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Fatigue in the shipping industry

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Summary and conclusions

Fatigue in the shipping industry is the central issue of the study reported on. This study sets out to find answers to the following research questions:
1. What can be concluded on the basis of national and international case descriptions of (registered) collisions and groundings and on the literature as to the causal link between fatigue and the shift system or fatigue and the occurrence of collisions and groundings?
2. Which measures, both on board as well as ashore, are (potentially) effective in reducing fatigue?
3. What is the effect of the most feasible measures (including substituting the two-shift system by the three-shift system) on the short shipping industry and the maritime education in the Netherlands?

Fatigue is conceptualised as a 'reduction in physical and/or mental capacity as the result of physical, mental, or emotional exertion which may impair nearly all physical abilities including: strength, speed, reaction time, coordination, decision making or balance' (IMO, 2001 a). The literature is quite clear on the debilitating effect of fatigue on (different aspects of) performance.
The desk study suggests that fatigue may be a causal factor in collisions and groundings in up to 11 to almost 23 percent of the cases. It should be noted though, that fatigue as a cause of accidents like collisions or groundings will be underreported. Navigators on watch will only seldom admit that they have fallen asleep or that they have been very tired or stressed. Additionally, reports of accidents are generally written by those crew members who are directly involved in the near misses and accidents, and may therefore involve bias (Baker & McCafferty, 2005). In the FSI documents studied it was found that 60 to 81 percent of all the collisions and groundings (excluding those involving fishing ships and passenger ships, or involving other incidents than collisions and groundings) were caused by 'human error' (FSI 9/10, FSI 10/9, FSI 11/4, FSI 13/WP2).
Fatigue behaviours that are often mentioned when fatigue was considered to be a cause of collisions and groundings are 'activation problems', meaning decreased vigilance and decreased alertness, and 'perception (and sensory input) limitations', meaning a reliance on visual inputs, decreased attention to peripheral stimuli, uncertainty of the observations, and decreased communication. Particularly these fatigue behaviours are often found in reports from collisions and groundings occurring between 00:00 to 04:00 hours, but are also quite prevalent in collisions and groundings occurring between 20:00 to 00:00 hours (Philips, 1998). These were also the periods in which most collisions and groundings had occurred. In the 'Bridge Watch keeping Safety Study' the MAIB (2004) concluded that fatigue was a contributory factor in 82% of the groundings in the study, which occurred between 00:00 and 06:00 hours.
There is little literature to date that systematically measures all possible indicators of fatigue in the maritime industry in order to unequivocally support the view of a causal relationship. Research is also needed to address the unique combinations of potential stressors, which may interact in various ways to produce fatigue, poor health and increased accident risk.

Recent results in accident research (road transport) indicate that the risk of accidents at work is a function of hours at work and sleep deprivation (Philip et al, 2005). Folkard and Akerstedt (in Hanecke et al, 1998) reported an exponentially increasing accident risk beyond the 9th hour at work. The relative accident risk is doubled after the 12th

hour and tripled after the 14^{th} hour at work. In general, it is recommended to have at least 8 hours of rest per 24 hours.

The literature on the relationship between the shift system and fatigue is inconclusive. There are several sources in the literature that indicate that the two-shift system is more prone to result in collisions and groundings (e.g. MAIB, 2004; Lindquist, 2004). On the other hand, it is concluded that in a schedule of 4 hours on watch, followed by 8 hours off watch, long hours of watchkeeping are avoided, but this schedule will still result in a split of the sleeping period between the two times due to additional duties (Colquhoun et al, 1988). Zieverink and Kluytenaar (1997) report that the two-shift system is considered less taxing (as compared to sailing inland waterways and loading) because of its regularity and simplicity.
It appears that different shift systems have all their pro's and con's. Davis, Cameron & Heslegrave (1999) who compared three shift systems did not show one system to be superior to the others. From the perspective of fatigue the 12 hours on 12 hours off appears to be superior. However, for practical reasons other shift systems may be preferred.
The desk study did not add anything to the conclusion based on the literature since the number of cases for which the shift-system could be identified resulted in too few collisions and groundings per shift system to come to reliable conclusions.

On the basis of the literature and the interviews measures to manage fatigue were related to:

a. lengthening of the resting period;
b. optimising the organisation of work;
c. reducing administrative tasks;
d. less visitors/inspectors in the harbour/better coordination of inspections;
e. reduce overtime;
f. proper Human resource Management;
g. education and training;
h. development of a management tool for fatigue;
i. proper implementation of the ISM-code;
j. healthy design of the ship;
k. health promotion at work;
l. expand monitoring of fatigue causes, behaviours or consequences, including near misses.

The measures that were considered most necessary and effective in reducing fatigue were found to be:

1. proper implementation of the ISM-Code;
2. optimising the organisation of work on board vessels;
3. lengthening of the rest period;
4. reducing administrative tasks on board vessels.

Expanding monitoring of causes, behaviours and consequences, including near misses was also rated high on 'necessity', but is considered to be less effective in reducing fatigue. One could argue that expanding monitoring might be particularly important for understanding the size of the problem, and obtaining better insight in the causes of fatigue-related consequences, also other consequences than groundings and collisions. Because several organisations (e.g. EMSA, CHIRP) are already active in increasing the monitoring of causes, behaviours and consequences of fatigue, this option was not selected to be assessed on its consequences for the shipping industry and maritime education. It may be concluded, though, that since the shipping industry is such an international market, monitoring should take place at world-level, and not be restricted to a single country or Europe.

Although proper implementation of the ISM-Code is one of the main options in the list of prioritised measures, one still has to identify some concrete measures, since the implementation of the ISM-Code can in principle include any of the measures mentioned above. The choice depends on its fit to the need of, or possibilities in the organisation concerned. One could say the same for a 'Fatigue Management Program', which also is a policy instrument within the organisation to plan and implement measures to manage fatigue that fits the organisation. Fatigue management should be an integral part of safety management, and could thus be seen as part of the ISM-Code with specific attention to fatigue.

On the basis of the prioritisation of measures to manage fatigue, the consequences of the following measures were assessed for the shipping industry and the maritime education:

1. Replacing the two-shift system with the three-shift system, and an additional crew member on watch is added to the crew.
2. Adding a crew member but not an Officer in Charge (OIC). The additional crew member should be a person who will be able to take over some administrative tasks from the officer on watch or from the Master.
3. Changing the shift system into a more flexible one, with a rest period of at least 8 hours. A possibility is to introduce a 4-8/8-4 shift system.
4. Identifying administrative tasks that can be done by the organisation ashore using (wireless) ICT facilities.
5. Setting up the framework for a Fatigue Management Tool/ Programme.

In Table A these measures are compared on the basis of economic costs, consequences for the maritime education, and additional, often more practical arguments.

The replacement of a two-shift system by a three-shift system will have a huge financial impact on the Dutch (and EU) short sea shipping industry. Although this replacement is expected by several authoritative organisations, its effects have thus far not been proven. The Dutch (and EU) maritime education and training system will perceive an increased pressure as well. About 398 extra seafarers are estimated to be needed for the Dutch fleet alone, and 2,540 seafarers for the EU fleet. If this measure is implemented, at least a sufficient transition period is suggested.

The other three measures are options, but at present nothing more than that. Appending an additional crew member is expensive and hardly feasible due to the limited number of cabins. Appointing another seafarer authorised for the Watch, but also able to perform other duties on board (e.g. a 'Dual Purpose Officer' or MAROF-Maritime Officer) may increase flexibility in watch keeping.
Moving administrative tasks to the shore organisation in combination with a high-speed Internet connection is difficult to arrange due to the onboard responsibility. Secondly, such connections can only be established through satellite, which is still quite expensive. However, in consequence to the ISM the implementation planned maintenance on board is more structured now. Especially on smaller ships the experience is that planned maintenance has been incorporated in service contracts with suppliers. In these cases as a consequence the workload/paperwork has already been reduced.

ICT developments on board may additionally increase efficiency and reduce the administrative burden on board, dependent on how well ICT on board is already developed.
The suggested improvement of the actual shift system flexibility appears to be an interesting option. The main goal of the shift system proposed is to provide the seafarers with a resting period of at least eight hours per 24 hours, but keeping regularity in the shift across this 254 hour period. Except for the change of the 2 shift-system by a 3-shift system, all other measures hardly affect the maritime education and training system.

Table A: A summary review of the implications and consequences of the measures to reduce fatigue in the shipping industry

Measures	**Estimated costs**	**Educational consequences**	**Additional remarks**
Add an Officer in Charge	Employer: € 99-121.000,-/year Sector -NL-: € 17,9-21,9 mln/year	Increased pressure: 3000 new crew members EU-wide Dutch/EU ship owners could train seafarers outside EU (already happens)	
Add a crew member, but NOT an Officer in Charge		Additional courses should be developed/ course units should be added to courses of seafarers	This proposed measure is hypothetical: these officers would not have a full time job. Delegation of tasks makes more sense
Delegating administrative tasks ashore using ICT	Costs may range from a fixed amount of € until $ 2,800 per month for 2,000 minutes	'Delegation' should be an issue in Masters and OIC training Training should involve the most recent en relevant ICT developments in this respect	The present ICT offers are not good enough yet
Changing shift system, e.g. 4-8/8-4	No additional costs	No immediate consequences for the maritime education	*Advantage*: Seafarers have an eight hour rest period without extra costs
Fatigue management tool	No indication of costs to be given; depends on what measures the organisation will adopt	No general indication of the consequences for maritime education; dependent on measures adopted by organisation	Links up with ISM-Code. Care should be taken to restrict the administrative burden of such a tool

In general, prudence is called for every intention to ‘interfere’ in the already stable but competitive sector.
Despite this reservation, it is recommended to study the ISM-Code and to investigate whether the Code shows any deficiencies or even shortcomings related to fatigue notification, or opportunities for fatigue prevention or reduction. For the large majority of ships the ISM-code has only been in force since three years. So it must be taking into

account that the potential positive impact of the ISM-code related to safety management, and potentially fatigue management as well needs more time to fully develop and grow. Understanding how the Fatigue Management Programmes in some other related sectors like road transport, have been developed and implemented my provide interesting lessons for fatigue management in the shipping industry. Close cooperation between the (Designated) Authorities (the Ministry, the Transport and Water Management Inspectorate and classification bureau), the ship owners/ operators and the KVNR (Royal Association of Netherlands' Ship owners) is a must to improve fatigue management within the framework of the ISM-Code.

Main conclusions on the relations between fatigue, collisions and groundings and the shift system:

- Fatigue is causally related to a deterioration in performance. Clear debilitating effects are reported for example vigilance, alertness, perception, the quality of the information processing as well as timing.
- Fatigue may be a causal factor in 11 to 23 percent of the collisions and groundings. It should be noted though, that fatigue as a cause of accidents like collisions and groundings will be underreported. Better (international) monitoring of fatigue is warranted.
- Both the desk study and the literature on the relationship between the shift system and fatigue are inconclusive.
- In the literature it is generally concluded that a period of 8 hours of uninterrupted sleep is optimal.

Main conclusions regarding the measures and their consequences:

- Measures that were considered most necessary and effective in reducing fatigue in the Netherlands were:
  - proper implementation of the ISM-Code;
  - optimising the organisation of work on board vessels;
  - lengthening of the rest period;
  - reducing administrative tasks on board vessels.
- Replacing the two-shift system by a three-shift system by adding an Officer in Charge is the most expensive option with considerable financial consequences for the employers and results in an increased pressure on the maritime educational system. It should additionally be kept in mind that the evidence on the causality of the relation between the 2-shift system - fatigue - groundings and collisions' is inconclusive.
- Adding a crew member designated with administrative tasks is not a real option, since the amount of tasks is not enough for a full time job. Delegating tasks may be a better option. Appointing seafarers authorised for watch and being able to perform other tasks on board may be an option. In time (cheaper) ICT programmes may improve the possibilities to delegate (more) administrative tasks ashore.
- Changing the shift system, e.g. into 4 hours on '-8 hours off -8 hours on -4 hours off-' is an interesting option, which accommodates the advise to have at least 8 hours of rest, and preserves the regularity in shifts over 24 hours.
- Setting up a Fatigue Management Program as integrated part of the USM-code is in line with the implementation (trajectory) of the ISM-Code in that it accentuates fatigue management as part of safety management. It allows organisations to be flexible in their fatigue management. An evaluation of how the ISM-Code is implemented at present is warranted.

1 Introduction

The Ministry of Transport, Public Works and Water Management, and more specifically the Directorate-General for Civil Aviation and Freight Transport (hereafter called the Ministry) commissioned TNO Work & Employment (TNO) and Maritime Simulation Rotterdam b.v. (MSR) to perform a study on 'fatigue' in the shipping industry. Central to this study is the relation between 'fatigue' and the occurrence of collisions and groundings. One of the aims of this project is to assess the relationship between fatigue and collisions and groundings, to inventory measures to prevent and manage fatigue, and to map the consequences of these measures for the competitiveness of the sector as well as for the maritime education.

