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# Human Factors as Causes for Shipboard Oil Pollution Violations

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ABSTRACT: Shipping is a crucial transportation mode for world trade. Operation of ships has become a specialisation. Maritime training addresses the needs and in doing so is heavily regulated. STCW lays down the requirements for such training and all training patterns in the world follow these. An important aspect of the training is the environmental factor. Ships use and carry large quantities of oils. This increases the potential for pollution. The laws and penalties on this front have increased and become stricter. This has decreased the operational pollution yet, there are violations occurring. The natures of violations are not only physical but also in documentation such as falsification of Oil Record Book entries etc.
A study was undertaken to understand the effect of factors such as training, experience, attitude and fatigue on the oil pollution violations. The adequacy and effectiveness of current maritime training has been verified with reference to STCW and the recommended Lesson Plans of the IMO. Training apart, hypotheses on other human factors have been framed and tested by statistical methods. In this paper the human factors of experience, attitude and fatigue are projected and the results are discussed. The various statistical methods such as ANOVA, Chi-square and correlation analyses have been applied as appropriate to the nature of the data obtained from the survey results. The survey conducted amongst seafaring officers formed the basis for the hypotheses and the tests.
Whereas training is found to be adequate, attitude and fatigue are shown to be the primary factors affecting oil pollution violations. Negligent attitude appears to diminish with increased experience but good attitude towards pollution prevention practices remain irrespective of the variation in experience or training. The factor of fatigue has a mention in many studies and the study validates the same. The concerns on this front are highlighted and recommendations for further probing into attitude-behaviour and fatigue are suggested.
Mind-set behaviour training at management levels and pro-activeness of companies in overcoming some reasons for fatigue such as long working hours etc. are suggested. It is observed that attitude and fatigue could be the main causal factors which are resulting in pollution violations.

## 1 INTRODUCTION

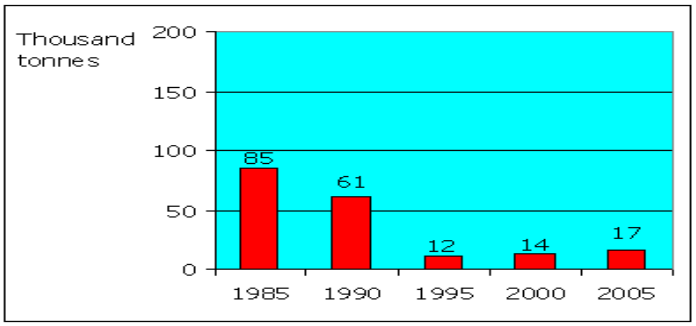
In comparison with other modes, shipping is the most economical means of transportation and over 90% of world's trade is being routed through ships. Ships use various oils in their machineries and also transport oils. This gives scope for oil pollution of the oceans. Controlling pollution lies in the competency of the professionals operating the ships. Training provides the skills and knowledge to carry out the ship operations efficiently.

The STCW regulates the maritime training in substance as also in conduct of pre-sea training, post-sea training and assessment of competencies. The aspects of environmental pollution by oil, chemicals, garbage, sewage, emissions et al., are addressed in these standards. MARPOL (Marpol 73/78) lays down regulations for constructional and operational aspects with regards to environmental protection. Various bodies like Port State Control etc. ensure compliance of the regulations. Non compliance will result in various control measures. Towards the later half of the last century, regulations and control measures have become stricter, especially on the environmental front.

Because of these stern measures, oil spills have reduced significantly as shown in Table 1. In the recent years, violations on these types of oil pollutions have resulted in heavy monetary fines and incarceration punishments, often leading to criminalisation of

the seafarer. Defences to liability are limited, as proof of the offence does not require evidence of intent or negligence (Hebden, 1995). A trend of criminalising pollution violations can be seen from the increase in the number of environmental laws like the recent European Union directive on pollution violations.

Table 1: Reduction in Oil spills (Global Scenario)
(Source: International Tanker Owners Pollution Federation Ltd., 2006)




In spite of these measures, pollution violations continue to occur. BIMCO (Baltic International Maritime Council) conducted a study (2006) and Table 2 displays the number of analysed cases where sanctions were taken against the seafarers for pollution violations, after a deliberate act or negligence had been admitted or proven in court. The noticeable feature of the report is that all of them were oil pollution related offences.

