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Seafarers' Current Awareness, Knowledge, Motivation and Ideas towards Low Carbon-Energy Efficient Operations

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Abstract: International and national concern about detrimental climate change has generated pressure for the shipping industry to play its' role in reducing the 3.3% of global carbon emission it emits. On the 1st January, 2013, the IMO (International Maritime Organisation) enforced regulations to support the reduction of shipping carbon emissions by improving energy efficiency. These measures directly and indirectly affect the daily operations of seafarers and onshore performance and managerial personnel. Whilst the industry has made efforts to raise the awareness of many stakeholders and research has been undertaken to investigate energy efficiency barriers, little has been done to capture the opinions, needs and knowledge of seafarers. A questionnaire was distributed in the last quarter of 2011 to investigate seafarers' awareness, knowledge and motivation towards carbon emissions in general and towards shipping carbon emissions. It also investigated opinions as to which personnel have the most influence over carbon reductions and what are the most important operational improvements that can be made. The authors have collected 317 questionnaire responses. The primary benefit of this study is to support the identification of an operational strategy to improve energy efficiency, including the development of LC-EE (low carbon-energy efficiency) MET (maritime education and training), which is shown to be needed.

Key words: Low carbon, energy efficiency, maritime education and training, awareness, knowledge, motivation, seafarers.

1. Introduction

Carbon emissions (specifically carbon dioxide (CO_2)) are considered to be of most concern out of the GHGs (greenhouse gases) regarding climate change [1, 2]. This is due to their combination of damaging GHG properties, large proportion in the atmosphere, and the influence that changes in human activities can have over their proportion in the atmosphere [3]. As a result, several international and national carbon emission reduction targets have been introduced [4-6]. Shipping and aviation have been identified as industries where the combustion of fuel, producing carbon emissions as a by-product, often occurs between nations and therefore the apportionment of responsibility and thus reduction is not as clear cut as it is for land-based industries. The IMO have, therefore, taken responsibility [4] to ensure that the shipping industry plays its' role in reducing the 3.3% of global CO_2 emissions it was predicted to have emit in 2007; 2.7% from international shipping alone [7]. On the 1st, January 2013, the amendments made to The International Convention for the Prevention of Pollution from Ships, Annex VI [8] entered into force including the addition of the first maritime energy efficiency regulations. The regulation associated with energy efficient ship design, the EEDI (energy efficiency design index), is applicable for all new build ships, and ships that undergo major conversions, above 400 gross tonnes [9]. The calculated EEDI value for the ship is benchmarked against an EEDI baseline value and, only if the EEDI is within the limit, the ship design is certified to be built. The regulation associated with energy efficient ship operation is the

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SEEMP (Ship Energy Efficiency Management Plan). All new and existing ships above 400 gross tonnes are required to have a specifically developed SEEMP onboard by the first of the intermediate or renewal survey [10].

The EEDI will affect the daily operations of seafarers in the long term as it is expected to catalyse the development and installation of new low carbon technologies and innovations [11] such as those presented in Ref. [7]. It will take some time for the next generation of the world fleet to exhibit these new technologies and innovations and for the existing fleet to take up retrofits. Nevertheless, it is necessary for those who will be in charge of their direct operation, the seafarers, to have the awareness and motivation to accept the changes, as well as the knowledge and skills to operate them safely and to maximise their energy efficiency potential. The aim of the SEEMP is to provide a document and tool to be used by the ship's master, operators and owners, to monitor the ships' and fleets' energy efficiency performance over time and identify operations where efficiency improvements can be made. However, whilst suggestions for best practices are listed, the details of how to implement these practices are lacking. The suggested best practices within the SEEMP include: voyage optimisation, optimum ship handling, hull maintenance, propulsion systems and maintenance, waste heat recovery, improved fleet management, improved cargo handling, energy management, and fuel types [10]. Many of these improvements require management and onshore personnels' involvement (for example, the decision to install weather routing, or adjusting the average voyage speed). Nevertheless, regardless of the decision level, the majority of the improvements will directly and indirectly affect the daily operations of seafarers. Again it is, therefore, evident that seafarers must have the awareness, knowledge, skills, and motivation required to make the best energy efficiency decisions and implement operational changes in line with the ship's SEEMP and beyond, in a safe and efficient manner.

This paper has been constructed with Section 2 introducing the need to assess seafarers' current energy efficiency awareness, knowledge, skills, motivation, and educational and training requirements, in order to provide a framework for effectively achieving energy efficient ship operation. Section 3 describes the design and methodology behind the questionnaire developed to investigate seafarers current attitudes and requirements. Section 4 discusses the profile of the questionnaire participants. The questionnaire results are presented and discussed in Section 5. Conclusions are drawn in Section 6 followed future work considerations in Sections 7.

2. The Research Gap

Buhaug et al. [7] estimates that between 25% and 75% of the CO_2 emissions emit by the shipping industry per tonne-mile can be saved using a combination of technological and operational measures; such as those incentivised by the EEDI and SEEMP. Furthermore, Buhaug et al. [7] state that "many of these measures appear to be cost-effective, although non-financial barriers may discourage their implementation". The cost effectiveness of different measures is also assessed using marginal abatement cost curves in Refs. [12-14]. Bazari et al. [11] make an assessment of the CO_2 savings expected with the mandate of the EEDI and SEEMP alone in light of different growth, regulation uptake, fuel price and wavier scenarios. Conclusions include that the EEDI and SEEMP will provide significant CO_2 savings although not enough to meet CO_2 reduction targets with world trade growth as predicted. Therefore, further regulations and financial incentives [15, 16] are likely to be implemented. This only increases the need for the industry to be aware and ready to adapt to new designs, technologies and operations.

There are many internal and external stakeholders in the shipping industry that have direct and indirect influences over ship operations. The cargo owner and charterer influence the need for transport within certain locations and time limits, and they dictate clauses stated in the charter party. Dependent on split incentives, discussed in Rehmatulla & Smith [17] and Johnson & Andersson [18], the ship owner, charterer or another stakeholder may have the most influence over the installation of energy efficient technologies and systems to support energy efficiency practices. Regarding ship operators, the commercial department (i.e., voyage manager) has influences over the ship scheduling and voyage plan, whilst the technical department (i.e., the ship superintendent) tends to deal with maintenance and the daily issues regarding the ship. Furthermore, third party companies offering technical support, such as weather routing or continuous performance monitoring systems, may also be employed. There are many more stakeholders that have not been mentioned here and, even those that have been mentioned here, have many more responsibilities and influences over operations related to energy efficiency. Defining this network of stakeholders has not been the focus of this research paper, however, acknowledging the complexity of organisational structures is fundamental for considering the practical implementation of energy efficiency best practices: requiring willingness to commit, resources management and teamwork between all stakeholders. Bielić [19] discusses how different organisational structures impact on various personnels' responsibilities, communication, teamwork and decision-making. Rehmatulla & Smith [17], Johnson & Andersson [18] and Acciaro et al. [20], investigate barriers to implementing low carbon shipping, primarily gathering the perspective of ship owners, operators and management companies as well as charterer and cargo owners. Nevertheless, both recognise the importance of seafarers in realising efficient ship operation at an implementation level although the seafarers themselves are often very detached from the operational decisions made by other stakeholders onshore.