A special aspect relates to the two-shift system (six hours on and six hours off). Although fatigue as a cause is mentioned in cases of accidents, the causal link between the two-shift system and fatigue has not been proven. Therefore the conclusion some studies came up with, i.e. the substitution of the two-shift system by a three-shift system (6 hours on, twelve hours off or 4 hours on and 8 hours off), seems to be somewhat premature. Apart from the fact that a firm establishment of a causal relationship between the shift system and fatigue has not yet scientifically been established, the effectiveness and consequences of measures directed at a change of the shift system are not studied and therefore unknown.

However, there are indications that an international ban of the two-shift system may become a reality. This will have consequences for the shipping industry in general, but it is expected to have a major effect on the Dutch shipping industry, particularly for the competitiveness. The main consequence would be that more personnel has to be sent on each voyage. As a result personnel costs will increase. Although the three-shift system is common in the Netherlands, the two-shift system is as well. This is an important reason why the Ministry wants to know whether there is a causal relation between the shift system and fatigue.
If the two-shift system will be banned without a reasonable transition period it is assumed that the necessary qualified personnel may not be available on short notice.
Alternative and perhaps more acceptable, potentially effective measures are looked into as well. This justifies a testing in practice as well, including an estimation of how much the implementation of this (and other) measure(s) that may be effective in preventing and managing fatigue will benefit or cost. Since the term generally used is 'fatigue management', using 'fatigue management' will include preventive action.

The research questions of this study are formulated as follows:
1. What can be concluded on the basis of national and international case descriptions of (registered) collisions and groundings and on the literature as to the causal link between fatigue and the shift system or fatigue and the occurrence of such collisions and groundings?
2. Which measures, both on board as well as ashore, are (potentially) effective in managing fatigue?
3. What is the effect of the most feasible measures (including substituting the two-shift system by the three-shift system) on the short shipping industry and the maritime education in the Netherlands?

In this draft report the first two research questions will be dealt with based on the available analyses of collisions and groundings in the shipping industry, as well as by searching the literature in order to answer the first question. The second question will be answered both by searching the literature as well as by interviewing relevant organisations within the sector.

2 Fatigue in the shipping industry: a definition and model of analysis

Although there is an emerging recognition that neurobiologically based sleepiness or fatigue contributes to human error as a root cause of many accidents in industrialized, technology-rich societies, the concept of fatigue does not have a clear definition (e.g. Dinges, 1995). Thus, prevalence data are always dependent on the particular definition used.
The IMO (2001 a) has, however, formulated a definition of fatigue in which fatigue is conceptualised as a 'reduction in physical and/or mental capacity as the result of physical, mental, or emotional exertion which may impair nearly all physical abilities including: strength, speed, reaction time, coordination, decision making or balance'. The IMO thus acknowledges the relation between fatigue and human error as indicated above.

Fatigue can be divided into categories in many different ways. However, systematic studies seem to find between three and five dimensions, including general fatigue (tired, bushed, exhausted), mental fatigue (cognitive impairment), physical fatigue, and sleepiness (tendency to fall asleep), and sometimes motivation or lack of activity" (Akerstedt et al, 2004).
The distinction between acute fatigue and cumulative or chronic fatigue (e.g. used by the USCG, 1998) may be an interesting one with regard to prevention. Acute fatigue is limited to the effects of a single duty period, such as a 9 to 5 hours working day, which may result in a 'micro sleep' (just being away for a split second) or actually falling asleep. Cumulative fatigue occurs when there is inadequate recovery between these duty periods. Thus, cumulative fatigue usually presents a picture of day-to-day changes for the worse. It is clear that causal factors as well as preventive measures may be very different, dependent on the type of fatigue. In order to actually fall asleep, one often is chronically fatigued and has accumulated a sleep deficit over time. Chronic fatigue therefore, is considered to be a precursor of acute fatigue, but environmental factors may additionally be important. Falling asleep will occur sooner when the tasks and working conditions are dull, monotonous, and when the temperature is high. On the other hand, it is unlikely to fall asleep in a hectic environment, and when a lot of activity takes place. Ergonomic equipment, machines and soft ware that is designed according to ergonomic standards may also limit negative consequences when the seafarers' behaviour is impaired due to fatigue.
The situation of managing chronic fatigue is quite different from that of managing acute fatigue. Having a wide set of risk factors like long working hours, working at night, high job demands, the noise on board or in the cabin, and social relations at work, managing or reducing risks by managing work-related risks may be one solution. Additionally personal characteristics and life may have its impact on the individual resulting in fatigue. Particularly Chronic fatigue may not only result from quite a different set of predictors, but may result in quite a different set of preventive measures as well. Preventing the accumulation of fatigue over time can deal with working schedules, the quality of the sleeping cabins, the social relations on board, the demands (e.g. number of tasks) imposed upon a person and the autonomy to handle these demands, as well as with procedures on how to deal with alcohol (consumption) on board or with other kinds of organisational measures.
The operational impact of seafarers on their circadian rhythm, which also is an important ingredient of fatigue, particularly where it is not aligned with the day-night cycle

of these seafarers, may have an important effect on both their acute and chronic fatigue. Its effects are familiar to anyone who has suffered jet lag (USCG, 1998).

The model used to look at fatigue in this study distinguishes three levels of fatigue (see also figure 1):

- Work load: the factors causing fatigue at work of seafarers/nautical personnel.
- Consequences for the coping capacity, life style, sleep quality and fatigue.
- Effects on performance, behavior, human error collisions and groundings.

Within these three levels the relation between work load and coping capacity (of the individual) constitutes an important role. The relation between work load and coping capacity determines how heavy the job is, and the risk of chronic fatigue to occur.
With respect to the work load it is important to distinguish between four work load areas: physical load, the environmental load, mental load and perceptual load (figure 1).

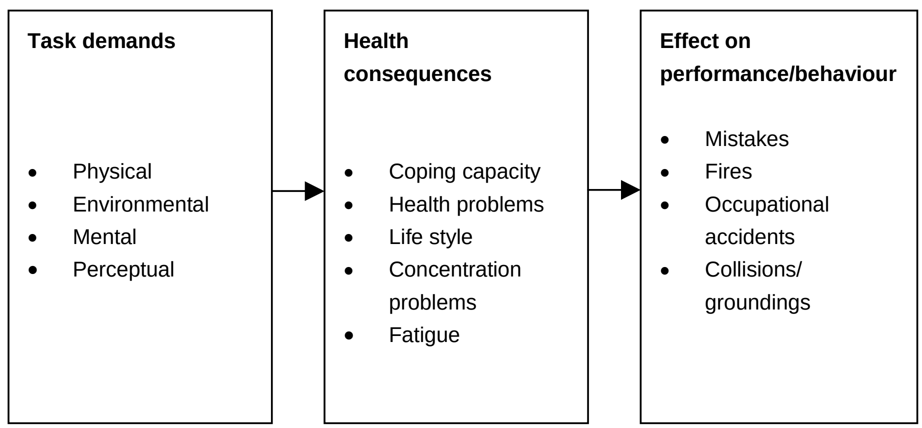

Figure 1: The three level model of fatigue

Every work load area distinguishes several work load aspects. In total 27 different aspects are discriminated (Table 1).

Table 1: The four work load areas with different aspects

Physical load	Environmental load	Mental load	Perceptual load
Energetic load\	Skin	Aggression	Alertness
Lifting	Smell, type of material	Tension	Perception
Carrying	Sensation	Human suffering	Concentration
Pushing	Temperature	Time pressure	Assessment
Pulling	Hearing damage,	Irregular/continuous work	Reaction time
Static load	noise	'Uncomplete' job	
Repetitive movements	Vibrations	Short cycled tasks	
	Protective clothing,	Decision latitude/autonomy	
	safety means	Opportunities for contact	

This model of analysis will be used to assess chronic fatigue in this project, and for finding solutions or measures to prevent and manage fatigue.

3 Methods

The project was designed in three phases:

1. A desk study as well as a literature and web search was performed in order to establish (1) the relation between the shift system and fatigue and (2) the relation between fatigue and collisions and groundings. The search was also used to (3) inventory the information available on fatigue measures that were shown to be, or could be potentially effective in the shipping industry.
2. Interviews and a workshop were held with stakeholders in the sector in order to collect their views on the issue of fatigue in the shipping industry, its causes, consequences (the causality between the shift system and fatigue, and fatigue and collisions and groundings in particular), and measures of (potential) relevance to prevent and manage fatigue in the sector.
3. The consequences of the most important measures were estimated. Consequences in terms of costs and benefits, but also for the competitiveness of the sector as well as from an educational perspective are to be assessed. One of the measures that should be taken into account in this phase was the replacement of the two-shift system (6 hours on, 6 hours off) by the three-shift system (4 hours on, 8 hours off).

According to this phase-wise planning of the project, the following activities took place:

- Analyses of collisions and groundings as have been reported by the Shipping Council in the Netherlands (http://www.rvtv.nl/english/index.html). Since 2004 this board has become part of the Dutch Transport and Safety Board. These 'Dutch' reports by the Shipping Council in the Netherlands were analysed on both the share of collisions and groundings that were attributed to fatigue, as well as on the relation of the shift system and fatigue/collisions and groundings. To get more insight into the degree in which international collisions and groundings as reported by the IMO have been related to fatigue as (one of the) cause(s), several documents of the IMO subcommittee on Flag State Implementation (FSI) have been analysed as well (FSI 9/10, 2000; FSI 10/9, 2002; FSI 11/4, 2003; FSI 11/4, 2005). From these documents, however, it was unable to relate collisions and groundings to the shift system.
- A literature review was performed based on:
  - Reports and other documents on fatigue, provided for by the Ministry.
  - Search in Pubmed using key words as fatigue, sleep(iness), work-rest schedule, shift work, accidents, working hours.
  - Websites of organisations identified as important regarding 'fatigue' in the sector or playing an important role in the sector or on this subject internationally (e.g. IMO, MAIB, USCG).
- Face to face interviews with stakeholders that were directed at (1) informing them about the project, (2) asking them about the issue of fatigue, as well as on the prevalence of fatigue, its causes and consequences and measures to prevent or to reduce (the consequences of) fatigue. The organisations interviewed are:
  - The seafarers' union in the Netherlands (FWZ).
  - The Dutch Masters' Association (NVKK).
  - Dutch Ship owners (three) and their representative (KVNR).
  - The Dutch Transport and Safety Board.
  - The Netherlands Shipping Inspectorate.
  - Occupational physician regularly providing services to the shipping industry.

In addition, some organisations were interviewed by telephone in order to specifically ask them about additional opportunities for monitoring collisions and groundings or near accidents of these kind. These organisations interviewed by telephone were:

- The Port Authority of Rotterdam, since they have access to the 'monitoring VTS/Vessel Traffic Services' which records ship movement in the harbour, and consequently each ship collision.
- The PSC (Port State Control), an organisation that inspects the 'safety manning document' as it functions in practice.
- P&I-organisations (related to insurances); these organisations are expected to have all information on accidents but their information probably is not very accessible.
- The EMSA (European Maritime Safety Agency); this organisation is working amongst others on a European database on collisions and groundings.
- Dredging companies; they are (also) there when accidents have occurred.

- A workshop was held with the same stakeholders as were interviewed face to face. The aim of the workshop was to (1) present, and if necessary discuss a definition of fatigue, (2) present what was found in the literature on causal relations, (3) present measures to manage fatigue as were found in the literature or that came to us from the interviews, and (4) prioritise the measures with the stakeholders; Since the workshop aims appeared to be set too high, the topic of the measures could not be addressed in due time. Therefore a questionnaire about which measures would be useful or valid in the shipping industry to prevent or reduce fatigue, and a request to rate them on several criteria was sent to the stakeholders. After a first round of 'communication about the measures', the final questionnaire specifying measures was sent out with the request of the stakeholders to prioritise the measures (see annex 1).
- On the basis of the priorities provided by the stakeholders, a ranking of measures was made, and a selection of most promising measures was made. Next their consequences were assessed in terms of costs and benefits, and to the effects on the competitiveness of the sector as well as to the educational consequences. Replacing a two-shift system by a three-shift system was explicitly meant by the Ministry to be one of the measures subjected to this analysis. Since some of the measures were not formulated specifically enough, a group of 22 seafarers, constituted by Masters, Chief Officers, Officers in Charge and some others completed a short questionnaire in which they, amongst other things, were asked to specify tasks and activities to be performed at sea, and identify tasks that could be delegated (see Annex 2). This group of seafarers was -for different reasons- at the premises of MSR to take a course or otherwise, and was willing and available to help out. This sample is by no means a representative, random sample, but was not pre-selected for this purpose either. The need to elaborate more on some aspects of the measures proposed was not anticipated. It can still be decided that this issue is still something that should be done more thoroughly.