Table 2: Pollution related violations; Findings in cases
(Source: BIMCO Report, March 2006)

| | Pre-2000 | 2000 | 2001 | 02 | 03 | 04 | 05 |
|---|---|---|---|---|---|---|---|
| Malta | | | 1 | | | | |
| France | | | | | | | (1) |
| Greece | | | | | | | 1 |
| Singapore | | | | | 1 | | |
| USA (25) | | 1 | 2 | 4 | 5 | 5 | 8 |
| Total (29) | | 1 | 3 | 4 | 6 | 5 | 10 |

Note: In the French case, though the Master was fined, "it is unclear whether or not there was an intent to break the law or if negligence was involved"

Training of the officers imparts the knowledge of regulations and the serious consequences of violations. In a grosser sense, the shipboard officer is given the responsibility of shipboard functions having an environmental impact. He is termed as a "public interest" officer (Hendrik, 2006) and therefore it is recognised as a social responsibility not to violate. Yet the incidence of violations indicates that there could be other reasons for pollution violations being committed by the officer. The Paper has highlighted the results of a study undertaken under this perspective.

## 2 LITERATURE REVIEW

The classic Theory of reasoned action (Fishbein & Ajzen, 1975) is based on the premise that intention of a person predicts and influences the attitude of a person. Attitude towards behaviour and subjective norms are what could influence the intention itself. Attitude towards behaviour is based on what people think about the outcomes of their decision. Subjective norms are what people believe as acceptable behaviour or otherwise.

Oil pollution acts and falsification may be assumed as the intended actions (attitude-behaviour). A serious outcome will be the penalisation. With regard to norms, it is unacceptable. Based on the theory, the outcome and the norms have to be considered before any action. The action would constitute the attitude-behaviour. The most important aspect is that the seafarer must be aware of this. Awareness comes from the knowledge. Knowledge in a profession is gained from training and experience.

A traditional assumption in this regard is that increases in knowledge (knowledge quantum) are associated with greater influence of attitudes on behaviour (Fabrigar et al, 2006). A study, using an open-ended knowledge listing task, assessed attitudes toward protecting the environment. The study found that attitudes based on high amounts of knowledge were more predictive of environment-related behaviour than were attitudes based on low amounts of knowledge. It was also established with their experiments that attitudes predicted behaviour, regardless of complexity. Simply put, it may be assumed that knowledge affected the attitude of a person's profession related actions.

In an argumentative sense, with better knowledge it can be expected that a person will exhibit a better attitude while discharging his duties. Traditional knowledge dissemination formats are curriculum based training and on-the-job training. Development of operational practices is the outcome of such training. For example, if it is known that oil pollution causes harm to environment and also the person, it will lead to a concerned attitude and the work practices will follow suit. On the other hand, a person may still commit the violation being fully aware of the knowledge. This may be presumed to be the negligent attitude. In reference to context, it may be said that attitude-behaviour towards pollution prevention, therefore, might have a relationship with knowledge (training and experience). The comparative approach of the study is then justified.

Additionally, some deliberations on maritime education and training are also reviewed to substantiate the orientation of the study and its composition. Feelings and beliefs of the learner are two components of attitude identified in discussing concepts of

learning. It is observed that the learner feels anxious about things he cannot do and confident about things which are achieved (Baillie, 1997). It is further observed that attitudes are closely associated with personal experiences. Knowledge, attitude and experience have a determining effect on behaviour of a person in an ambience where professional skills are put into use.

Further, a P&I Club report (UK P & I Club, 2005) on manning clearly identifies the human factors affecting the performance of the ship's staff. An analysis of the claims in Figure 1 indicates that human errors have been the causes for almost 42% of the claims.

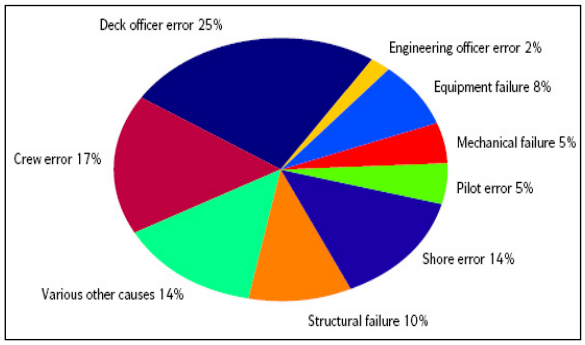



Figure 1: Main Causes of Major P&I Claims

The Report also identifies the factors which are listed in Table 3. Morale, motivation, loyalty, conditions of service and management policies can affect the attitude. It is perceived that fatigue, training and experience will have a greater influence on attitude-behaviour resulting in violations. Training may be assumed to be equal to all the officers but the intensity and effect will require verification. On the other hand, training itself can affect attitude.