With increasing environmental concern the industry has primarily focused on raising the awareness and knowledge of management stakeholders via regulations, conferences and training course. Whilst this is a very necessary step to overcoming many of the barriers to low carbon shipping, in parallel, comparatively little focus has been made towards increasing the awareness, knowledge skills and motivation of seafarers.

The STCW (International Convention on Standard of Training Certification and Watchkeeping for Seafarers) 1978, was updated in 2010 to include changes in each chapter for marine environmental awareness training [21]. However, the requirements for the training are vague and will be incorporated under the Seafarer Basic Safety Training. This is not likely to be sufficient to raise the awareness profile and knowledge of energy efficient shipping to the level that is required. In 2011, Banks et al. [22] conducted interviews with different industry stakeholders and concluded that there was no formalised training for seafarers. Banks et al. [22] also proposed a framework for effectively introducing energy efficiency awareness, knowledge, motivation and skills amongst both cadets and seafarers. During visits to MET (Maritime Education and Training) institutes in 2012, the author experienced that the awareness and knowledge amongst some trainers was not yet established, let alone amongst seafarers. This was demonstrated during discussions by the trainer emphasising what the author considered to be the less significant parts of the regulations with respect to seafarers, whilst omitting the significant points. The IMO have worked together with the World Maritime University to propose the framework for an energy efficiency education and training course in the form of a Model' Course [23, 24]. Nevertheless, an area of research that appears not to have been captured is seafarers' current levels of awareness, knowledge, skills and motivation towards energy efficiency, nor their ideas on best energy efficient practices. It is considered that such research is valuable for constructing an effective and practical framework for effectively achieving operational energy efficiency improvements.

3. The Questionnaire

3.1 Questionnaire Objective

The objectives of the questionnaire were to investigate participants' current levels of awareness, knowledge and motivation towards carbon emissions in general, shipping carbon emissions, and towards making operational changes. It also aimed to investigate the participants' education and training needs and preferences for learning.

The target group for this questionnaire was seafarers. To distribute and receive adequate responses from the target group contact was established with management personnel in four different shipping companies who could distribute the questionnaire to their seafaring staff with directed authorisation and encouragement to participate. The participating shipping companies were predominantly larger, more environmentally aware and proactive companies. It was, therefore, decided that the questionnaire would also be distributed amongst a class of seafarers undergoing continual professional training at a MET institute. This group could be assumed a control group as the participants worked in a wide range of companies and worked on a wide range of ships; thus their answers are much less likely to reflect only one company policies and procedures. The questionnaire was also distributed to student cadets undergoing their initial seafarer education at two MET institutes so as to capture differing opinions based on variations in experiences and education over the years. It was not possible to know how many seafarers received the questionnaire so it has not been possible to determine the response rate for the questionnaire.

3.2 Questionnaire Design

The first stage of the questionnaire design included defining the key opinion questions suitable for addressing the questionnaire's objectives. Factual questions were also identified to provide information about the participants' background experiences that may influence their opinions and response behaviour. The structure of the questionnaire included six parts where Part 4 was split into A and B:

Part 1: personal background;

Part 2: general awareness, knowledge and motivation towards carbon emissions;

Part 3: shipping carbon emissions awareness, knowledge and motivation;

Part 4A: energy efficient observations and experiences-systems (for engineers to complete);

Part 4B: Energy efficient observations and experiences-voyage planning/voyage operations (for deck officers to complete);

Part 5: onboard energy efficient operations;

Part 6: education and training preferences.

The response formats were determined for each question taking into account the analysis techniques available. Linguistic (open-ended, written answers) and single and multiple-choice answer formats were used for the factual questions in Part 1. The rest of the questionnaire used single five-category Likert Scales, ranking questions (based on dependent multiple five-category Likert Scales) and linguistic answer formats. Five-category Likert Scales, were selected for the following reasons: they are relatively quick and simple to complete making it more likely for participants to provide a response; they are less susceptible to missed answers due to misinterpretation and demands on written English skills (in comparison to other formats such as linguistic answers); they provide a quantitative way to analyse qualitative responses (discussed in Section 3.5); they are a well established method commonly utilised for psychometric studies. The wording of the five categorise for the scales was selected carefully to avoid induced bias as far as possible [25].

Oppenheim [26] discusses the benefits of using a series of questions or attitude scales to assess if an answer reflects truthful opinions. Taking this into consideration, a series of questions were used in each part of the questionnaire. Many of the Likert Scales provided additional space for expansion with linguistic answers and the ranking questions also asked for the top three to be stated. Comparing these results provided insight into consistencies or inconsistencies, and where information was lost with one answer format some information was produced by the completion of other questions.

An introduction to the questionnaire was added to inform the participant why it was important to complete the questionnaire and the key points about its format. It also provided assurance that responses would remain anonymous.

3.3 Questionnaire Methodology

After the initial design of the questionnaire, it was given to colleagues in the department of Naval Architecture, Ocean and Marine Engineering who had previously spent time at sea. Comments and feedback were provided after completing the questionnaire, focusing on confusing wording and misinterpretations. The questionnaire was revised and then given to management personnel in the shipping companies. After further review, the last stage of testing was undertaken by distributing the questionnaire to a group of cadets in one of the MET institutes. The author was present at the time of completing the questionnaire and gathered feedback during and after completion. The results from this testing group were analysed to test the analysis strategy.

3.4 Questionnaire Techniques

Discussions with the management personnel soon made it apparent that each company and ship had different resources available for distributing and collecting the questionnaire. For this reason, the questionnaire was developed in the following formats:

(1) Via an online link using a Google questionnaire document: this was suited for ships that had internet access, or for participants who completed the questionnaire onshore.

(2) A PDF document: this suited ships where seafarers printed the questionnaire onboard or the company sent it out to them. The participants completed the questionnaire by hand and then either scanned and emailed it, or put it in the post.

(3) A protected word document: this suited ships where emails could be received and sent and access to Microsoft word was available. In these cases, the online link could not be opened due to restricted internet access.

3.5 Questionnaire Analysis

All PDF and word documents were entered into the online survey so that one excel document could be exported and downloaded. The analysis of the quantitative data was carried out in the statistics program SPSS [27] and final graphs were produced in Microsoft Excel.

Likert Scales are descriptive and subjective due to the expression of personal opinions and judgments; hence the five-categories have no mathematical value although they relate to each other in a specific order: ordinal data. Although not statistically correct, the Likert Scale is often associated with numeric values so that a quantitative analysis can be conducted for qualitative results [25]. Values 1 to 5 were assigned to the Likert Scales used, with 5 being the least desirable and 1 the most. The frequency of category selection was used to display results, apart from for the ranking questions where a mean value was given. Whilst determining the mean has the advantage of being able to rank what the variables, the specific values should not be considered independently. The N number of participant responses collected for each question has been given in the caption of each figure. In the case of rating questions, where one variable was not completed, the entire response was removed from the analysis of that question. Where there was another category provided for the single and multiple-choice questions, the count has been included in the frequency analysis and the additional written information has been treated as linguistic. Similar linguistic responses were grouped together.

3.5 Questionnaire Distribution

The questionnaire was distributed in the last quarter of 2011 and over the first quarter of 2012. Received 317 responses in total of which 84% were hardcopies and 16% were online.