4 Results

In the first paragraph the desk study will be described including the Dutch incident/accident reports on collisions and groundings analysed. The analyses provide some insight in the potential contribution of fatigue on collisions and groundings. It can also (partly) relate the collisions and groundings to the shift system.
Secondly, the report on the literature regarding the prevalence of fatigue in the shipping industry, on the causal relationship between fatigue and collisions and groundings, and on what is known about the shift system and fatigue is presented. The literature review will end up in presenting what is known about effective measures to manage fatigue.
In a consecutive paragraph we will present the views of the national stakeholders on the above subjects, and present their priorities as to what they perceive to be important and effective measures against fatigue.
A final paragraph will present the consequences of the implementation of the potentially most important measures in terms of their costs and benefits, and their consequences for the competitiveness of the Dutch shipping industry and the maritime education.

4.1 Desk study on collisions and groundings

4.1.1 The Dutch situation

This paragraph reports on secondary analyses of collisions and groundings as have been reported since 1997 by the Shipping Council in the Netherlands (http://www.rvtv.nl/english/index.html, since 2004 this board has become the Dutch Transport and Safety Board). In this report we are able to present the results of these analyses until (the beginning of) 2005, and we thus will cover a period of (almost) 9 years. In this period a total of n=191 groundings and collisions were studied. A selection was made of cases (1) took place at 'short sea' (excluding accidents with fishing and passenger vessels), (2) were related to 'human factors', and (3) were classified as a 'collision' or 'grounding' (so no fires or occupational accidents on board were included).
On the basis of the dossiers 58 cases were selected. In 13 of these 58 cases (22,4%) 'fatigue' was identified as (sometimes one of the) causal factor(s). In annex 3 all 58 cases are described. Below a short summary of these analyses is presented with specific emphasis on the role of fatigue and the shift system.

From all 58 cases the type of shift system could only be identified in 53% of the cases. In three of these cases different shift systems were used at sea as compared to the harbour situation. In the latter case a three-shift system (4-hours-on-8-hours-off) was the case when at sea, whereas a two-shift system (6-hours-on-6-hours-off) was the case in the harbour (see Table 2).
In those cases where it was clear what shift system was used (n=32) the two- and three-shift systems occurred almost equally often (Table 2). In those cases where fatigue (or fallen asleep) was reported as (one of) the cause(s) of the accident, and when it was clear which shift system was used, 5 (out of 13) cases were related to fatigue in the two-shift system, whereas only 2 (out of 15; 13%) cases were related to fatigue in the three-shift system. Although these findings appear to favour the three-shift system above the two-shift system on fatigue related to collisions and groundings, the differences as found on these shift systems is based on too few cases to be significant.

Table 2: An overview of the two- and three shift system and -when known- the attribution of fatigue as a cause of the collisoin or grounding across 1997 until august 2005

	Total number of groundings and collisions	Groundings and collisions where fatigue is perceived to be a cause
Two-shift system	13	5
Three-shift system	15	2
Differences of shift system according to job at sea -versus- in harbour	3	-
Shift system unknown	27	6
Total	**58**	**13**

Issues that came forward in those 13 cases where fatigue played a role were no mandatory look-out, falling asleep/being 'absent' for a while, no watch alarm was set, and no proper navigation. Alcohol was involved on several of these occasions as well.

Other aspects that played a (causal) part in the collisions and groundings studied were:
1. no proper preparation of the voyage;
2. no proper manning of the bridge;
3. no proper outlook;
4. not a proper navigation;
5. insufficient communication with other ships;
6. too high speed at restricted view.

In some of the above mentioned cases a pilot was on board of one of the ships. In these cases it is often the bridge organisation that was the problem like unclear agreement as to the division of tasks and the route to follow, the master/crew who put too much confidence in the pilot and left the pilot on his own, no communication with other ships and harbour control, and a wrong assessment of the situation by the pilot.

4.1.2 The international situation

In order to understand the incidence with which fatigue is considered to be a causal factor for collisions and groundings outside the Netherlands, several FSI documents haven been analysed. This information is presented in Table 3. Up front it can be said that no information on the shift system can be deduced from the FSI-documents. In these analyses the collisions and groundings involving fishing vessels and passenger ships were excluded as well. In the analyses we classified collisions and groundings as a result of 'human error' (excluding language problems as (one of the) cause(s)), which may be related to fatigue in some cases but less likely in other ones), as fatigue and other or related causes result into falling asleep at some point.

Table 3 indicates that 'human errors' is most often considered the, or one of the causes for collisions and groundings (60% - 81%). Only in 11% to 20% of the cases fatigue was explicitly stated to be a cause of these kind of accidents.

Table 3: The incidence of collisions and groundings as related to 'human error' and to 'fatigue' outside of the Netherlands (excluding other accidents than collisions and groundings, excluding collisions and groundings of fishing vessels and passenger ships).The percentage is related to the relevant cases

	FSI 9/10	FSI 10/9	FSI 11/4	FSI 13/WP.2
Groundings & collisions	1996-1999	1998 - 2000	1997-2000	1999-2002
Human error	11 (73%)	38 (60%)	23 (72%)	30/31 (81%)
Fatigue	2 (13%)	9 (14%)	3/4 (11%)	7/8 (20%)
Total of relevant cases	**15**	**63**	**32**	**37**
Total number of cases	**38**	**68**	**72**	**107**

4.2 Literature on fatigue, causes, consequences and measures

In this paragraph the results of the literature on fatigue is described. Important information is presented on the prevalence of fatigue and fatigue behaviours, as well as on the causes and consequences of fatigue, and on measures aimed at fatigue management.

4.2.1 The prevalence of fatigue and fatigue behaviours in shipping

The desk study reported above suggests that fatigue may be a causal factor in collisions and groundings in up to 11 to 23 percent of the cases. In 2003 the Ministry commissioned an analysis of the reports by the Shipping Council. In this study it was found that 'fatigue' was third (14%), after 'no watch' (22%) and 'no proper watch' (21%) when main causes of groundings and collisions were concerned (Simons e.a., 2003, 2004).
Fatigue has been related to accidents in other sectors as well. It plays an important role in commercial road transport in almost 20% of the road accidents. Even more than 50% of the drivers operating on the international transport routes actually reported to have been falling asleep behind the wheel (European Transport Safety Council, 2001; Van Schagen, 2002).

The MAIB (Marine Accident Investigation Branch; 2005) concluded in their annual report that in 2004 there have been a worrying number of merchant ships involved in collisions or near misses. It was stated that '…while the details of the accidents may vary, the fundamentals remain depressingly consistent: fatigued crews, due to undermanning; falsified hours of work records; no dedicated lookout on the bridge; and poor situational awareness/anticipation/judgement by officers of the watch – classic symptoms of fatigue…'.

The multidimensionality of the fatigue concept is, however, a problem, not only regarding its definition, but the measurement as well. It also makes comparisons of aetiological studies rather difficult. In the literature a variety of behaviours have been associated with fatigue. These behavioural manifestations were obtained from laboratory experiments (including perceptual, motor and cognitive tests, sleep propensity, reaction time and simulations), as well as field experiments. Using a neurobiological model, behaviours were sorted into the following categories (see e.g. Philips, 1998; Table 4):

1. Activation problems - attentional failures, slips and lapses.
2. Perception limitations - limiting visual and auditory sensation.
3. Information processing problems - interpretation, encoding and correlational deficits.
4. Aversion to effort - failure to act.
5. Differing effort - failure to act properly.

Table 4: Fatigue behaviours (after Philips, 1998; Dinges, 1995; Dawson & McCulloch, 2005)

Fatigue Behaviour	Primary reference
1. Activation Problems	
Decreased vigilance (during a constant task)	Mackworth 1950; Krueger, 1989
Decreased alertness (to a possible problem)	Akersteds & Folkard, 1990; 1994; Condon et al, 1988; Folkard & Monk, 1979; Froberg et al, 1975; Haworth et al, 1988; Hockey, 1986; Stokes and Kite, 1988; Broughton, 1988; Vidacek et al., 1993
Gaps, lapses or blocks	Brown, 1989; Haworth et al, 1988; Hockey, 1986
2. Perception (and Sensory Input) limitations	
Reliance on visual (eyes and radar) inputs	Bryant, 1991
Decreased attention to peripheral instruments	Hockey, 1986
Uncertainty of observations	Bohnen and Gaillard, 1994
Decreased nighttime communication	Bryant, 1991; Graeber, 1989; Ohashi & Morikiyo, 1974
3. Information Processing Problems	
Decreased encoding/registration of recently acquired information	Hockey, 1986
Failure to interpret information as part of a single, integrated system	McFarland, 1971
Decreased ability to correlate dynamic processes	Luczak, 1991
Information processing deficiencies in secondary task	Gaillard & Steyvers, 1988; Sablowski, 1989
4. Aversion to Effort	
Low effort, low probability of success	Hockey, 1986
Easy, but risky alternatives	Hockey, 1986
Response latency/decreased speed of execution	Hockey, 1986
Lower standards of accuracy and performance	McFarland, 1971

Fatigue Behaviour	Primary reference
5. Differing effort	
Increased variability of timing actions	Dinges, 1992; Dinges, 1995; Hockey, 1986
Decreased performance with lower/peripheral processes	Gaillard & Steyvers, 1988
General performance decrement	Akerstedt, 2004; Akerstedt and Folkard, 1990, 1994; Belenky, 1998; Brown, 1989; Condon et al, 1988; Dinges et al, 1997; Greandjean, 1970; Folkard & Monk, 1979; Haworth et al, 1988; Hockey, 1986; How et al, 1994; Stokes & Kite, 1994; Neri et al, 1992; Parasuraman, 1986; Philip et al, 2005

Many of the studies presented in Table 4 are not performed in the shipping sector. The findings are, however, rather robust when it comes to changes in human behaviour. From this list it is apparent that the study of the relation between fatigue and performance goes back several decades. Through these decades these studies result in the conclusion that performance decrements are to be expected in cases of fatigue, whereas the performance decrements are related to all stages of information processing, i.e. to activation, perception, information processing, aversion to effort and differing effort as well.

In an interesting study Philips (1998) performed an analysis of hundred 'Accident At Sea Reports' of the Australian Department of Transport Marine Incident Investigation Unit, in order to identify these five 'fatigue behaviours'. Of the 100 incidents analysed, 38 were groundings and 24 were collisions. In order to constrain behaviours to watchkeeper error, the analysis of fatigue behaviours was limited to collisions and groundings. These reports were coded according to the fatigue behaviours identified in Table 4 (see figure 2).

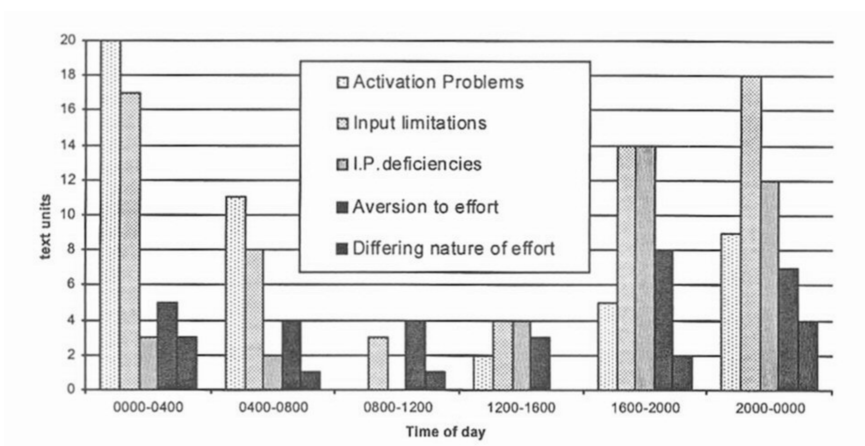

Figure 2. Fatigue behaviours as identified in text units of the reports on collisions and groundings by time of day (Philips, 1998)

The frequency of all fatigue behaviours was higher during the night watches and lower during the morning and afternoon watches. This distribution was most noticeable in the activation behaviours, with a ten-fold increase in the 00:00 to 04:00 watch compared to the 12:00 to 16:00 watch.

The collisions and groundings also showed a strong diurnal variation, peaking during the 00:00 to 04:00 watch, with a trough during the day (08:00 to 12:00 for collisions, 12:00 to 16:00 for groundings). Such a distribution of accidents by time of day has been described by other researchers as well (Philips, 1998).

On the basis of their 'Bridge Watchkeeping Safety Study' the MAIB (2004) concluded that “Fatigue was considered to be a contributory factor in 82% of the groundings in the study which occurred between 00:00 and 06:00”.