Table 3: Human Factors Affecting Performance of Ship's Staff

| Factors | Remarks |
|---|---|
| Fatigue | Long working hours etc., |
| Morale | |
| Motivation | |
| Loyalty | |
| Training | Adequacy or intensity of training lacking |
| Language | Multinational crew |
| Conditions of service | |
| Experience | Lack of work exposure |
| Standards of Certification | STCW |
| Environment | Multi-cultural ambience |
| Management Policies | Companies' pro-activeness |

The factor of motivation could affect the attitude towards work practices. In an analysis of human factors affecting the performance of OWS (Oily Water Separators), Hendrik (2006) makes some relevant observations. It is observed that OWS and associated systems exist for the benefit of the public rather than for the owners and the crew. From the human factors point of view, these systems are not automatically functional and additional motivational procedures are required. Two motivational procedures are mentioned, one, the threat of random and severe penalties and secondly, the incentives for whistle blowers (Hendrik, 2006). In analysing the root causes for non-compliance with pollution procedures, it is observed that behavioural causes contribute (Kumar & Loney, 2008). The most significant predictor was the 'expectation' that a procedure or a regulation must be violated because of the combined reasons of time pressure, no alternative methods and poorly constructed procedures. The other predictors are a feeling of control, opportunity for short cut and faulty planning. The study focussed with the assumption that these factors of training, attitude, experience and fatigue have affecting relationships with oil pollution violations.

The factor of training was given an exclusive treatment in the study such that the other factors were tested with relevance to training. This paper focuses on these factors alone with temporal shifts on the factor of training.

## 3 FRAMEWORK OF THE STUDY AND METHODOLOGY

The conceptual framework was shaped with two approaches as shown in Figure 2. The next step was to find if any relationship exists between training, the other human factors and oil pollution violations. Adequacy of training was checked first and then the examination of relationships between the human factors followed. The study relied on data obtained from a survey conducted amongst shipboard officers. The composition of the sample population was largely Malaysian but a section of Indian officers were included for better representation of the global officers. While a miniscule percentage comprised of other nationalities, in total, 522 officers were surveyed. The officer sample contained engineers predominantly as the scope for oil pollution was greater with the engineers.

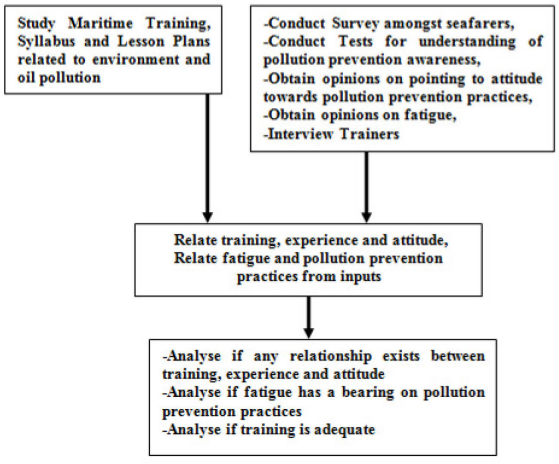



Figure 2: Skeletal Framework of the Study

Table 4. Training: Measurement Methodology

| Independent Variable | Measurement Methodology | Criteria | Tested Hypotheses | Decision adequate |
|---|---|---|---|---|
| 1.Learning content: Syllabus. IMO Lesson Plans & STCW'95 requirements | Content analysis of STCW'95, IMO Lesson Plans, training hours & Syllabi | Content & training hours = or > prescribed | Adequacy of Training | Training |
| 2. Analyses based on test scores for groups with varying amount of training exposure (Awareness) | ANOVA | If Sig.F < 0.05 then Reject $H_{O1}$ | $H_{O1}$ & $H_{A1}$ | Since Sig.F > 0.05 then Accept $H_{O1}$ |
| 3. Analyses based on acceptance and non- acceptance to violations for groups with varying amount of training exposure (Attitude) | ANOVA | If Sig.F < 0.05 then Reject $H_{O2}$ | $H_{O2}$ & $H_{A2}$ | Since Sig.F > 0.05 then Accept $H_{O2}$ |
| 4. Analyses based on acceptance to involvements in pollution violations for groups with varying amount of training exposure | CHI SQUARE | If Sig.$\Psi^2$ < 0.05 then Reject $H_{O3}$ | $H_{O3}$ & $H_{A3}$ | Since Sig.$\Psi^2$ > 0.05 then Accept $H_{O3}$ |

