaccuracies in numbers from different nations which have been considered for computation of supply.

While Covid 19 may have resulted in reduction of the projected demand for now, this may also be nullified in due course as the situation improves.

Hence the number of seafarers being produced by different nations may need to continue. But what needs to be understood is that producing at trainee levels alone cannot be a solution to the shortfall. There is an urgent need to rationalise the availability of different ranks for filling the required slots as they come up. This means that systems and practices to support the seafarers moving up the ladder from trainee levels, without compromising on competence, need to be innovatively conceived and implemented to ensure that for all rank slots there are sufficient numbers available.

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Mr. Pawan Kapoor has vast and varied working experience of over 38 years in the maritime industry of which 28 years has been with maritime education, training, quality assurance, development and management of organizations and related activities.
The highlights of his 27 years' shore career have been the development of the International Maritime Training Centre - IMTC (formerly known as the Indian Maritime Training Centre), which he was also leading from 1998 to 2002. He was then the Chief Executive of the Tolani Maritime Institute, the premier private maritime institute in Pune, India, spread over 120 acres with over 100 staff and 700 students. Besides various academic and infrastructure developmental tasks at the institute, he spearheaded the change management program to provide the institute a university like organizational structure.
He is a certified trainer. Besides teaching marine engineering subjects, his experience of developing and running organizations, and interacting closely with management gurus of the well-known IIM Ahmedabad, has provided him with the expertise in training in management and human resource areas too.
Through various human resource and management programs in maritime and offshore sector, he has trained close to 2000 people till date. These include professionals with seafaring as well as non-seafaring backgrounds. He also continues to guide engineers for developing their competence and conducts several value additions programs for deck and engineering staff.
He is a lead auditor of ISO systems and has been consulting companies in development and restructuring of their systems to meet customer and internal requirements.