4.2.2 *Underreporting of fatigue*

It should be noted that watchkeepers only very seldom admit that they have fallen asleep or that they have been very tired or stressed. Therefore, it is possible that the reported figures are too low (Lindquist, 2004). Reports of accidents are generally written by those crew members who are directly involved in the near misses and accidents, and may therefore involve bias (Baker & McCafferty, 2005).

The National Research Council (1990) additionally stated that they believe that the impact of fatigue in casualties is substantially underreported as most accidents are not investigated in sufficient detail to identify its exact role.

The Parliament of the Commonwealth of Australia (2000) concluded that '…while there is no doubt that fatigue in transport is a widespread and serious issue, there is doubt about the consistency and comparability of the information that is currently collected and reported about fatigue in the various transport sectors. There is an urgent need for definitional inconsistencies to be sorted out, for data collection approaches to be standardised and for consistency to be achieved between the different jurisdictions and different transport modes. As well as being important in their own right, these improvements would help overcome the widely perceived problem of underreporting of fatigue related accidents.

Fatigue is also dangerous in that people are poor judges of their level of fatigue (IMO, 2001 a, b).

4.2.3 *Causes of fatigue*

According to the report by Simons et al (2003, 2004) the causes of collisions and groundings can be classified into three categories:

1. Watch keeping: no proper Look Out, or sailing too speedy.
2. Navigation: improper preparation of the journey, improper organisation at the bridge.
3. The manning system: No Look Out, fatigue. A third follow-up study by the Netherlands Shipping Inspectorate (Hachmang, 2005) did show that 40 % (35 of the 85 inspected vessels) of the Dutch flagged maritime vessels did not appear have an extra Look Out during night hours.

With respect to the causes of fatigue, the IMO (2001 a, b) adopts a much broader view, and states that: '… It must be recognized that the seafarer is a captive of the work environment. Firstly, the average seafarer spends between three to six months working and living away from home, on a moving vessel that is subject to unpredictable environment factors (i.e. weather conditions). Secondly, while serving on board the vessel, there is no clear separation between work and recreation. Thirdly, today’s crew is composed of seafarers from various nationalities and backgrounds who are expected to work and live together for long periods of time. All these aspects present a unique combination of potential causes of fatigue'.

Additionally, the majority of ships now spend less than 24 hours in port. Time in port was traditionally a time for crews to rest ashore prior to leaving port. In many cases crews are now expected to unload/load a vessel, prepare the vessel to sail and then sail the vessel from port all within a very short time frame. Demands for quick turnaround times for ships in port, combined with inadequate crew levels, clearly have the potential to present a significant fatigue risk for crews, particularly those who have been engaged in loading and unloading duties (Parliament of the Commonwealth of Australia, 2000).

Pollard, Sussman & Stearns (1990) state that in comparison to other freight transportation modes, merchant shipping is characterised by longer than average working weeks, non-standard 'work days', extensive night operations, and periods of intense effort, preceded by periods of relative inactivity. They arrange the causes of fatigue in this trade into:
1. Organisational factors (relating to how ships are managed, crew continuity, work rules, paperwork etc.).
2. Voyage and scheduling factors (e.g. dependent on the frequency of port calls).
3. Ship-design factors (e.g. level of automation).
4. Physical environment (this factor mainly deals with the weather conditions).

Quite concrete contributing causes to fatigue increase they reported are:
- Inflexible work-rules creating imbalanced workloads/work-rules requiring unnecessary time on duty.
- Lack of port-relief crews and/or incompetent relief.
- Lack of understanding procedures and tasks requiring retraining during voyage.
- Burdensome and unnecessary paperwork.
- Officers with poor 'people management skills', and tolerance for unfit personnel, which is an encouragement of interpersonal conflict.
- Tolerance of substitute-abuse problems.
- Poor morale.
- High personnel turnover; with new personnel, resulting in a lot of 'training on sea' seems.
- Inspections… they are frequent, not attuned to one another, sometimes even inadequate.
- The schedules, often with short stay for rest at harbours (<24 hours), its unpredictability, long working times.
- Long periods of duty involving personnel with cargo operations.
- Low level of automation of the system, resulting in all kinds of additional problems.

Additionally, the Dutch Shipping Inspectorate (Hachmang; 2005) indicates that the administrative burden on board has increased, despite the fact that some procedures are intended to increase safety on board (e.g. ISM-code, and the ISPS-code). This results in increased audits, mainly by other organisation than the Shipping Inspectorate. Examples of organisations that increasingly audit are vetting companies, ports & harbours and certifying organisations (see also par 4.4.3.4). Increased audits results in increased workload, more working hours, and less time for sleep. All this may consequently result in increased fatigue.

The MAIB Bridge Watching Study (2004) has reviewed in detail the evidence of 66 collisions, near collisions, groundings and contacts between 1994 and 2003 (who met special selection criteria) that were investigated by the Branch. It concluded that minimal manning, consisting of a master and a chief officer as the only two watchkeeping officers on vessels operating around the UK coastline, leads to watchkeeper fatigue and the inability of the master to fulfil his duties, which, in turn, frequently lead to accidents. It was also found that standards of lookout in general are poor, and late detection or failure to detect small vessels is a factor in many collisions. The study concludes that the current provisions of STCW 95 in respect of safe manning, hours of work and lookout are not effective.

The situation as reported in the studies above all results in the common causes of fatigue known to seafarers, which are lack of sleep, poor quality of rest, stress and excessive workload.

4.2.4 Sleeping problems of seafarers

Little is known about the direct or intermediate consequences of these 'causes' of fatigue in relation to sleeping problems of seafarers. A study by Smith, Lane & Bloor (2001) commissioned by the Health and Safety Executive (HSE) in the UK on sleeping problems compared seafarers (n=555), installation workers in the offshore (n=385) and onshore workers (n=68). There were some differences between the seafarers and installations workers[1], but more than 50% of the seafarers and 44% of the offshore installation said they needed 2-3 days to adjust after their work period. Over 50% of the installation workers feel the amount of sleep they obtain offshore to be less than adequate. Perhaps most interestingly, the proportion of seafarers reporting dissatisfaction related to insufficient sleep is lower than in either the other two groups (i.e. offshore installation workers and onshore workers), particularly as they are more likely to experience split sleep. Seafarers do, however report least to have adequate rest (29%) and adequate sleep (78%; as opposed to 54% and 85% in the offshore installation workers, and 56% and 90% in the onshore workers respectively).
In Table 5 an overview is given of self-reported disturbed sleep. Table 5 indicates that there are indications of a more frequently disturbed sleep in seafarers and offshore installation workers as compared to onshore workers, although waking up disoriented does not occur very often, and is not a particular problem for seafarers and installation workers. Having difficulty falling asleep and particularly waking up during sleep and having a restless sleep are much more of a problem. There are also indications of noise and motion to be the cause of a disturbed sleep, particularly in seafarers. It is acknowledged that the 'onshore workers' is a relatively small group. In the Dutch work force on average about 20% reports to have chronic sleeping problems. This percentage is slightly increasing (from 20,7% in 2000 to 21,7% in 2004; www.cbs.nl; POLS-GE).

[1] The most common work/leave cycle for seafarers in this study is the 4 weeks-on, 4 weeks-off cycle, and for the installation workers the 2 weeks-on schedule. About 37% of the seafarers and 44% of the installation workers worked more than 85 hours/week.

Table 5: Disturbed sleep (quite a bit/always; Smith, Lane and Bloor, 2001)

	Seafarers (%)	Offshore installa-tions workers (%)	Onshore workers (%)
How often do you:			
Have difficulty falling asleep	24,0	26,3	13,0
Wake during sleep	44,6	49,5	37,6
Have restless/disturbed sleep	43,4	43,3	31,8
Wake up confused/disoriented	6,2	8,2	10,1
How often do the following disturb your sleep:			
Noise	36,6	32,2	15,9
Motion	44,9	4,4	-

4.2.5 *Literature on causal relations between fatigue and collisions or groundings*

In general, it is difficult to indicate fatigue as the main contributing or causal[2] factor to an accident (Lindquist, 2001). An accident at sea rarely is the result of a single event and it is up to the investigator to identify every feature in what might be a long causal chain (Lang, 2000).

Perrow (1999) describes the marine transport as an error-inducing system, where a large interconnectiveness exists between the ship with its power plant, steering apparatus, cargo and crew on board, with the rest of the seaway such as other ships, rules of the road, regulations and horrendous environmental problems of fog, ice and storms, and with other influences such as the fragmented shipping industry, national jealousies and interests and insurance pressures. He describes this complex system as a system in which it is likely to have accidents such as collisions and groundings. Technological improvements did increase output (e.g. by travelling faster) but probably have helped increase accidents.

With accident examples Perrow (1999) shows that the Master builds up a perfectly reasonable mental model of the world, which works most of the time but occasionally turns out to be almost an inversion of what really exists. Perrow emphasises that an authoritarian structure on board appears to be inappropriate for complex ships in complex situations. However, liability pressures demand one responsible person and may lead to an information overload of the master. In Europe, the social imperative moderated the technological push in a way that the master and other officers work as a team (Gaffney, 1982). The equipment is designed to support teamwork where a helmsman or lookout is expected to contradict the mate or master if necessary. So all are expected to share and check their mental models, and all share the responsibility.

Fatigue now in itself is an inducing factor for the mental models to be incorrect or to misjudge a situation in which proper and fast handling is required. From this point of view the existence of fatigue may not be a direct cause of an accident but is certainly a contributing factor to the unintended or misintended actions that lead to accidents.

The MAIB Bridge Watchkeeping Study (2004) has reviewed in detail the evidence of 66 collisions, near collisions, groundings and contacts between 1994 and 2003 that

[2] In a methodological sense 'causality' is a relative concept, but factors important in distinguishing causal from non-causal associations are (1) the strength, (2) consistency, (3) specificity, (4) temporality, (5) plausibility, and (8) experimental evidence of the association between 'cause' and 'consequence' (Rothman, 1986; p. 16-20).

were investigated by the Branch, and concluded the relation between fatigue and collisions and groundings was plausible. This broad review of the detailed data collected highlighted three principal areas of concern as follows:

- Groundings and fatigue: a third of all the groundings involved a fatigued officer alone on the bridge at night.
- Collisions and lookout: two thirds of all the vessels involved in collisions were not keeping a proper lookout.

The study concluded that watchkeeper manning levels, fatigue and a master's ability to discharge his duties are major causal factors in collisions and groundings, whereas a poor lookout is a major factor in collisions as well.

Analyses reported by Smith, Lane & Bloor (2001) on the other hand, provide little evidence for a major role of fatigue in offshore accidents. This does not mean that fatigue plays no part, but it rather shows that it is impossible to determine the impact of fatigue from data of this type (survey), largely due to the inadequacies inherent within current reporting systems. Despite the fact that a high percentage of seafarers reported relatively many sleeping problems in that study, the literature review they performed confirmed the absence of information on seafarers' fatigue. They conclude that it is essential, therefore, that further research is conducted on this topic.

In his extensive review Dinges (1995) concluded that '…although seafarer fatigue is not a new concept, there has been little research to date examining work and rest schedules in the maritime industry. Research has established a link between fatigue, poor mental health and accidents in other areas of the transport industry. However, due to a lack of evidence, we can only infer the existence of such relationships in the maritime industry…'. Since 1995 some studies have been performed in the shipping industry, but there are few, if any, studies, which systematically measure all possible indicators of fatigue in the maritime industry, namely accident statistics, self-report, performance and physiological data. Research is also needed to address the unique combinations of potential stressors, which may interact in various ways to produce fatigue, poor health and increased accident risk (McNamara et al, 2000).

Recent results in accident research indicate that the risk of accidents at work is a function of hours at work and sleep deprivation (Philip et al, 2005). Folkard and Akerstedt both reported an exponentially increasing accident risk beyond the 9th hour at work. Folkard calculated the relative accident risk from 5 published studies and found it to be doubled after the 12th hour and tripled after the 14th hour. He concluded that the safest system would be based on 6- to 9-hour shifts (Hanecke et al, 1998).

4.2.6 *Literature on causality between the shift system and fatigue*

The literature on shift systems and fatigue is not completely conclusive.
The two-watchkeeper shift system consists of six hours on and six hours of. This results in long working days (at least 12 hours). Because of its regularity and simplicity it is considered as least taxing (as compared to sailing inland waterways and loading and unloading activities; Zieverink & Kluytenaar, 1997).