4. Profile of Questionnaire Participants

Part 1 of the questionnaire asked participants to provide background details about their experiences considered to shape their current views. Participants were asked to provide details about where they had completed their MET. Fig. 1 demonstrates that the majority of participants where educated in the UK (26%) and India (25%); the latter including the 11% of students. 21% of participants did not respond to this question. Nevertheless, as whole participants have been educated and trained in a large range of countries; thus encompassing the global maritime community and including a range of educational and cultural differences.

Participants were asked to select one or more types of vessels they have previously or presently work on. Fig. 2 demonstrates that 66% of the 317 participants have worked on tankers whilst only 26%, 20% and 13% have worked on bulk carriers, containers and LNG (liquefied natural gas) vessels, retrospectively. Thus, the comments proved within the questionnaire responses are most likely to be based on tanker operation expertise but may also include operational experience onboard other vessel types.

Fig. 3 demonstrates the job roles that the participants currently work in. 35% of participants are from the bridge team (Master/Captain and Deck Officer) and 33% are from the engineering team (Chief Engineer and Engineer). This is a good response both in terms of sample size and proportion; particularly beneficial for the analysis Parts 4A and 4B specific to the engineering and bridge teams retrospectively. Lastly, Fig. 4 demonstrates that 84% of participants have had more than 1 years sailing experience and therefore the results can be assumed to represent the opinion of seafarers at sea. (The 16% of participants who have had less than 1 years experience includes the 11% of students (Fig. 4).)

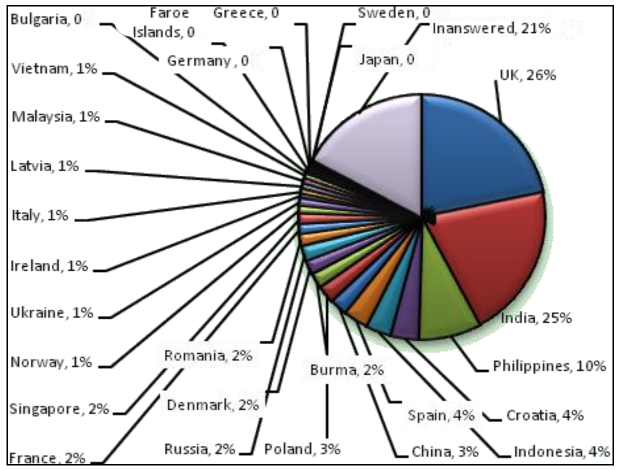

Fig. 1 Country of MET (*N* = 317).

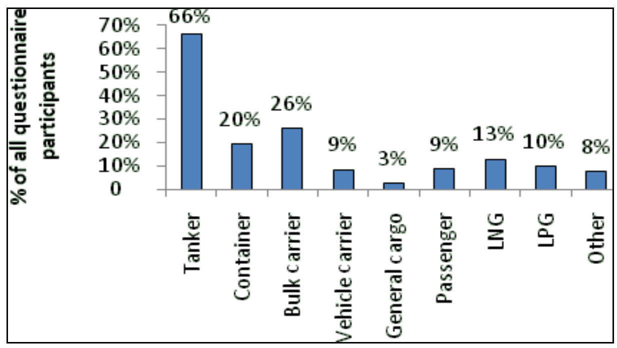

Fig. 2 Types of vessels participants currently or have previously worked on (*N* = 317).

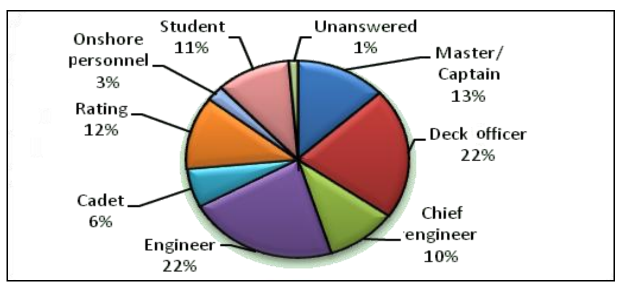

Fig. 3 Job role of participants (*N* = 317).

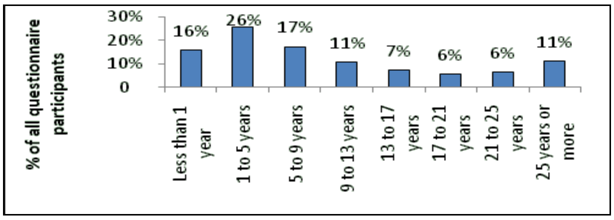

Fig. 4 Years experience at sea of participants (*N* = 317).

5. Questionnaire Results and Discussion

5.1 General Awareness and Knowledge of Carbon Emissions

With the introduction of regulation and the increasing introduction of operational changes toward energy efficient operations, if seafarers do not have the background knowledge and understanding of why these changes are being enforced upon them it will result in blind following of mandated procedures. It is already known that workload on seafarers is high and increased procedures set by management are not always well received. Therefore, a lack of awareness, knowledge and understanding of why changes are occurring is likely to generate negative attitudes towards the subject and lead to possible negligence or a build up of resentment between stakeholders (see Quotes. 1 and sections 5.4, 5.5, 5.7 and 5.9). Such attitudes will not allow for the behavioural change that is needed for effective carbon emission reductions. For this reason, even if the seafarers themselves remain sceptic about climate change, it is necessary for them to understand the scientific background, how it is prompting international pressure to make changes, and hence why reactive changes are happening within and out-with the shipping industry (Quotes. 1). To assess participants' current opinion about the effects of carbon emissions, they were asked about their general awareness and knowledge.

Fig. 5 demonstrates that whilst the largest proportion of participants believe they are aware of the effects that carbon emission have on our world, there are still 23% who believe they are only fairly or a little aware. Only 20% of participants have the confidence to say they are very aware. Awareness levels are the foundation on which to build knowledge and motivation and therefore this result clearly demonstrates that there is a need to increase awareness.

Fig. 6 demonstrates that participants believe they have less knowledge than awareness about the effects that carbon emissions have on our world (assuming the Likert Scales are comparable). Only 6% believe they are very knowledgeable. In a similar way to awareness, without this knowledge how can it be expected that seafarers will have the understanding and motivation to develop more technical knowledge. To further emphasis this point and to demonstrate the real benefit of this knowledge, Fig. 7 shows that the participants who believe they have more knowledge

'Proactive attitudes to implement and explain for long and short term gains'

'… each country has to be responsible not target, the seafarers … Why we are targeted because we are the easy catch …'

Quotes. 1

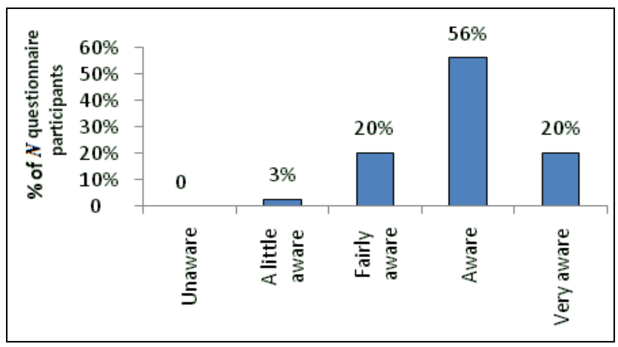

Fig. 5 Participants' awareness of the effects carbon emissions have on our world (*N* = 314).