Table 5: Human Factors: Measurement Methodology

| Independent Variable | Measurement Methodology | Criteria | Tested Hypotheses | Decision adequate |
|---|---|---|---|---|
| 1. Analyses based on test scores for groups with varying amount of experience (Awareness) | ANOVA | If Sig.F < 0.05 then Reject $H_{O4}$ | $H_{O4}$ & $H_{A4}$ | Since Sig.F > 0.05 then Accept $H_{O4}$ |
| 2. Analysis based on acceptance and non-acceptance to violations for groups with varying amount of experience (Attitude) | ANOVA | If Sig.F < 0.05 then Reject $H_{O5}$ | $H_{O5}$ & $H_{A5}$ | Since Sig.F > 0.05 then Accept $H_{O5}$ |
| 3. Analyses based on correlation between citing fatigue as a reason to acceptance and non-acceptance for violations | Correlation Analysis | If Spearman's Coefficient, $\rho < 0.05$, then Reject $H_{O6}$ | $H_{O6}$ & $H_{A6}$ | Since Spearman's Coefficient $\rho > 0.05$ then Accept $H_{O6}$ |

Table 6: Summary of Results-Hypotheses

| Hypotheses | Result |
|---|---|
| Training could be inadequate | Training is adequate |
| $H_{O1}$: There is no significant difference in levels of oil pollution prevention awareness between officers with varied hours of training<br>$H_{A1}$: There is significant difference in levels of oil pollution prevention awareness between officers with varied hours of training | Accept $H_{O1}$ |
| $H_{O2}$: There is no significant difference in attitude towards pollution prevention practices between officers with varied hours of training<br>$H_{A2}$: There is significant difference in attitude towards pollution prevention practices between officers with varied hours of training | Reject $H_{O2}$ |
| $H_{O3}$: There is no significant relationship between number of hours of training and involvement in oil pollution violation incidents<br>$H_{A3}$: There is significant relationship between number of hours of training and involvement in oil pollution violation incidents | Accept $H_{O3}$ |
| $H_{O4}$: There is no significant difference in levels of oil pollution prevention awareness between officers with varied years of experience<br>$H_{A4}$: There is significant difference in levels of oil pollution prevention awareness between officers with varied years of experience | Reject $H_{O4}$ |
| $H_{O5}$: There is no significant difference in attitude towards pollution prevention practices between officers with varied years of experience<br>$H_{A5}$: There is significant difference in attitude towards pollution prevention practices between officers with varied years of experience | Reject $H_{O5}$ |
| $H_{O6}$: There is no significant relationship between fatigue and pollution prevention practices<br>$H_{A6}$: There is significant relationship between fatigue and pollution prevention practices | Reject $H_{O6}$ |

Six hypotheses were framed of which, 5 were based on the human factors of attitude, experience and fatigue. The adequacy of training was checked by content analysis of maritime training (engineering stream) syllabi with reference to STCW (Standards of Training, Certification and Watchkeeping) and IMO Lesson Plans. The statistical tests were chosen according to the nature of the data and the type of hypothesis. Appropriate criteria were established for acceptance or rejection of the hypotheses. The tests and criteria for validating the assumptions of the study are projected in Table 4 and Table 5. Further inputs were obtained from trainers attached to maritime institutes.

## 4 RESULTS AND DISCUSSION

The content analysis of the training syllabi and IMO Lesson Plans showed no apparent lack of training. The quantitative training appears to be sufficient with 17 hours, which is well above the 15 hours indicated in the IMO Lesson Plans in the post-sea scenario. The hours of exposure to training on pollution get enhanced if pre-sea quantum and the modular courses were also considered. The other hypotheses were verified by statistical tests, the results of which are summarised in Table 6.