In a schedule of 4 hours on - 8 hours off watch (i.e. a 3-shift system)-, continuous long hours of watchkeeping are avoided. However also in this shift system, mainly because of additional duties that have to be performed in the 'off-watch' periods, sleep is usually 'split' between these two times, which results in a disruption of the natural 24 hours rhythm of rest and activity (Colquhoun et al, 1988; Sanquist et al, 1997). A split

shift is a major factor in preventing adaptation of physiological rhythms to shiftwork in the shipboard situation (Plett et al, 1988).
The MAIB Bridge Watchkeeping Safety Study (2004) concluded that it is of serious concern that in 88% of the fatigue related accidents, the vessels involved carried only two bridge watchkeeping officers. In each case, no lookout had been posted, the autopilot was engaged, a watch alarm was either not fitted or not used and the unaccompanied watchkeeper had fallen asleep. In their 2004 annual report the MAIB (2005) concludes that '…Comparing the three watchkeepers system with the two-watchkeepers systems, it can be concluded that the three-watchkeeper system is not perfect, but certainly an improvement'. The resultant MAIB recommendation, to ensure that all merchant vessels over 500grt have a minimum of a master plus two bridge watchkeeping officers, has gained much support around the world. It was also the outcome of the discussions at the MAIG meeting in Copenhagen in 2004 (Lindquist, 2004).

On the other hand, the USCG (2003) concludes that carrying three teams on board may meet a minimum criterion for fatigue and error production: with two teams on 12 hours of work per day, too many errors might occur due to fatigue. The use of four teams to reduce fatigue effects would, however, also present problems: with four teams working 6 hours per day, or working 8 hours per day and taking one day in four off, crew members would probably become bored and inefficient. Also, the ship would need to carry supplies for 1.3 times as many people as it does for three teams.
Additionally, Davis, Cameron and Heslegrave (1999) compared the 4&8, 6&6 and 12&12 watch schedules. This comparison did *not* show that one watch schedule was superior to the others in terms of maintaining the optimal crew state. Each watch schedule had both positive and negative aspects. The most important factors in preventing fatigue are sleep duration and quality. From this perspective, the 12&12 watch schedule affords the best opportunity to minimize fatigue, though special consideration should be given to managing fatigue for the personnel working overnight. The personnel on the 12&12 watch had the greatest opportunity for sleep quantity and quality, followed by the personnel on the 4&8, and finally personnel on the 6&6 watch. However, research indicates that the 12&12 watch schedule may only be better for day watchkeepers since sleeping during normal daytime hours is not as restorative as sleeping during normal night-time hours. The latter is also reported by Rutenfranz et al (1988) who collected information on sleep length and sleep quality on board ships over periods of up to two weeks from watchkeepers working a '4-on/8-off routine'. Within the watchkeeping crews the 3rd Officers had by far the shortest sleep length.
Even though it may be possible to get better sleep on the 12&12-watch schedule, other watch schedules may be preferred for practical reasons such as weather conditions, workload and crew preferences. In the analyses on the Dutch reports in collisions and groundings (see 4.1.1) it was also noted that some ships used different schedules at sea as compared to the harbour where loading and unloading activities took place.

Already in 1990, the National Research Council recommended the use of a shift system in which each watchkeeper has a 10-14 hour period of unbroken free time each day to permit uninterrupted sleep. The USCG (2003), however, concludes that it is almost impossible to have 7-8 hours of daily uninterrupted sleep. To maintain endurance, crewmembers were eating large meals immediately before going to bed after watch (also drink large amounts of coffee before going to bed), crewmembers were being kept awake by noise associated with crews handling rigging near the vessel or slamming doors, and crewmembers were being awakened by sudden movements or by fumes from the diesel engines.

4.2.7 Literature on potential measures to manage fatigue in the shipping industry

Measures to manage fatigue in the shipping industry can be classified as (IMO, 2001 a, b):

1. *Organisational factors*; staffing policies, role of riders and off shore personnel, paperwork requirements, schedules-shifts, overtime, breaks, company culture and management style, training and selection of personnel.
2. *Voyage and scheduling factors*; the frequency of port calls, time between ports, the routeing, weather and sea conditions 'en route', traffic density etc.
3. *Ship-specific factors*; these factors include ship design features that can affect or cause fatigue, or that can make it less likely that mistakes are to be made when performance is somewhat reduced.
4. *Environmental factors*; factors like temperatures, humidity, excessive noise levels, etc. can cause fatigue. Environmental factors may also produce physical discomfort, or contribute to the disruption of sleep. These factors can be divided into factors internal and external to the ship. There are a number of things that can be done to address these causes, some more manageable than others (see IMO, 2001 a).
5. *Procedures and Guidelines*; although not in the IMO guidelines on fatigue, procedures and guidelines may additionally help in managing fatigue. Some procedures and guidelines may be part of the policy within the organisation, but others are international. The ISM-code, for example, is recently implemented at the international level, amongst other things to reduce fatigue and increase safety. Views on the effectiveness of these measures differ (see paragraph 4.3).

Organisational factors may be the staffing policies, paper work requirements, the role of riders and shore personnel, schedules -shift, overtime, breaks etc., company culture and management style, training and selection of crew, as well as more specifically the adoption of a *fatigue management pro*gram or a *safety culture program* (e.g. Belenky et al, 1998). According to the IMO (http://www.imo.org/home.asp) an organisation with a safety culture is one that gives appropriate priority to safety and realizes that safety must be managed like other areas of the business. According to the IMO, the key to achieving safety culture is:

- Recognizing that accidents are preventable by following correct procedures and established practices.
- Constantly think safety.
- Seeking continuous improvement.

The adoption of a fatigue management program links up with the idea behind the ISM-code where organisations are requested to explain how they deal with fatigue management in their organisation. This ISM-code provides the organisation to be flexible in their measures to manage fatigue, and choose those measures that fit best to their organisation. So an organisation may plan a specific course, but may also choose to have tasks be shifted ashore, or have a watch or a purser, or someone else be added to the crew on board.

Davis, Cameron and Heslegrave (1999) recommend that personnel receives fatigue awareness and fatigue management training to help them avoid fatigue, as much as possible, and better prevent and manage the effects of fatigue. A 'Bridge Resource Management' (BRM) course appeared to have a positive effect on the reduction of accidents (MSR, 2005). A recommendation drawn from that report is that all Officers of the Watch should attend a BRM course. Recommended is to make it mandatory by IMO. Bridge Resource Management is a training program designed to ensure effective use of personnel and equipment during vessel operations. It is designed to reduce errors and omissions in bridge operations through a simple system of check and delegation of duties.

From the perspective of work load (particularly regarding physical, mental and perceptual), an organisational approach, and a fatigue management or safety culture program would provide important opportunities as well.

Adopting an optimal shift system may also be such a measure to be taken within the framework of a fatigue management or safety culture program. The MAIB proposed to change the two-watchkeeper system for the three-watchkeeper system. As shown in paragraph 4.2.6, the evidence is not conclusive as to which system would be best. From the perspective of fatigue management, the study by Davis, Cameron and Heslegrave (1999) even suggested a 12 hours on and 12 hours off shift.

In the study by Smith, Lane and Bloor (2001) the seafarers, offshore installation workers and onshore workers were asked how well they knew the legislation to control working hours. This knowledge appeared to be much higher amongst the seafarers and offshore group than amongst the onshore workers: 71% of the seafarers reported to know about this legislation, against 50% of the offshore installation workers and 38% of the onshore workers. On the other hand, only 8% of the seafarers, however, reported to have received a fatigue management training, against 11% of the offshore installation workers and 7% of the onshore workers.
In this study, the workers were also asked how useful they expected different measures to be (Table 6).
Table 6 indicates that the measures expected to be most effective by these workers are extra manning and less paperwork.

Table 6: Answers of workers as to how effective they expect different measures to be in reducing fatigue (Smith, Lane & Bloor, 2001)

Measures to reduce fatigue (very/extremely useful)	Seafarers (%)	Offshore installation workers (%)
Tougher laws	34,8	43,8
Extra manning	66,1	70,6
More leave	32,8	69,4
Less paperwork	53,5	41,7

Reducing shipboard fatigue will thus require orchestrated actions by many groups, including flag states, ship owners and operators. Naval architects and ship designers make their unique contribution by improving the design of shipboard conditions (IMO, 2001 a, b).

4.3 Views of the stakeholders on fatigue, its causes, consequences and management

Interviews with all stakeholders in the Netherlands were held. We will shortly report on (1) their ideas on fatigue as a 'problem', (2), the factors causing fatigue, (3) the causal relation between fatigue and accidents, mainly collisions and groundings, (4) the particular role the shift system in this relation, and (5) measures to prevent fatigue.

4.3.1 Stakeholders and their view on fatigue as 'a problem'

With regard to the view on fatigue as a potential risk in the shipping industry, the employers and their representatives have a clearly opposing view as to that of the employee representatives, the Netherlands Shipping Inspectorate and the representative of the Occupational Health Service. The employer representatives do not recognise fatigue as a significant problem in the shipping industry. However, some representatives mentioned that in some parts of the shipping industry work is more demanding than in other parts, for example in container shipping, scheduled/line service, or ships with short journeys (many harbours). This could have consequences for fatigue if this is not tackled (managed) by the master. The master‘s management qualities are indeed a critical factor.

Additionally, there is the subjective perception of fatigue. Recent measures on fatigue management like the ISM-Code are being implemented, but result in extra workload, in the perception of some seafarers more than others. This may be dependent on the skills or competences of the seafarer. As an example: the obligation of Master Reviews as part of the ISM code will prevent incidents and accidents by better communication. In the beginning this may feel like extra paper communication activities or paper work. Similarly, there are the issues of delegation responsibilities of the master, planned maintenance and outsourcing of loading and unloading activities. On the long run this will lead to less work load. At present it will be felt like an additional work load, particularly by the less skilled seafarers. Particularly the employers representative do not want to discuss new measures until the recently implemented measures have been fully implemented and could have come to effect.

However, in the eyes of the employee representatives as well as in the eyes of the Inspectorate, fatigue is a problem in the shipping industry that deserves attention. The profession can be harsh and the seafarers are not receiving a proper reward/ compensation for this hardship. Measures are put forward to prevent fatigue, but in practice they are not fully implemented and are acted upon as a ‘paper reality'. Instead of managing fatigue it is increasing the work load because the crew has to deal with additional administration. Moreover, there is a (macho) culture of not admitting that one is tired. It is often criticised that seafarers don’t take their sleep when they can, but watch video instead. The other side of this is that the seafarers may want to sleep but are not able to sleep because of noise or health problems, problems at home or other social issues (e.g. conflicts with a colleague). If one or more of these issues are at hand, they often are not communicated and discussed on board the ship.

The representative of the occupational health service indicates that fatigue is present in employee seafarers, and that it can pose an accident risk.

4.3.2 Stakeholders’ view on the causes of fatigue

Factors that cause fatigue among crew members according to the employer representatives are:

- The increased administrative tasks and different inspections (Port State Control, labour inspectorate, environmental inspectorate, harbour inspections). Inspections may interfere with the master’s sleep, and sometimes different inspections are not well coordinated (dealing with several different inspections in a short time span). Crew members feel they are under constant surveillance = subjective work load).
- The competences of the crew members. When crew members can not handle their job they start to complain about how fatiguing their work on board of the ship is.
- The competence of the master. The master plays a major role in making a journey safe. Sometimes the master may experience pressure from the shipping company or from customers, but the master finally decides what will happen. They are expected to think along with the people ashore (they have to be assertive and take their responsibility). Moreover, the master’s role is in a transitional phase; the focus changed from technical knowledge to good communication and is now moving in the direction of process management. The master has to learn to delegate.

Sometimes this is impossible because of cultural aspects: e.g., in some cultures it is not accepted that someone else than the master does the talking.

- Especially older crew members experience problems with these changes like the extra paper work and dealing with authorities.
- The climate on board of the ship can be a risk factor, although it may be experienced as positive as well. Sometimes tensions can arise between crew members, which may cause stress. Cultural differences can contribute to conflicts, misunderstandings, causing even more stress. One shipping company also mentioned that the sense of belonging together as a group may be lacking in an international crew, whereas trust and working together as a team is necessary when working on board.
- Problems at home, such as a family member who is ill, problems with children or marital/relational problems. These problems may cause sleeping problems.
- Lack of self discipline to make sure one gets enough sleep. The culture on board is that one does not admit that one needs some sleep (macho culture). Also there are more leisure activities on board (such as DVD's and internet) that may conflict with the time to sleep.
- Relatively poor health and life style (few exercise, not so healthy eating and drinking habits, smoking) of crew members.
- Some sectors of the shipping industry can be intensive and can thus be a risk for fatigue. However, the biggest part is chartering which is not that intensive. Actually, for a lot of masters in the short sea sector, the amount of activities to be done is a reason for them to like the job. They don’t want to be ‘just an operator’.
- Issues for improvement:
  - Several activities like loading and unloading the ship and maintenance at peak hours can be outsourced (ISM-Code). Also communication problems are dealt with by the ISM-Code. Through a clear distribution of tasks and duties ISM may contribute to fatigue prevention.
  - Accommodation has recently been improved, but may -particularly since it is a decision at the organizational level- be an issue for improvement in the future as well.