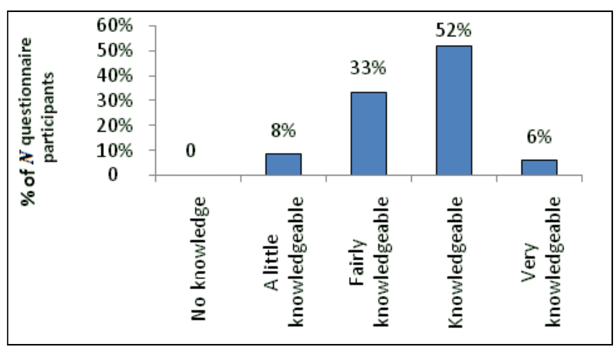

Fig. 6 Participants' knowledge of the effects carbon emissions have on our world (*N* = 311).

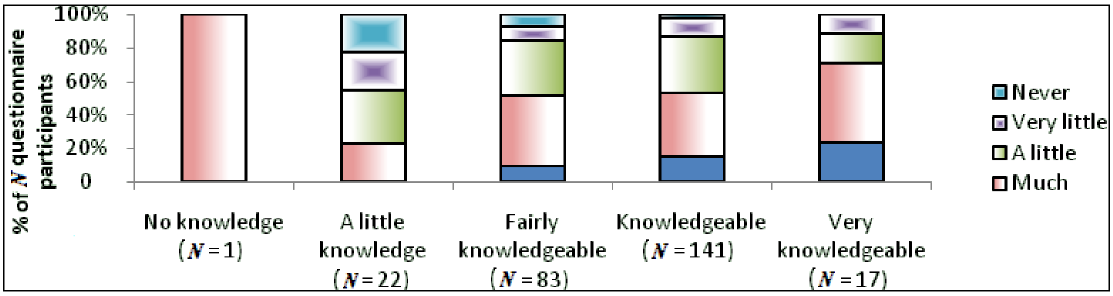

Fig. 7 How much participants have currently tried to make energy efficiency improvements onboard depended on their level of knowledge about the effect that carbon emissions have on our world.

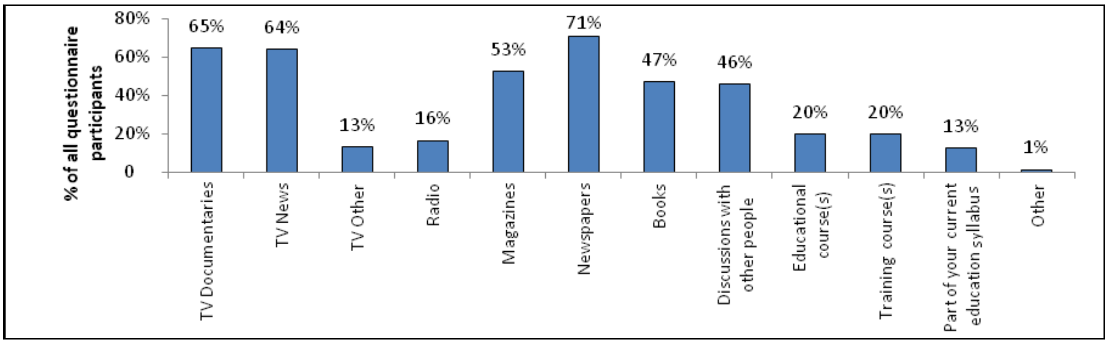

Fig. 8 Methods for knowledge acquisition regarding the effects that carbon emissions have on our world (*N* = 311).

about the effects that carbon emissions have on our world have currently tried more to make energy efficiency improvements onboard. The motivational benefit of general carbon knowledge is evident. (The result for no knowledge can be ignored as it is based on only 1 response and thus is reflective of personal opinion and not of seafarers in general.)

5.2 Knowledge Sources for LC-EE

Fig. 8 demonstrates that the most common method for current knowledge acquisition about the effects of carbon emissions is via newspapers followed by TV documentaries, TV news and magazines. It is known that the knowledge content within these sources is neither comprehensive nor specific to carbon emissions, particularly to shipping, and thus these sources do not provide the knowledge levels required for effective shipping carbon emission reductions. Fig. 8 also demonstrates that less than half of the participants have discussed the topic with other people indicating that energy efficiency for carbon emission reductions is not a topic of focus and hence discussions: "share and discuss" has been quoted and identified in many linguistic response as an effective method for learning. A significant result also shown in Fig. 8 is that only 20% of the 311 participants have gained knowledge about the effects of carbon emissions via an education or training course. The participants who have undertaken such courses were asked to provide additional details about the training and education. No comments appeared specific to the subject of energy efficiency or carbon emissions; although awareness of other GHGs (sulphur oxide and nitrogen oxides) appears to be increasing.

5.3 Technical Awareness and Knowledge of How to Achieve Carbon Emissions

Within the questionnaire participants were asked to provide written answers about how the operation and maintenance of systems and voyage planning can be improved to achieve energy efficiency savings. Only a relatively small proportion of participants provided an answer to these questions (taking into account that there was a part for the engineering and bridge teams). As discussed in Section 3, a reduced response rate to questions requiring linguistic answers is expected.

However, although no conclusive support, the low response rate could also be indicative of a lack of ideas and knowledge of how energy efficiency improvements can be carried out. The responses provided contained many reoccurring general comments that lacked in technical content; such as, target management and design decisions, switch off lights and use less fresh water (see Quotes. 2). Furthermore, some comments between participants varied greatly and in a few instances appeared contradictory. All these points demonstrate an uncertainty or a lack of awareness, knowledge and/or motivation as to how seafarers can contribute towards carbon reductions. It should be the case that seafarers instantly recognize the key best practices and what can or has already been carried out. This is not saying that all seafarers do not already have the level of technical knowledge needed, but it is clearly currently not at the forefront of their focus. This topic needs to be given emphasis, particularly for operational improvements at a seafarer level and not just for management and design improvements.

5.4 Motivation towards Carbon Reductions (Importance and Possibility)

The questionnaire participants were asked how important they think it is to reduce global and shipping carbon emissions, how possible they think it is to do so, and how possible it is for crew to help do so. These questions were asked to provide an indication of the participants' motivation towards the subject. The following set of graphs Figs. 9-12 demonstrate average (median) positive views of seafarers. However, there is still a spread of results across the scale for all questions. Figs. 9 and 10 show that 2% of participants believe it is very unimportant to reduce carbon emission and a further 4% believe it is neither important nor unimportant. It can also be determined by comparing mean values, that the average view of participants is that it is more important to reduce global carbon emissions than shipping carbon emissions (the mean response decreases by 4%, from 4.56 to 4.37).

Figs. 11 and 12 demonstrate how possible participants believe it is to reduce shipping carbon emissions and how possible it is for crew to help do so. It cannot be expected that crew will make a conscious effort to reduce carbon emissions if they do not think it is possible. Fig. 12 in particular shows a large spread of responses, with 40% of participants believing that it is only fairly or slightly possible. There is also a large decrease (11%) between how possible participants believe it is to reduce shipping carbon emissions (Likert Scale mean of 3.94) and how possible it is for crew to help do so (Likert Scale mean of 3.50). This, therefore, demonstrates that there is a need to teach and demonstrate to participants (increasing their awareness and knowledge) how it is possible for crew to help reduce shipping carbon emission.