Tests of bad (negligent) attitude and good attitude were conducted. While a deviation from normal, legal oil pollution prevention practice was considered as a bad attitude, conformance to rules was considered as good attitude. The sample population was divided into 5 groups based on the levels of training exposure and it was assumed that attitude differed with the training exposure. Based on the ANOVA, the next hypothesis, $H_{O2}$ is rejected with Sig. levels being equal (0.05). Also, the post-hoc tests indicate a decline of test scores for bad attitude with an increase in number of training hours. However, tests on good attitude showed no difference (Sig.0.611>0.05) and post-hoc tests showed no variation in average scores. It may be well assumed that existent good attitude does not enhance or diminish with increase in training hours. Good attitude is prevalent irrespective of the amount of training, while bad attitude reduces with increased amount of training. A parallel may be drawn with the attitude-behaviour patterns being affected by knowledge (Fabrigar et al, 2006). Increase in knowledge (training) does influence the attitude-behaviour.

The next hypothesis to be tested was to see if training made a difference to the officers' involvement in pollution incidents. A similar test was done for the human factor of experience assuming that increased experience will reduce involvement. Assuming increased training would mean increased experience, the involvements were tested with groups with varying experience. With Sig. $\Psi^2 = 1.00 > 0.05$, it is seen that increase in experience does not affect (bring down) pollution violations. Though this validates the acceptance of $H_{O3}$ where training was the factor, the relationship with experience was not tested by framing a hypothesis. It was seen that a hypothesis relating experience and involvements might fall into Type I error (Rejection of the Null when True). This is because an inference showing that increased experience increases number of violations might not be true, as the scope for pollution violation increases with increase in experience (work period).

The next test was on experience and awareness. Training on pollution matters is enhanced even after the shipboard officer reaches high ranks. An increase in experience exposes the officer to increased training hours and hence the knowledge. Officer sample was grouped into 7 varying levels of experience and it was assumed that experience would increase knowledge of pollution awareness. Results of $H_{O4}$ confirm this. With Sig. 0.576 > 0.05 but HOV Sig. 0.013 < 0.05, $H_{O4}$ is rejected, leading to the inference that increase in experience increases awareness. This outcome is not similar to that of $H_{O1,}$ where groups of varying training hours were tested for awareness. This syllogism leads to a conclusion that quantitative training has the same intensity to all the officers who undergo training, whereas, with gain in experience the quality of the training gained (knowledge) improves.

Experience and attitude measures were tested next. Proceeding to next hypothesis, with Sig. 0.187 > 0.05, but HOV 0.037 < 0.05, $H_{O5}$ is rejected. The scores for bad attitude tests show a decline with increase in years of experience. Increase in experience is seen to diminish bad attitude towards pollution practices. Further tests of experience with good attitude test scores showed no relationship (Sig.0.157 > 0.05) between them.

This is similar to the outcome of $H_{O2,}$ where increased training diminished bad attitude but did not affect good attitude. It may be inferred that increased experience and training hours lessens the bad (negligent) attitude towards pollution prevention practices though existent good attitude does not enhance or diminish with increased training and experience.

The last of the hypothesis, $H_{O6}$ was tested and the factor of fatigue showed significant relationship towards pollution prevention practices at $\alpha = 0.01$ itself. With this, $H_{O6}$ is rejected. Here, it was assumed that fatigue affected the shipboard operational practices particularly those pertaining to oil pollution prevention. This is further supported by the survey opinion shown in Figure 3, where a maximum number of respondents have identified fatigue as the major factor causing difficulties in MARPOL (pollution

prevention) practices. Also, fatigue is the primary factor affecting performance of shipboard staff as identified in the P&I Report on manning (2005). The IMO guidelines on fatigue (2001) and measures for mitigation prevail with the assumption that fatigue is a major factor affecting performance. The results of the study validate the same.

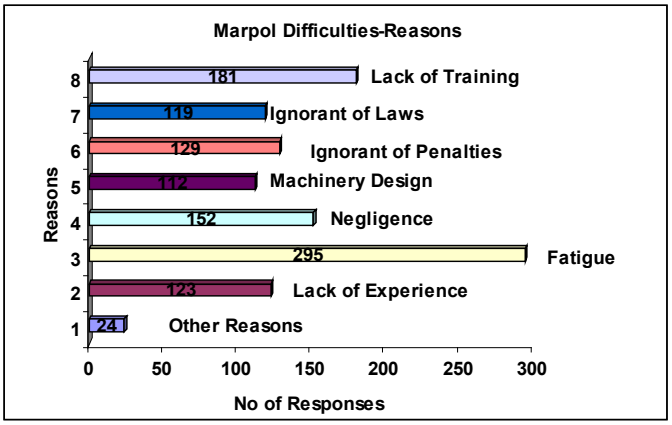



Figure 3: Reasons for Facing Difficulties in MARPOL Practices

Other tests of correlationship between experience, awareness test scores and attitude test scores showed no significant relationship. Amongst these tests, good attitude test scores comparatively showed a higher relationship with experience. But ANOVA scores were given more credibility as ANOVA tests are statistically more reliable for data being scalar.