The comments from the employee representatives and Inspectorate to a large extent coincide with those mentioned by the employers, although they have some specific points as well. Their additional comment is presented below stressing the fact that:

- Ships sail with minimum crews and seafarers often make long working days, which may cause a lack of sleep. They often work 7 days a week for several months. This also means that in situations of emergency the crew is probably undermanned.
- Employees experience pressure from their colleagues ashore. The master receives messages from different departments of the shipping company, and these messages may be conflicting. The colleagues ashore do not always take this in consideration and leave the problem to the crew on board.
- International competition is high. Dutch crew members are expensive and for this reason Dutch crew members are replaced by crew members from other countries or the ship is put under a flag of convenience. The Dutch crew members fear loosing their jobs. Therefore, they do not stand up for themselves and take a position; they complain but do what the employer asks them to do. Also the Inspectorate does not complain too much.
- Crew members work overtime because of the financial benefits, and finally become dependent on the extra money earned by their overtime hours.
- Noise (machines, from loading and unloading operations) and vibrations (ship’s engine) during sleeping periods.

- The shift systems are not synchronised with arrival times in harbours. During arrival at harbours most crew members are needed on deck, which often means keep on working. Particularly a 2-shift system offers few possibilities to compensate.
- Shorter passage times in the harbours is the trend meaning that it is less often possible to stay in the harbour during the night.
- Crew members do not recognise it when they are tired and are not well informed regarding fatigue.
- The prevailing culture is one of 'always going on’ for the sake of the ship performance.
- Planning is not based on a realistic number of activities.
- The 'subjective workload' increases due to low payment, cuts in activities that are fun.

The Shipping Inspectorate additionally reports on the increase in audits and inspections, whereas only a minority of these are performed by the Inspectorate. Many other organisations perform inspections like the vetting companies, Port State Control, harbour inspections as well as inspections by Certification Bureaus.

The occupational health representative adds that in the last few years the crews on board of ships have become smaller, and the quality of the (international) crew has decreased, while the workload of officers has increased due to increased administrative tasks and paperwork. These developments are mainly the result of economisation by shipping companies. Especially younger seafarers are prepared to go along with this, and work hard for a good salary. Officers more often experience a mental workload and sailors more often experience physical workload.

4.3.3 Stakeholders’ view on causality between fatigue and collisions or groundings

According to the employer representatives' fatigue is a risk factor, but not a problem. In their opinion, statistics and more in particular the absolute figures do not indicate that fatigue should be seen as a problem.
The employee representatives agree that there is not enough significant information about the causes of accidents like collisions and groundings. There are so many other causes that lead to accidents in which fatigue has no role. The Inspectorate indicates that masters are obliged to report accidents, but indicates that this only happens with a small number of the accidents. Near misses are not registered. A relatively small percentage of the accidents at sea is caused by fatigue. Moreover the registration of working and sleeping hours can be falsified, and the culture is not promoting in admitting the existence of fatigue. Other causes of accidents are not enough crew members on board (particularly the officers on watch), climate on board (people on board are very loyal to one another, and do a lot for each other such as replacing a colleague while already working for a long period of time), pressure from employer and customers, only one watchkeeper and no outlook, and no proper use of technical devices on the bridge (e.g. watch alarm). In cases where fatigue plays a role, it is often in collisions and groundings and in fires.

4.3.4 Stakeholders' view on causality between the shift system and fatigue

The employer representatives do not think that there is a direct relationship between the type of shift system and fatigue. In their view, none of the studies present clear evidence for a causal relation between (said to be) fatigue related incidents and the 2-shift system. In their view, other issues such as the absence of a dedicated look out, improper navigation or alcohol abuse are the cause of the incidents. Statistics, and

more in particular absolute figures, do not indicate that the 2-shift system should be seen as a negative factor for safety in shipping.
Especially for smaller shipping companies the replacement of the 2-shift system by a 3-shift system would have huge consequences both financially (more crew members means more costs) and practically (their ships are not equipped for more crew members, e.g. they do not have enough cabins on board). The shipping companies will lose their flexibility in manning theirs ships in an optimal way. Shipping companies that operate well will suffer for shipping companies where things go wrong.
The employee representatives indicate that the 2-shift system may cause fatigue. With the 2-shift system employees make long working days (12 hours per 24 hours), and have interrupted sleep (2 times 6 hours off every 24 hours). There is too little compensation in case the voyage does not (completely) proceed as planned. However, they stress that there are other causes of fatigue that need to be taken in consideration as well, like the necessity to perform additional (administrative) tasks, the pressure from colleagues ashore, the international competition, the prevailing culture onboard and the attractiveness of the financial benefits when working overtime (see 4.3.2).

4.3.5 Stakeholders' view on measures to manage fatigue

The employer representatives indicate that crew members can be trained to handle the increased amount of paperwork, in dealing with authorities, and in dealing with cultural differences on board.
The employer representatives, however, fear that the present research will lead to even more rules. They indicate that here already are many rules regarding safety. Some of these rules are an improvement, but some of these rules are not effective. Furthermore, enforcement of the regulations is not always sufficient, and needs improvement. At the same time new legislation (e.g. the ISM Code, which is applicable to all ships since July 1st 2002), has been introduced and should deserve a chance to show its effects. This code may at first lead to higher work pressure, but eventually will help to lower the work pressure. These new rules deserve a fair chance to prove their effectiveness.
Furthermore, some organisations already have taken measures to prevent fatigue and high work load. For example in one of the shipping companies that were interviewed employees were offered a fixed pay to prevent them from working overtime. This led to a significant reduction in overtime hours. Before the implementation of the fixed pay, employees used to make a lot of extra hours for the extra money.

Employee representatives indicate that replacing the 2-shift system by a 3-shift system is not necessary the best solution. There are other alternatives, which offer both the shipping companies and crew members more flexibility. One solution would be to have more crew on board the ships. This could be an extra watchkeeper or a person performing administrative tasks, depending on the situation. The crew members should be involved in making the manning plans and deciding whether an extra crew member is needed. Other measures that can be taken to prevent or manage fatigue are:

- Make an inventory of tasks of the crew members that can be delegated to the shore.
- The gap between shore and ship needs to be bridged by involving crew members in the company (offer them a job ashore for a while).
- The personnel department of shipping companies can be offered training in how to deal with the employees at sea.

The Inspectorate suggests the following measures:

- According to the regulations for 'Safe Manning' masters have the final responsibility for everything, while he doesn't have the tools in hand to do his work properly. This should be changed; masters should be offered more protection.
- Crew members should be trained to be more assertive and stand up for themselves.
- Something should be done to decrease the amount of paperwork and regulations on board. One solution would be for different inspectorates to exchange information, which might reduce the amount of inspections on board of the ships.
- Some tasks could be delegated ashore, for example loading and unloading the ship.
- Finally, when the above measures have not been effective more crew members are needed on board.

The representative from the Occupational Health Service suggest to:

- Improve the health and fitness for duty of crew members by promoting exercise and facilitate exercise on board.
- Improve the shift schedules by critically looking at the structure of the schedules; more frequent changing shifts and circulation of tasks (making work less monotonous) during the night.
- Improve sleep quality by improving/optimising sleep facilities and providing enough time to sleep (minimum of 8 hours continuous sleep).
- Reduce workload from officers by reducing bureaucracy and spreading the amount of paper work among different officers.
- To gain a better insight into fatigue and workload among seafarers a questionnaire research among seafarers is needed and registration of near misses and accidents needs to be improved.

4.3.6 *Additional monitoring opportunities*

As indicated in the methods section (chapter 3), some organisations were additionally interviewed by telephone in order to specifically ask them about additional opportunities for monitoring collisions and groundings or near accidents of these kind. From these organisations, only the EMSA (European Maritime Safety Agency) in Brussels was able to contribute to additional monitoring of fatigue and fatigue related causes and consequences. The EMSA has developed a taxonomy to be used for the construction of a large data base. Human factors are prominently present in this taxonomy. The EMSA based itself on the 'Guidelines on fatigue' from the IMO (2001 a) and uses 49 codes for causes of fatigue, e.g. the crew factor, quantity of sleep, watch system, design factor(s), hours of work, problems at home, taking medicine, jet lag etc.

At the moment there are no data yet in the EMSA data base. At the end of October 2005 a pilot will be started with a number of member states. March 2006 they hope the data base is fully operational with shipping accidents since January the 1st, 2006. The Netherlands does not contribute to this pilot.

An EU-directive is under construction aiming at an obligation of each country to report shipping accidents information to the EMSA. This should, however, become a blame free obligation. This is, however, not fully developed yet. Before this directive is finished, all countries are stimulated to participate. When a country participates it can use the data base to report on the statistics of shipping accidents. General information from the EMSA data base should be available to all countries, but specific information should only be available to the country that delivered the information. The identification of shipping companies should be impossible.

In Great Britain a special reporting program on accidents and near accidents was started called CHIRP (Confidential Human Factors Incident Reporting Programme; http://www.chirp.co.uk/new/default.htm). CHIRP is an independent confidential and voluntary reporting programme for people employed or having an active interest in the aviation and maritime industries (for the latter see: http://www.chirp.co.uk/new/Maritime/IndexMaritime.htm). CHIRP is not intended as a systematic monitor of incidents or events related to safety such as the EMSA initiative. CHIRP's primary purpose is to receive confidential reports and, when relevant to represent safety related issues to the respective operational management and/or regulatory agency without revealing the identity of the reporter. Disidentified reports are published regularly in newsletters to raise awareness among professional groups to safety related issues raised through the programme. CHIRP is not a "whistle blowing" programme. CHIRP is known from aviation, where it has been in existence since 1982. In 2003, it was introduced as a new safety element to the maritime sector as an innovative way of promoting the improvement of its safety culture. The CHIRP aviation programmes are funded by the UK Civil Aviation Authority; CHIRP for the maritime industry is funded by the Department for Transport. The independent charitable status of CHIRP ensures its impartiality in dealing with all reports received; no matter which organisation may become involved in subsequently remedying any report problems.

4.4 Consequences of the implementation of potentially important measures

On the basis of the literature and the interviews with stakeholders, a list of potential measures was constructed (see annex 1). In this paragraph the results of the prioritisation of the types of measures in this list is presented. Next an assessment of the consequences of the most promising measures is provided.

4.4.1 Priorities in measures to manage fatigue

It was clear that on the basis of the interviews some additional types if measures had to be taken up in the list of potential measures to manage fatigue. These measures were related to the health, health behaviours or coping styles of the crew members, and to the identification of new ways of monitoring causes of fatigue, fatigue behaviours or fatigue consequences. The types of measures that all stakeholders were asked to rate were related to:

1. lengthening of the resting period;
2. optimising the organisation of work;
3. reducing administrative tasks;
4. less visitors/inspectors in the harbour/better coordination of inspections;
5. reduce overtime;
6. proper Human resource Management;
7. education and training;
8. development of a management tool for fatigue;
9. proper implementation of the ISM-code;
10. healthy design of the ship;
11. health promotion at work;
12. expand monitoring of fatigue causes, behaviours and consequences, including near misses.

The measures were to be rated on a five point scale as to their necessity, effectiveness in reducing fatigue, feasibility, practicality, period needed for implementation, costs and benefits.

Only four of the stakeholders mentioned in the Methods section gave their scores on the twelve potential measures. The KNVR is one of those who did not rate the potential measures.[3]

In figure 3 the average ratings by the four respondents on two highly important criteria, necessity to implement the measure and their assessment of the measure's effectiveness in reducing fatigue.

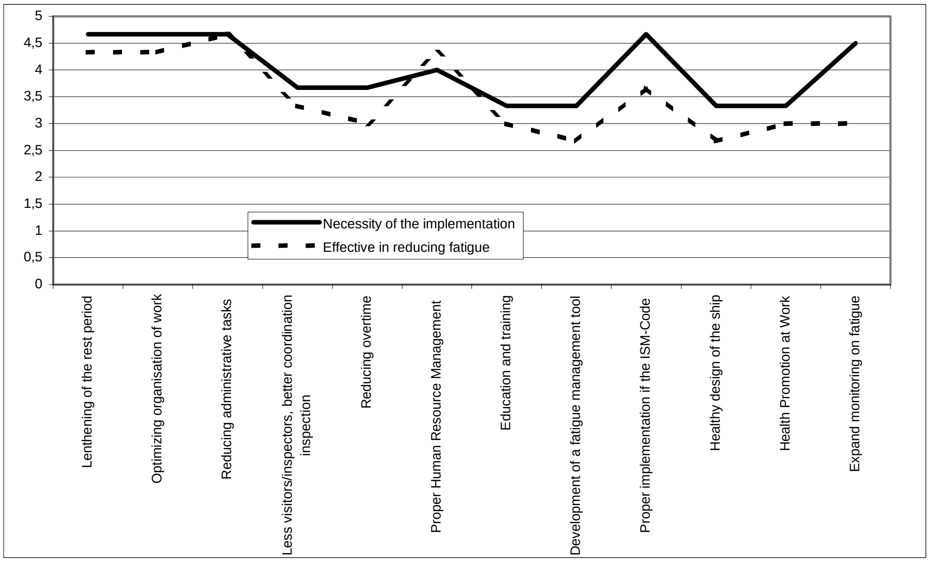

Figure 3: The average rating by the four respondents of the measures suggested

From figure 3 it can be concluded that the most necessary and effective measures appear to be:

1. proper implementation of the ISM-Code;
2. optimising the organisation of work on board vessels;
3. lengthening of the rest period;
4. reducing administrative tasks on board vessels.