'Keep the main engine parts in tiptop condition to guarantee the performance recommended by maker'

'During cargo operation, there is great potential to optimizing the use of cargo pumps'

'The deck team should stop cargo service machines in time after cargo operation and inert gas generators'

'Route and speed instructions should be given to the vessels, where the eco speed must be better defined to ensure all utilise the lowest possible steady main engine load point during a given voyage'

Hull Scrubs.'

'Prop Polish and high performance antifouling'

'Good quality fuel should be used'

'By reducing unnecessary operation of machinery'

'Steady running of the vessel at sea'

'The safest and shortest route should be selected.'

'Reduce use of incinerator.

'Good support should be provided from the company by providing vessel spare parts to maintain vessels machinery'

'Train bridge personnel to think further ahead to be able to minimize alterations of course'

Quotes. 2

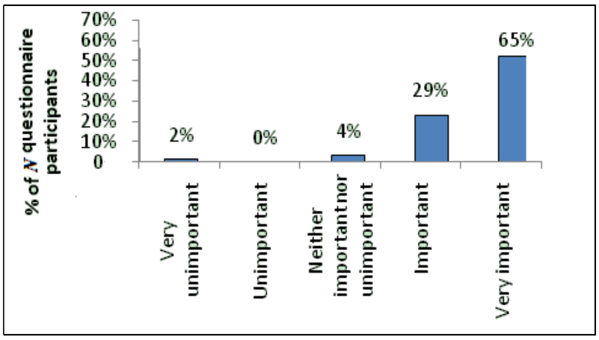

Fig. 9 How important participants believe it is to reduce global carbon emissions (*N* = 314).

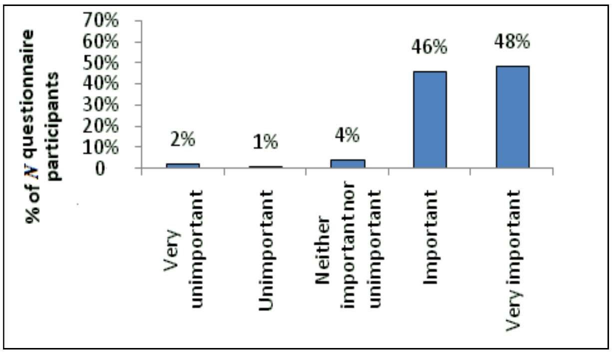

Fig. 10 How important participants believe it is to reduce shipping carbon emissions (*N* = 314).

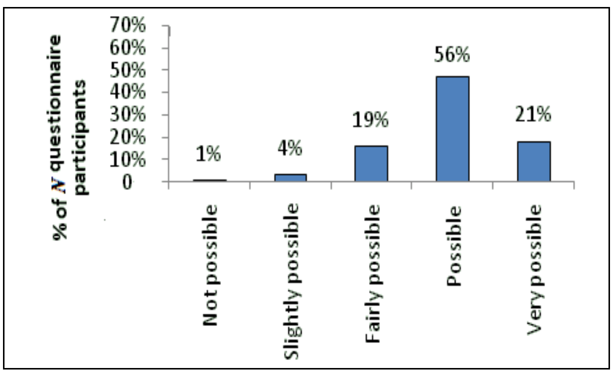

Fig. 11 How possible participants believe it is to reduce shipping carbon emissions (*N* = 314).

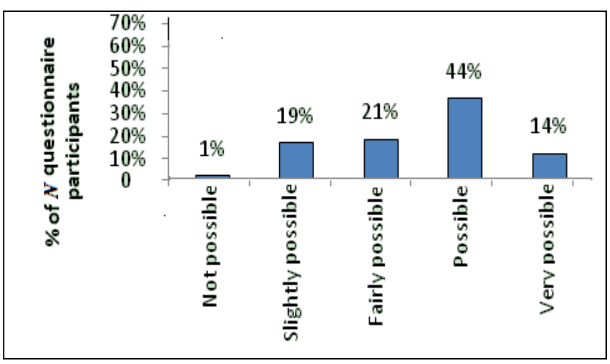

Fig. 12 How possible participants believe it is for crew to help reduce shipping carbon emissions (*N* = 314).

Fig. 13 shows that 74% of participants would like to know more or a lot more about how crew can help reduce shipping carbon emissions, but 27% would still only like to know some or a little. This demonstrates a lack of motivation and could be due to any one of the following: low motivation to learn in general; lack of interest in the subject; a reluctance to learn additional tasks to implement. These are very important considerations that need to be taken into account when developing an educational course or attempting to inspire motivation. Sections 5.6 discuss effective methods to achieve just this.

Fig. 14 demonstrates a large spread of responses across the scale for how much participants have currently tried to make energy efficiency improvements onboard, with 49% trying a little, very little or never. Participants were asked to provide written details of how they have currently tried to make energy efficiency improvements, or why they have not. The current efforts described were similar to those stated within the technical knowledge, Section 5.3 and Quotes. 2. Some reoccurring comments that appeared for why efforts have not been made are shown in Quote. 3 and Quotes. 4.

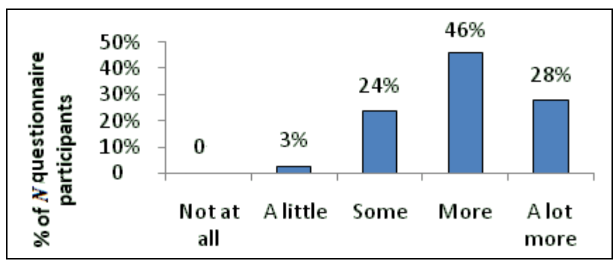

Fig. 13 How much more participants would like to know about how crew can help reduce shipping carbon emissions (*N* = 312).

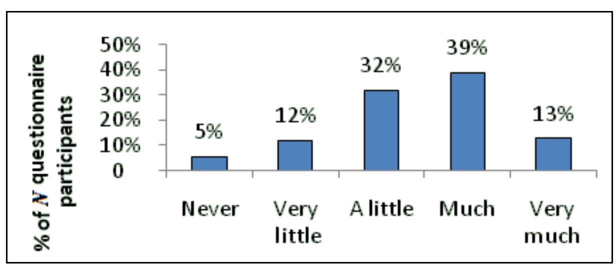

Fig. 14 How much participants have already tried to make energy efficiency improvements onboard (*N* = 269).

'Proper knowledge, training and motivation are not there'

Quote. 3

'Very busy on board, extremely busy. It is better to stop using your car and continue with bicycle'

'Limited by operation requirements and resources. Lack of time and man power'

'This priority is not so high in my mind'

'No time to think about that'

'Not much mainly because I am part of the deck department, but I do my best to contribute for the carbon emission cause'

Quotes. 4

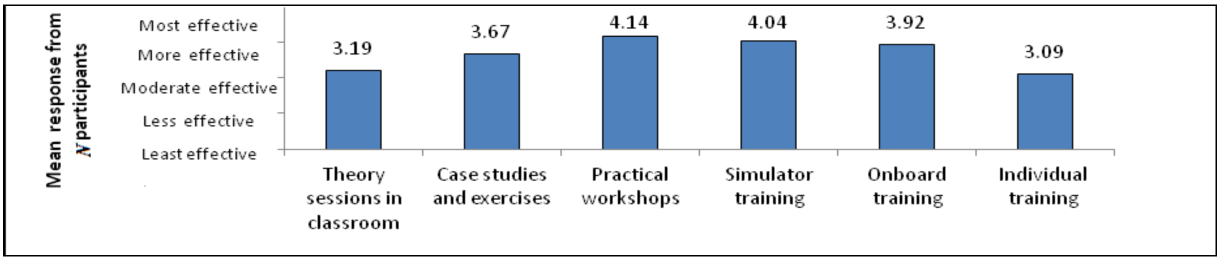

Fig. 15 Effectiveness of methods for MET (*N* = 274).