## 5 CONCLUSION

The study recommended realistic approaches to enhance training by development of simulator exercises, increasing case studies, upgradation of the trainers' knowledge, treatment of environmental protection as an independent subject etc. Focussing on the other human factors, the study highlights few issues of concern. The recommendations are apparently based on the over-all results summarised in Figure 4.

The basic factor of training may be assumed to have been imparted effectively. Experience, on the other hand is a factor where strategic control is not possible. Attitude-behaviour is a major causal factor as much is fatigue considering the oil pollution violations. In the first place, further studies in these areas must be undertaken. Many factors may be cited which could be affecting attitude-behaviour and fatigue. Multi-cultural ambience, long working hours, absence of mate, extended shipboard stays, pressure from superiors and principals etc. are a few worth a mention. With projected shortages in ship manning, these issues will adversely contribute to the deviant behaviour causing pollution violations.

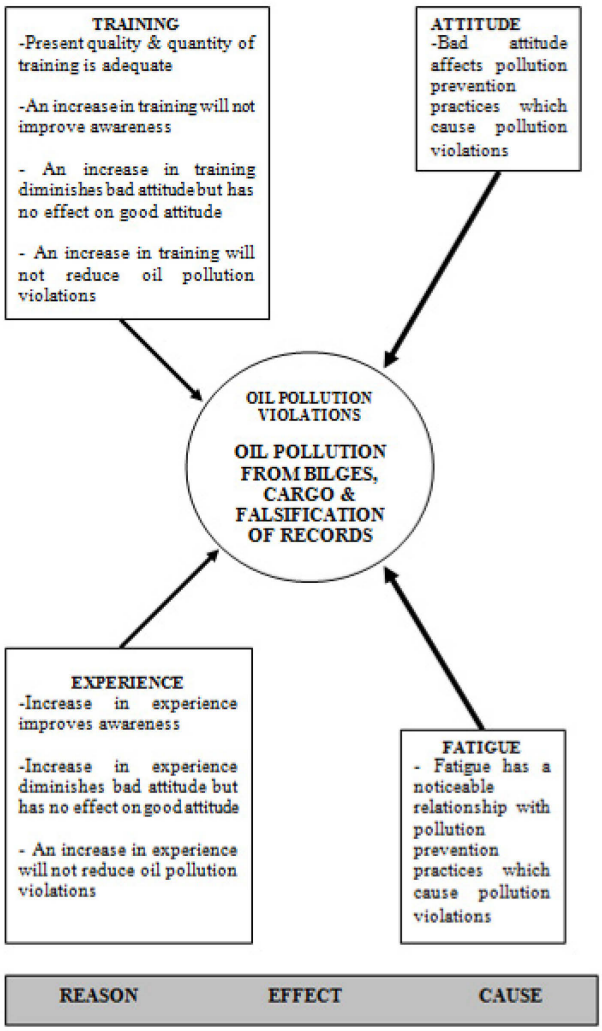



Figure 4: Effect of Training and Human Factors on Oil Pollution Violations

As a paradigm approach, training on mindset-behaviour at early stages of an officer's career (less experience) may be included in the training formats. Many maritime training programmes around the globe follow regimentation systems. The systems apart from preparing the officers for the hardships of sea life also aim to inculcate ethical behaviour.

With regards to fatigue, the industry must find some creative solutions. It is observed that because of fatigue, reaction times when faced with a problem are greater and since concentration is also affected, the probability of an accident increases (Gonzales, 2000). Rearrangement of watch hours ensuring proper rest periods are being tried out which differ from the traditional four on-eight off patterns. A Finnish study in fatigue (2008) identifies specific factors such as sleep apnea, lack of fresh air and time of the day in the watch-keeping schemes as some of the factors influencing fatigue. Timely relief and healthy work ambience are other issues for

shipping companies to be pro-active about. In the broader scheme of things, attitude of the shipboard officer and the overbearing effect of fatigue might remain as ever present issues for the industry to contend with.

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