Expanding monitoring of causes, behaviours and consequences, including near misses was also rated high on 'necessity', but is considered to be less effective in reducing fatigue. One could argue that expanding monitoring might be particularly important for understanding the size of the problem, and obtaining better insight in the causes of fatigue-related consequences, also other consequences than groundings and collisions.

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[3] The KVNR made their reasons for not rating the potential measures explicit in a letter sent by e-mail. Their reasons can be summarised as follows: (1) the KVNR does not consider fatigue to be a problem but only a risk that is already successfully controlled (e.g. by the ISM-Code), (2) in the perception of the KVNR the request to rate the measures suggested a need for *new* measures and does not focus enough on existing measures, and finally (3) the KVNR is of the opinion that prioritising (if any) of the measures to prevent fatigue should and can be done best at the level of the particular shipping company or the particular ship, and not at the level of the shipping industry. Referring to the Company and ship based approach of the ISM-Code, different ships that are operated under different conditions by different companies will require a different prioritisation.

Ad 1: Proper implementation of the ISM-Code.
Practice is that the International Safety Management Code (ISM-Code) can incorporate very many aspects of fatigue management. The respondents are of the opinion that a proper implementation of this Code is not the case in many organisations (yet). The ISM-Code is only in force in the shipping industry for three years (July 1st, 2002), and hasn’t grown to its full potential yet. The ISM-Code may contribute in a positive way to fatigue management in that it provides a structured planning of activities on a vessel, e.g. both administrative tasks as well as planned or subcontracting maintenance. However, it now often leads to many complicated procedures and additional administrative tasks. The opportunity should be taken or provided to screen the ISM-Code on ways to reduce fatigue that fit the organisation or vessel and adds to the organisation's efficiency.
'Implementing the ISM-Code properly' can be conceptualised as covering measures such as indicated in the list above, and selecting one or more measures dependent on the fit to the specific organisation or vessel where it is implemented, for example as a 'Fatigue Management Program' or 'Safety Culture Plan'. Selecting some highly necessary and potentially effective measures may be part of such a program or plan or, when it concerns an additional crew member, may be part of a 'safe manning plan'. Another improvement can be achieved by increasing the cooperation between the ship and the organisation ashore.
The expected effectiveness in reducing fatigue, its feasibility and practical aspects involved are assessed as being high. A negative aspect is that the investment costs are assessed by the respondents to be high.

Ad 2: Optimising the organisation of work on board vessels.
All respondents indicate that the organisation of the work on board vessels can be improved. Two if the three indicate that the crew number should be better attuned to the type of work. In some cases an officer or a crew member designated to administrative tasks should be added. The Public Administration together with the ship owners should take care of that. Optimising the organisation of work on board vessels fits perfectly with a proper implementation of the ISM-Code, as well as with complying to other regulations like those from the Working Conditions Act (NL) or the General Framework for preventive action on the quality of work and employment (EU).
The expected feasibility, practicality and time span needed for implementation are all assessed as positive. It is expected that the implementation of this measure will pay out.

Ad 3: Lengthening of the rest period.
Lengthening of the rest period is considered to be an important issue when managing fatigue is the goal. This could be achieved through improving the organisation of work, the size of the crew as well as through optimising the shift system (working schedules). The aim should be a rest period of at least 8 hours per day (24 hours). One could think of a flexible shift system of 4-8 - 8-4, which may provide a period 8 hours uninterrupted rest possible, while keeping a regular shift on a 24-hour basis. A problem that such a shift system has to deal with is that according to the regulations on work and resting times, every worker should have a break after 6 hours of work.
Lengthening of the rest period is assessed very positively on several of the criteria. Some doubt is on feasibility, since commercial interests to a large extent influence the shift system used.

Ad 4: Reducing administrative tasks on board vessels.
Increased legislation and the increase in inspections, not just by the Government, but also by vetting companies and by the ports to a large extent are responsible for the increase in administrative tasks.
One solution may be to add a crew member other than an officer on watch. Other suggestions are more tasks to be performed by the organisation ashore, e.g. using ICT. More standardisation as to the forms to be used, or using a central administration may tackle the increase in administrative tasks due to an increase in (quality) control at its source. At present, particularly the central administration is a bridge too far, and international measures are necessary, e.g. to standardise forms and paperwork. When measures like ICT development in order to delegate more administrative tasks ashore, or having an additional crew member performing administrative tasks on board, are concerned the Ministry of Transport may play a role in further elaborating and evaluating these measures. The ship owners could then decide how they could realise this in their own organisation.

4.4.2 *Consequences of the implementation of potentially important fatigue management measures*

On the basis of findings presented in 4.4.1 the following measures were assessed as to their consequences for the short shipping industry and the maritime education:

1. Replacing the two-shift system with the three-shift system; an Officer In Charge (OIC) of the watch is added to the crew.
2. Adding a crew member but not an Officer in Charge (OIC). The additional crew member should be a person who will be able to take over some administrative tasks from the officer on watch or from the Master.
3. Changing the shift system into a more flexible one, with a rest period of at least 8 hours. A possibility is to introduce a 4-8 / 8-4 shift system.
4. Identifying administrative tasks that can be done by the organisation ashore using (more, and wireless) ICT facilities.
5. Setting up the framework for a Fatigue Management System or Tool (FMS/FMT); not with the intention to suggest a new 'system', but by elaborating on a comprehensive view on fatigue, as part of a safety management system, that has developed in other sectors of (road) transportation and manufacturing, fitting with the optimisation of work and of shift-schedules, including designing measures when the Master or OIC do become acutely fatigued on watch.

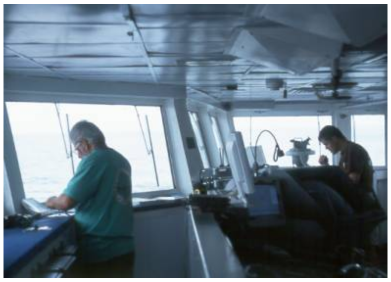
In the following paragraph the consequences for the shipping sector, mainly the (short) sea shipping, and maritime education and training system are described. In this paragraph the results of an additional small study are presented as well. Twenty two seafarers who were on training completed a short questionnaire. This questionnaire mainly aimed to identify administrative tasks or activities seafarers normally perform on board, to find out how much time was involved in performing these activities, and if these could be delegated either to someone else, or to the organisation ashore.

4.4.3 *Economic impact and consequences for maritime education of fatigue management measures*

4.4.3.1 *Replacing the two-shift system with the three-shift system, and an Officer in Charge (OIC) is added*

When discussing adding a crew member, first something should be said about the responsibilities, tasks and task descriptions onboard. Many ships sail at sea and therewith securing our demand for goods and materials. But as in each and every company, it can only flourish when a clear organisational structure is available, including tasks and task description.

Generally speaking, the ship type and size, and the trade it operates set the number of seafarers per vessel, i.e. (navigating) officers and marine engineers. For example, on a relative small sea-going vessel carrying break bulk more personnel is generally needed to carry out the operation then on a feeder vessel carrying containers. Cargo related operations may also be carried out by shore organisations.



Navigator with seaman standing watch

Next to the ship size and trade, ships can operate with different shift systems; a two- or three-shift system.
A two-shift system means that 2 seafarers execute a 6 hours-watch followed by a 6 hours-rest. This means that 2 people cover the 24 hours-watch service.
A three-shift system means that 3 seafarers execute a 4 hours-watch followed by an 8 hours rest. This means that 3 people cover the 24 hours-watch service. So the shift system influences the number of crew onboard a vessel.
Additionally, the service-leave schedule of seafarers should be considered. For example, the shipping company can agree with its personnel to spend 12 weeks onboard followed by 6 weeks leave. Such agreement put pressure on the personnel cost of the shipping line, and therewith on the profitability.
The considerations above mean that a ship owner/ operator always tries to find the optimal combination of crew, trade and ship. But it is not only the profitability that counts. There is also the human factor, possibly influenced by rules and regulations.

If, for whatever reason, the owner/ operator is forced to change its shift system from a two-shift to a three-shift system, additional personnel cost cannot be avoided. The financial impact is calculated taking the following assumptions into account:

- The sea-time/ leave schedule is 6 weeks on board, 6 weeks leave. On average, 6 weeks on board means 1.5 months duty at sea, and thus 1.5 months leave. So, on a 12 month basis, a seafarer is 6 months on board, and 6 months ashore.
- Onboard a vessel of a certain ship size the following people are employed:
  - 1 Master;
  - 1 Officer in Charge (OIC);
  - 2 sailors/AB's;
  - 1 engineer;
  - 1 cook.
- Only the Master and the OIC execute the watch.

Economic consequences
Changing the two-shift system with the three-shift system means that one additional Officer in Charge of the watch (OIC) must be added to the crew. This extra officer will also take part in the service-leave schedule. As a minimum 2 extra men are needed.
One extra officer means an extra annual wage of € 45-55,000[4] – this is including overtime compensation, travel cost and extra food.

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[4] The annual wage can be lower if an officer is temporarily employed, thus not having a fixed employment contract. It should be noted that the officer is employed on a Dutch flagged ship.

In order to secure the crew availability companies calculate by a factor 2.2. This factor includes not only salary cost, but also additional crew travel cost, cost for working-leave schedule and insurance cost.
If a ship owner/ operator changes its two-shift to a three-shift system the estimated additional cost per vessel per year is: 2.2 x € 45-55,000 = € 99-121,000.

So, what might be the financial impact for the maritime shipping industry in The Netherlands? In order to estimate this, we have to know the present prevalence of the two-shift and three-shift system, a figure that is not known exactly at present. From the analysis of 60 groundings and collision reports, about 25% sailed with a two-shift system, and with a three-shift system, whereas in about 50% of the groundings and collision the shift system was unknown from the reports. From the 22 seafarers who answered the short questionnaire about 50% of these crew members work with a two-shift system, and 50% with a three-shift system as well. On the basis of these sources it is assumed that 50% of the crew operates under a two-shift system and 50% under a three-shift system.
We also have to know how many (short sea) vessels operate under Dutch flag along the EU coast line. This, again, is not an easy-to-answer question. The problem is that there is not a univocal definition of short sea. But a common used method is to limit the ship size to 10,000 dwt and that the vessels operate in intra-EU short sea services.
Based on this definition the following overviews for the EU and Dutch short sea fleet are produced (Table 7 and 8).

Table 7: EU short sea shipping fleet by dwt range

Dwt range	**No of vessels**	**Total dwt**	**% of total dwt**	**AVG age**
≥ 1,000- <3,000	988	1,922,866	19%	24
≥ 3,000- <4,000	497	1,692,654	17%	16
≥ 4,000- <6,000	598	2,828,018	28%	12
≥ 6,000- <9,000	372	2,774,830	28%	14
≥ 9,000- <10,000	88	828,941	8%	11
Total	**2,543**	**10,047,309**	**100%**	**17.48**

Source: Lloyd's Register/ ING Bank Credit Risk Management, "Freight rates in short sea shipping I, Sector overview", 2003.

Assuming that 50% of the vessels should change its shift system from 2- to 3-shifts, 1,270 vessels are involved, and the financial impact for EU ship owners/ operators is estimated to be 2.0 x 1,270 x € 45-55,000 = € 114–140 mln annually.

Table 8 Dutch short sea shipping fleet by dwt range

	No of vessels	Total dwt	% of total dwt	AVG age
≥ 1,000- <3,000	146	296,464	18%	15
≥ 3,000- <4,000	96	329,797	20%	10
≥ 4,000- <6,000	77	362,979	22%	7
≥ 6,000- <9,000	38	286,928	17%	8
≥ 9,000- <10,000	40	376,125	23%	10
Total	397	1,652,293	100%	11

Source: Lloyd's Register/ ING Bank Credit Risk Management, "Freight rates in short sea shipping I, Sector overview", 2003.