Quotes. 4 demonstrate that there is clearly a current attitude and view point that will not allow for effective carbon emission reductions. It, therefore, needs to be made clear to crew that this topic is becoming more important, it is everyone's responsibility, there are ways that everyone can contribute, and efficiency can improve workload if resourced correctly. It has already been demonstrated that knowledge increases motivation to make effort (Fig. 7) stressing the need for knowledge to be transferred using the most effective methods for educating and training seafarers. Section 5.8 discusses how integrated operations can help achieve these points and increase motivation.

5.5 Effective Learning Methods

Participants were asked to rank which methods for teaching/learning are most effective. Learning from personal experience is known to be one of the most effective methods for teaching/learning and therefore it is no surprise that practical workshops, simulator training and onboard training are considered to be the most effective: noting that practical workshops are ranked as more effective than simulator training (Fig. 15). Exercises, including practical workshops, simulators and onboard, are an essential part of education as they demonstrate (quantify) potential savings that can be achieved by improved operations and how each saving varies with external or changing conditions. This knowledge and insight is what will help increase understanding of the benefits of best practices and hence increase motivation towards implementation. Simulator training allows seafarers to practice and observe low carbon energy efficient operations in a safe environment where performance can be monitored and instant feedback given. In particularly, it allows for situational awareness to be developed (enhancing both safety and efficiency) which was highlighted as a best practice amongst the suggested technical improvements: Quote 5. Therefore, where possible, simulator facilities should be utilized for LC-EE (low carbon-energy efficiency) MET. A disadvantage of onboard learning for the topic of LC-EE is that it is very dependent on the knowledge, skills and motivation of the supervisor. Therefore, if the supervisors do not have LC-EE awareness, knowledge and motivation themselves (as currently demonstrated within this questionnaire analysis) then this method may not be of greatest benefit. However, as LC-EE knowledge and motivation increases amongst existing crew this will become much more effective method for this topic and should be included within cadet onboard learning objectives. Individual learning has the benefits of flexibility and allowing for knowledge development at an individual's most effective rate. However, the disadvantage for this subject is that it largely depends on a trainee's motivation to learn, and if that is not there (demonstrated in Fig. 13), it cannot be expected to translate into motivation for LC-EE operations.

The delivery content and style of a MET course should be correct for the specific trainee group. The primary objective should be to enhance existing knowledge and skills and this should be made clear from the beginning of any course. In some cases, fundamental background may need to be revisited depending on the group of trainees to ensure understanding before more advanced techniques can be developed. However, if existing knowledge (learnt during basic training and previous courses) is laboured upon then the trainees will loose interest and hence defeat the objective of the course. It should be made clear to the trainees that they are recognised experts in their field (seeing as they carry out their jobs in a practical environment each day) and thus the MET should also provide a platform for discussion where the ideas and comments of the trainees are heard. If possible, the comments from the education and training should be fed back to the company or training institute as it is likely that the feedback will contain useful and beneficial comments regarding practical implementation and industry progress. It is also likely to increase trainees' motivation (though individual empowerment) and benefit shore-sea relationships through communication and knowledge exchange.

5.6 Incentive to Achieve Energy Efficiency and Hence Carbon Emission Reductions

In addition to education and training, various incentive methods should also be considered to raise awareness and motivation towards LC-EE (Quotes. 6). Firstly, Fig. 16 demonstrates that the majority of participants (94%) believe it is "important" or "very important" to introduce shipping carbon emissions regulations. This is further emphasised within the written comments as to why improvement efforts have not already been made. In addition to shipping regulations, company policy was also strongly commented on; the general view is that without mandatory pressure to carry out energy efficiency improvements, it will not happen due to existing high workloads and other priorities (Quotes. 4). Fig. 18, to

'Anticipation is always a key word in this issue'

Quotes. 5

'Well it depends on the topic, but in general, with respect to carbon reductions, the problem is not the knowledge, but the motivation to use the knowledge and information'

'Feedback that it actually works and makes a difference'

Quotes. 6

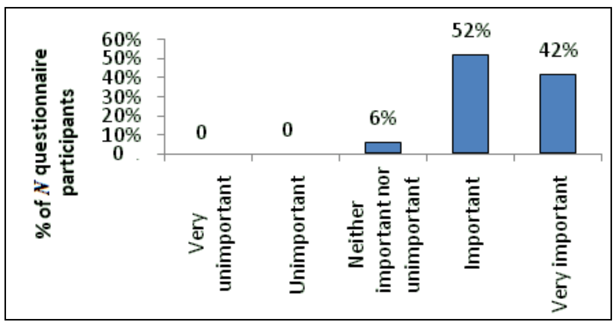

Fig. 16 How important participants believe it is to introduce shipping carbon emission regulation (*N* = 312).

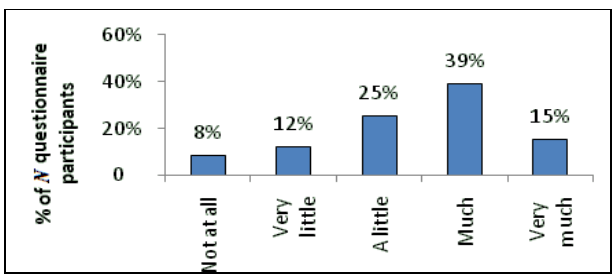

Fig. 17 How much participants think a reward would affect the amount they try to make energy efficiency improvements (*N* = 278).

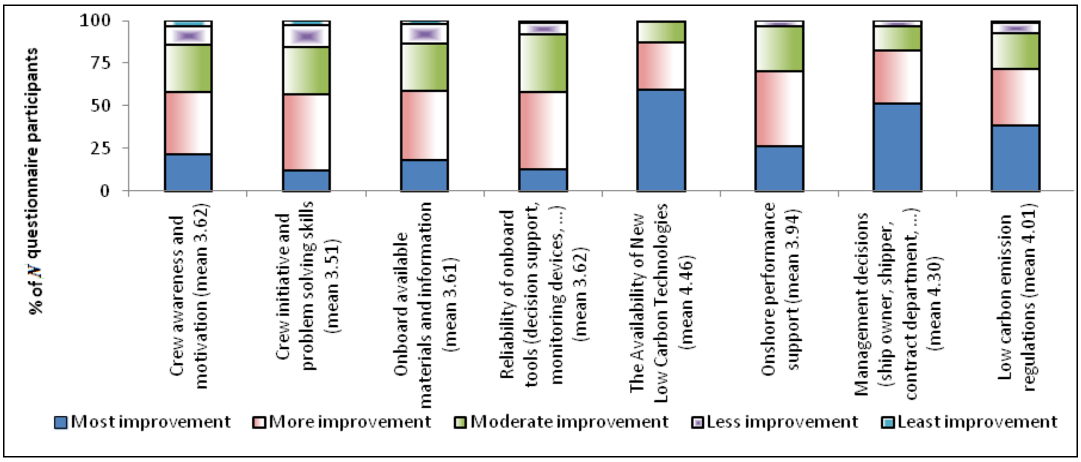

Fig. 18 Areas that participants' believe need the most improvement to achieve shipping carbon emission reductions (*N* = 264).

be discussed, further demonstrates that participants believe low carbon regulations are the third most important improvement area that needs to be made to achieve effective carbon emission reductions).

Participants were asked if a company reward would affect how much they try to make energy efficiency improvements onboard. Fig. 17 indicates that although, a reward is likely to make a positive difference, opinions over this question vary considerably and therefore it is not recommended as strong or certain method for increasing motivation.

5.7 Improvement Focus Areas

Participants were asked to rank the areas shown within Fig. 18 in order of improvement importance for achieving carbon emission reductions. Such a ranking order could be considered when identifying a LC-EE strategy or when prioritising operational improvement areas. It should be noted that the average (median) response for each question falls within needing more or most improvement and thus no areas listed need no improvement.

The availability of new low carbon technologies was ranked as the most important followed by management decision. Low carbon regulations followed by the remaining improvement areas were all ranked as needing more improvement. Improvement of onshore performance support was ranked 4th and this is discussed at greater length in the following Section 5.8. Reliability of onboard tools (decision support, monitoring devices) was ranked as the joint 5th most important improvement to make along with crew awareness and motivation. However, crew initiative and problem-solving skills was ranked last (8th). This indicates that the participants believe that seafarers have better initiative and problem solving skills, but they lack more the awareness and motivation to apply them to LC-EE savings. Onboard available material and information was ranked 7th indicating that it is not an area of primary concern for improvement, but is still an area for consideration. The written responses highlighted the following as key areas for improvement: fuel quality, availability of spare parts for maintenance, voyage scheduling, voyage handling, cargo handling, good plant management, training etc (also see Quotes. 7-9).

> 'All deck officers should be at least familiar with all engines on board. Thus they can plan work and this will lead for the improvement of the environment'

Quote. 7

> 'The ships management should educate and train all ship present personnel to be efficient and be given support from owners and charterers to run the vessel smoothly and efficiently'

Quote. 8

> 'Coordination between bridge and engine room'

Quote. 9

5.8 Integrated Operations

Fig. 18 has highlighted management decision and onshore performance as two key areas for most improvement. Participants were then asked which levels of personnel out of those shown in Fig. 19, have the most influence over the most carbon emission reductions. The shipping company was ranked first as having influence over the most reductions. This was followed by the engineering team and then the shipper, onshore shore support and the voyage contract department. The bridge team and deck team were ranked as having the least influence. The difference between the proportion of participants who responded most and more reductions for the engineering team and bridge team is large. However, optimised voyage planning as well as other operational improvement (see the SEEMP) can be carried out by the bridge team to achieve LC-EE operational improvements. There are also many voyage planning objectives that can be improved with good communication and co-operation among the bridge, engineering and onshore teams. Thus the large proportion difference between the results could be a due to low awareness and knowledge of how the bridge team can contribute towards reduction, or, it could be due to an association of energy efficiency and emissions with engineering operations. Whatever the reason, awareness and knowledge of operational improvements should be increased. (Further analysis into the ranking order dependent on participants' job role is suggested for further evaluation.)

Many written responses within the questionnaire also discussed how carbon emission reduction potential lies with management personnel, and that seafarers at sea have little or no influence. In addition, comments were also made that questioned why seafarers should be targeted to reduce carbon emission reductions when control and/or the most savings can be achieved ashore (see Quote. 1). This identifies the necessity to have clear communication between and to all levels of personnel, including seafarers. This could be achieved with a transparent company policy and making sure that company efforts, initiatives and changes are communicated effectively to all personnel so that no one group of personnel gains only part of the picture or feels unfairly targeted for contributions. This way seafarers will know that changes and efforts are also being made onshore (where the most reduction potential can be achieved) and thus a better, more positive and more "team effort" understanding and attitude can be achieved.

Continuing with communication between ship and shore, the onshore team were ranked 4th out of 7, as being able to help contribute towards moderate or more carbon emission reductions (Fig. 19). Onshore performance support was also ranked 4th out of 8 as an area that needs more improvement to achieve potential carbon emission reductions (Fig. 19). Furthermore, it was determined that 60% of participants would request information often or very often from onshore support; there is still only 40% of participants who would request it sometimes, not very often or never (Fig. 20). This raises two issues. The first is that the onshore support should be in a position to be able to provide useful advice and expertise to the onboard crew. Performance monitoring techniques should be developed and performance reports/feedback should be provided to vessels and distributed onboard so that seafarers can judge performance; thus increasing motivation as efforts made are realised: Quote. 6. The second point is that each level of personnel, both ashore and at sea, need to know where the other's expertise lie and what knowledge, data and information is available from each.

There should be opportunity to discuss this exchange amongst all involved personnel and how it can be valuable towards reducing shipping carbon emissions as well as assessing energy efficiency performance. It should be made clear that each level of personnel working at sea or onshore has their own expertise areas and therefore good teamwork and

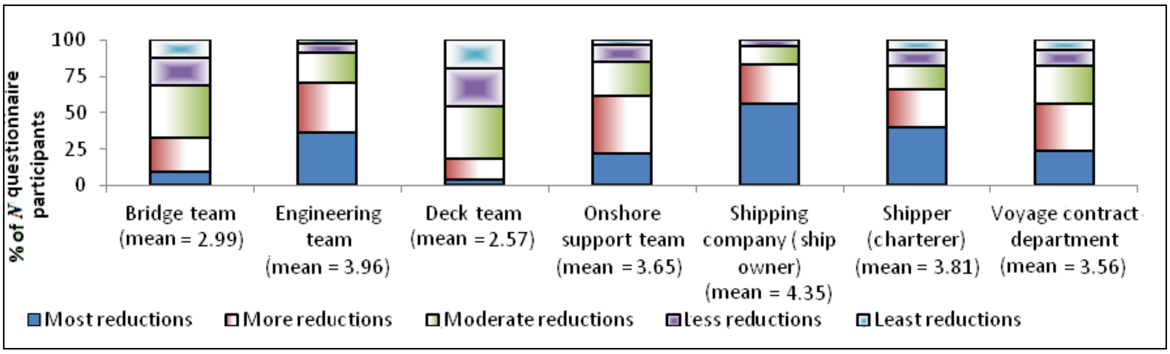

Fig. 19 The personnel that participants believe have the most influence over shipping carbon emission reductions (*N* = 250).

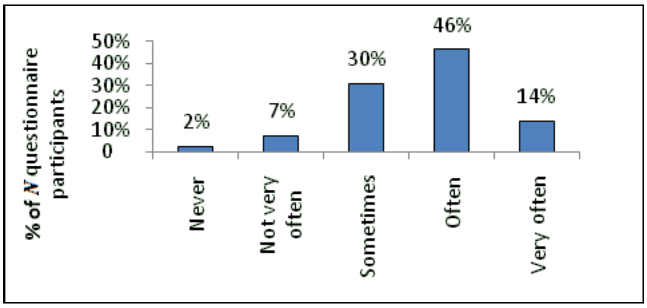

Fig. 20 How often participants would request information on "How to" from onshore support and follow it (*N* = 299).

communication management combining these expertises can increase motivation and teamwork to achieve low carbon efficient operations.

6. Conclusions

Currently general carbon awareness and knowledge is gathered via sources such as newspapers. Even the small percentage (20%) of participants who have undergone education or training and learnt about the effects of carbon emissions did not describe any courses that provided the focus needed for this subject. In conclusion, it is clear that the correct awareness, knowledge and knowhow needs to be provided to all seafarers to ensure that they know what the best practices for LC-EE operations are, and how to implement them effectively whilst maintaining a high level of safety. This is particularly important with the introduction of the SEEMP and therefore the correct LC-EE MET (utilising correct teaching methods to inspire behavioural change and motivation) should be provided. In addition, clear communication and integrated operations, onboard and between ship and shore, should be enhanced to achieve effective carbon reductions.

7. Future Work

In continuation of the questionnaire analysis presented within this paper, there is still a large amount of information that can be drawn from the questionnaire data to support a more detailed needs analysis of the target group. Investigation into the results should include looking at the differences between the teams onboard and onshore, counties of learning, and experience (years at sea). Furthermore, some groups of participants provided considerably more responses to the questionnaire than others. Therefore, results should be analysed to investigate the varying responses from participants who have worked for different sized companies; investigating the assumption that perhaps a larger companies may be more able to be proactive and invest and trial new technologies, innovations and trainings.

It is intended that this questionnaire analysis supports the development of a specific, formalised LC-EE MET course, suitable for delivery to existing seafarers, as well as new cadets. In addition to this, it may also provide useful information for management or performance review as well as support for the development of a LC-EE Strategy or Policy.

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References

[1] T. Quin, G. Plattner, M. Tignor, S. Allen, J. Boschung, A. Nauels, et al., Summary for policymakers, in: Climate Change 2013: The Physical Science Basis, Working Group I Contribution to the Intergovernmental Panel on Climate Change Fifth Assessment Report, Cambridge University Press, Cambridge, United Kingdom; New York, USA, 2013.

[2] L. Treut, H.R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, et al., Historical overview of climate change, in: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom; New York, USA, 2007.

[3] G.D. Farquhar, M.J.R. Fasham, M.L. Goulden, M. Heimann, V.J. Jaramillo, H.S. Kheshgi, et al., The carbon cycle and atmospheric carbon dioxide, in: Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom; New York, USA, 2007.

[4] Kyoto Protocol to the United Nations Framework Convention on Climate Change, United Nations, 1998.

[5] European Commission, http://ec.europa.eu/clima/ policies/ g-gas/ (accessed June 4. 2014).

[6] Climate Change Act 2008, Chapter 27 Part 1 Carbon Target and Budgeting, U.K. Government, The Stationery Office Limited, U.K., 2008.

[7] Ø. Buhaug, J.J. Corbett, Ø. Endresen, V. Eyring, J. Faber, S. Hanayama, et al., Second IMO GHG Study 2009, IMO, London, UK, Apr. 2009.

[8] IMO, Resolution MEPC. 203 (62) 2011 Amendments to the annex of the protocol of 1997 to amend the International Convention for the Prevention Of Pollution from Ships 1972 as Modified n the protocol of 1978 relating thereto (Inclusion of regulations on energy efficiency for ships in MARPOL Annex VI), 62nd meeting of the Maritime Environmental Protection Committee, 62/24/Add.1, Annex 19, London, UK, July 2011.

[9] IMO, Resolution MEPC 212 (63) 2012 Guidelines on the method of calculation of the EEDI for new ships, 63rd meeting of the Maritime Environmental Protection Committee, 63/23, Annex 8, London, UK, Mar. 2012.

[10] IMO, Resolution MEPC 213 (63) 2012 Guidelines for the development of a SEEMP, in: 63rd meeting of the Maritime Environmental Protection Committee 63/23, Annex 9, London, UK, Mar. 2012.

[11] Z. Bazari, L. Tore, Assessment of IMO mandated energy efficiency measures for international shipping, estimated CO_2 emission reduction from introduction of mandatory technical and operational energy efficiency measures for ships, in: 63rd meeting of the Maritime Environmental Protection Committee, 63/INF.2, London, UK, Oct. 2011.

[12] IMO, Reduction of GHG emissions from ships, marginal abatement cost and cost effectiveness of energy-efficiency measures, submitted by the IMarEST (Institute of Marine Engineering, Science and Technology), in: 62nd meeting of the Maritime Environmental Protection Committee, 62/INF.7, London, UK, Apr. 2011.

[13] J. Faber, B. Behrends, D. Nelissen, Analysis of GHG Marginal Abatement Cost Curves, report code 11.7410.21, CE Delft, Delft, Mar. 2011, [Online] www.cedelft.eu.

[14] S. Alvik, M.S. Eide, Ø. Endresen, P. Hoffmann, T. Longva, Pathways to low carbon shipping: Abatement potential towards 2030, DNV (Det Norske Veritas), Norway, Feb. 2010.

[15] ECCSA (European Community Shipowners' Associations), EU Commission proposal for a regulation on CO_2 MRV from maritime transport "facilitating the IMO progress', in: EU Parliament Policy Seminar, Brussels, Jan. 2014.

[16] Market Based Measures, IMO, http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Market-Based-Measures.aspx (accessed June 4, 2014).

[17] N. Rehmatulla, T. Smith, Implementation barriers to low carbon shipping, in: Low Carbon Shipping Conference 2012, Newcastle, Sept. 11-12, 2012.

[18] H. Johnson, K. Andersson, The energy efficiency gap in shipping–Barriers to improvement, in: IAME 2011 Conderence, Santiago De Chile, Oct. 26-28, 2011.

[19] T. Bielić, Influence of shipping company organization on

ship's Team Work Effectiveness [Online], bib.irb.hr/datoteka/405047.Bielic.pdf (accessed June 4, 2014).

[20] M. Acciaro, P.N. Hoffmann, M.S. Eide, The energy efficiency gap in maritime transport, Journal of Shipping and Ocean Engineering 3 (2013) 1-10.

[21] International Convention on for STCW (Standards of Training, Certification and Watchkeeping) Seafarers Including 2010 Manila Amendments, 2011 Edition, London, IMO, ISBN: 97892801 1528, 2011.

[22] C. Banks, I. Lazakis, O. Turan, A. Incecik, An approach to education and training of seafarers in low carbon-energy efficiency operations, in: Low Carbon Shipping Conference 2011, Glasgow, U.K., June 22-24, 2011.

[23] IMO, Air pollution and energy efficiency, update of the draft IMO model course on energy-efficient operations of ships, in: 65th meeting of the Maritime Environmental Protection Committee, 65/INF.17, London, UK, Feb. 2012.

[24] M. Baldauf, R. Bumler, A. Öl çer, T. Nakazawa, K. Benedict, S. Fischer, et al., Energy-efficient ship operation-training requirements and challenges, The International Journal on Marine Navigation and Safety of Sea Transportation 7 (2) (2013) 283-90.

[25] A. Agresti, Analysis of Ordinal Categorical Data, 2nd ed., John Wiley & Sons Inc., U.S., ISBN: 9780470082898, 2010.

[26] A.N. Oppenheim, Questionnaire Design, Interviewing and Attitude Measurement, New edition, Continuum, London, ISBN: 1855670437, 1992.

[27] SPSS Software–Predictive analytics software and solutions, International Business Machines IBM Corporation, U.K., http://www-01.ibm.com/software/uk/analytics/spss/.