Assuming that 50% of the vessels should change its shift system from 2- to 3-shifts, 199 vessels are involved, and the financial impact for Dutch ship owners/operators is estimated to be 2.0 x 199 x € 45-55,000 = € 17.9-21.9 mln annually.

Consequences for the maritime education

Nowadays, EU maritime academies deliver about 3,400[5] graduates in the EU every year. Not all graduates will be employed on short sea vessels because the shortage exists in other trades as well. So, the sector is (almost) short of crew.

Additionally, there is a sharp rise in age of the crew since 1990, especially in the age category 'over 50' (see Figure 4). More then 40% of the crew members belonged to this category in 2000, and 27% in the category '41-50'. In 2000 about 67% (!) was 41 years or older. Although the figures are slightly outdated, the situation has hardly improved.

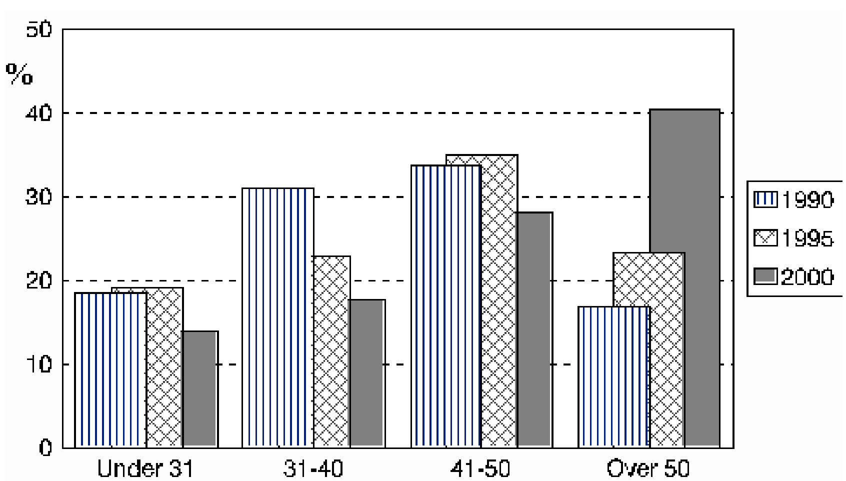

Figure 4: The age distribution of EU shipping crew from 1990 to 2000 (Source: Database STC Group, 2004)

On the basis of the calculations above we can estimate that on EU level about 3,000 crew members should be added to the short sea vessels when the two shift system is replaced by a three shift system. This would result in an increased pressure on the maritime training and education systems.

5 Source: Database STC Group, figure 2004.

In order to meet the demand of *Dutch* (and other EU) ship owners, seafarers are already educated and trained outside the EU. The KVNR already collaborates with the maritime education in the Philippines where people are already educated and trained by the Shipping and Transport College, Rotterdam. The education and training centre fully complies with the STCW'95 standard. Annually, between 70 and 90 graduates are selected by Dutch ship owners to work on their ships.
The following ten countries are the main 'suppliers' of seafarers: Bulgaria, China, Croatia, India, Indonesia, Philippines, Russia, Ukraine, Turkey and Vietnam.

4.4.3.2 Administrative tasks and costs

Looking at the consequences described under 4.4.2, one could argue that measure 2 and 4 both deal with the administrative tasks onboard vessels. Therefore, it is suggested to combine these two.
Not tackled within these two measures is a reduction of administrative tasks by standardisation of forms that have to be completed or provided to the inspecting bodies. It should be emphasized that these inspections are not only performed by the Shipping Inspectorate. In the view of the Inspectorate the bulk of inspections is even performed by other organisations like the vetting companies and ports. It would also help when these inspections could be better coordinated. Centralising administration may also be a key measure in reducing the administrative tasks that have to be performed now, and may provide opportunities to 'centralise' part of the inspections as well. All of these measures request some action at the IMO level, and may be unrealistic at present. Part of these measures may, however, also be considered as part of the ICT developments that may increase efficiency and reduce the administrative burden.
In this paragraph we will only elaborate further on consequences of (1) adding a crew member, but not an officer in Charge, and on (2) identifying administrative tasks than can be done by others, e.g. the organisation ashore using (wireless) ICT facilities.

The <u>first measure</u> has been defined **as adding a crew member, but <u>not</u> an Officer in Charge** (OIC). The additional crew member should be a person who will be able to take over some administrative tasks from the OIC or from the Master.

How to determine the cost implication?

- In order to get some background information the functions and levels of responsibilities onboard ships are described.
- Next, the most important administrative tasks of the OIC and the Master to be carried out on a daily basis are identified.
- Based on a short questionnaire among Masters, Chief Officers and OIC's the average hours spent on administrative tasks are determined.

In general, a Master is the person who has the command over ship and crew, and who is responsible for keeping the general order onboard a ship. An OIC is a navigating officer, marine engineer or 'Dual Purpose Officer' (MAROF; Maritime Officer) who carries out the duty related to navigation (bridge) as well as the engine room while in port or at sea.

Abilities specified in the standards of competence are separated into 7 functions[6]:

1. navigation;
2. cargo handling and stowage including stability;

[6] Source: STCW '95 (Standards of Training, Certification and Watchkeeping) Code 1978, as amended in 1995.

3. controlling the operation of the ship and care for persons onboard;
4. marine Engineering;
5. electrical, electronic and control engineering;
6. maintenance and repair;
7. radio communications.

Responsibilities are defined at the following levels:
- management level – Master/ Chief Officer;
- operational level – OIC;
- support level – all other sea-going personnel.

On an average sea-going vessel, the Master/ Chief Officer has, amongst others, the following (administrative) tasks:
- keeping up the crew list;
- check/ decide on ship stability;
- prepare & complete clearing documents;
- bookkeeping;
- ISPS (International Ship and Port Facility Security Code);
- ISM (International Safety Management).
- Under the ISM Code, it is the shipping line that should clearly formulate and lay out down, in writing, the Master's responsibilities related to:
  - the enforcement of the safety and environmental policy of the shipping line;
  - motivate ship's crew to preserve the company policy;
  - give relevant instructions and orders in clear and simple use of language;
  - supervise that certain demands are met;
  - review the SMS (Safety-Management System) and report shortcomings to the organisation ashore.

It is the shipping line that should supervise that the SMS used onboard contains a note clearly emphasizing the Master's authority.
Additionally, it should be emphasized that the Master has the highest rank and responsibility to make decisions on safety and environmental issues and, if necessary, call for the shipping line's assistance.

The SMS must incorporate the following:
- a safety and environment protection policy;
- instruction and procedure to ensure safe operation of ships and protection of the environment in compliance with relevant international and flag state legislation;
- flag state legislation;
- defined levels of authority and lines of communication between and amongst shore and shipboard personnel;
- procedures for reporting accidents and non-conformities;
- procedures to prepare for and respond to emergency situation;
- procedures for internal audits and management reviews.

For all above-mentioned tasks the Master spends (on average) about 2.4 hours per day[7] on his/ her administrative tasks.
A Master spends about 6 months at sea per year, which corresponds to 180 calendar days. As a result, the Master or Chief Officer roughly spends 432 hours on administra-

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[7] This figure is the result of the short questionnaire among in total 22 Dutch seafarers.

tive work annually. However, per vessel, the Master's the annual administrative burden is 876 hours (2.4 hours times 365).

According to the questionnaire, the Officer in Charge (OIC) has the following tasks and related administration to record:

- maintenance;
- safety equipment registration;
- UTM (Universal Transverse Mercator = maps of the sea);
- NTM (Notices to Mariners = updating charts and books);
- ship's log;
- preparation voyage;
- voyage reporting; and
- keeping up the cargo administration.

Under the ISM Code no specific tasks are mentioned for the OIC. The OIC has to do its regular tasks related to his/ her position onboard, plus the (delegated) tasks/ orders given by the Master.

For all tasks mentioned above, the OIC spends (on average) about 2 hours per day[8] on his/ her tasks.
Next to this, an OIC spends about 6 months per year at sea, which corresponds to 180 calendar days. As a result, the OIC spends roughly 360 hours on administrative work annually. However, per vessel, the annual administrative burden of the OIC is 730 hours.

As suggested, one person is added to the crew to take over some administrative tasks from the OIC and the Master. On a yearly basis 2.2 people are needed.
These 2.2 persons should have (given the present situation, and maximum)1606 hours of administrative work per 360 calendar days.
This calculation of economic costs is hypothetical because having one extra crew member only for administrative work, i.e. 4.2 hours a day, is too expensive. It appears to make more sense that the Master of OIC delegate administrative tasks to another officer or ashore.

The second measure has been defined as **identifying administrative tasks that can be done by the organisation ashore using (wireless) ICT facilities.**

Currently, most ships can send-receive data via satellite and they do have Internet onboard, but the extent at which the (administrative) work on board is automated may vary considerably between vessels. This means that the gain by expanding the ICT facilities may be different for different organisations and vessels.
Internet onboard ships can only be realised via satellite. In general, the connection is not very fast due to limited bandwidth[9]. The provider 'Inmarsat' launched a new satellite recently. With this new satellite wideband Internet of 128 kb/s can be offered worldwide. Inmarsat has the ambition to upgrade the link to 432 kb/s in 2007, in order to enable telephone and Internet traffic at the same time. Boeing's division 'Connexion by Boeing' offers a 256 kb/s ship-to-satellite connection and up to 5 Mb/s visa versa, but only on the Northern hemisphere. However, this speed at a limited geographical

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[8] This figure is the result of the short questionnaire among in total 22 Dutch seafarers.

[9] Source 'Technisch Weekblad', 11 November 2005, article 'Felle concurrentieslag om breedband op zee', page 5.

area has a cost: USD 2,800 per month for 2,000 minutes. Some other market players are Eutelsat, Iridium Satellite LLC and Telemar Scandinavia. It can be concluded that the actual Internet ICT facilities at present do limit ship-to-shore connections either through limited bandwidth or high cost.
Apart from this, the administrative tasks described for the Master/ Chief Officer and the OIC all deal with activities carried out onboard ships. The crew members are responsible for completing the registration forms. This means that when this kind of administrative tasks is to be transferred to the organisation ashore, the crew should still have to check the data. This would mean that actually additional paper work is created.

Additionally the seafarers in the small survey, referred to in Annex 2, answered to the question as to 'which administrative tasks might be transferred to the shore-based organisation' the following:

- Quite some information might be further computerised (the information is not specified).
- Transferring administrative tasks might be effective, but not very practical. In most cases the shore organisation does not know when and what something can/ must be done onboard the vessel.
- Most of the tasks can only be carried out onboard the vessel.
- If certain data is administered by the shore organisation, still those responsible onboard should check the data for errors.
- Transferring administrative tasks might be effective; more time remains for other work onboard.
- Transferring administrative tasks will not be effective. Presently, already a massive flow of information is exchanged between the vessel and the shore organisation.
- Transferring administrative tasks can be effective, as long as the work is done well defined and done correctly.
- The disadvantage of transferring administrative tasks to shore is that the crew loses track of the situation.
- Too much paperwork is directly related to the ship’s operations and therefore cannot be transferred to the organisation on shore.

It can be concluded that, in close consultation with a diversity of crew members, some administrative tasks might be transferred to the shore organisation. A software application could be developed aimed at supporting the crew during their administrative tasks. Despite the small survey, these activities or tasks have not been identified yet. It is even questionable whether such a shift of administrative tasks eventually will benefit ship’s operation. At this stage more detailed information is not available. It is suggested to organise meetings with shipping lines and Masters and crew to discuss the possibilities, and stipulate the financial benefit, if any. This exercise may even benefit from the involvement of relevant ICT expertise.
Additionally ICT may make the administrative tasks onboard more efficient, resulting in a reduction of time spent on these tasks. However, this benefit will dependent on the present ICT-usage on board.

The effect of the above-mentioned measures on the maritime training and education systems is expected not to be immense. It should just aim at optimising its information on ICT-systems available on their market and continuously assessing its value for the sector. On the other hand, not every person has the natural instinct/ skills to delegate (administrative) tasks, Masters included. In order to lighten the administrative burden and in some cases to delegate tasks, it is suggested that additional courses on communication and delegation are provided.

4.4.3.3 *Changing the shift system into a more flexible one, with a rest period of at least 8 hours. A possibility is to introduce a 4-8 / 8-4 shift system*

As mentioned before, a two-shift system at present often means two people cover the 24 hours watch, often resulting in a schedule of 6 hours on and 6 hours off. Suggested here is that 4 hours on watch is followed by an 8 hours rest, followed by 8 hours on watch and finally 4 hours rest.

The work-rest pattern can be described as follows:

Master	OIC
Rest 6 hrs	Work 6 hrs
Work 6 hrs	Rest 6 hrs etc

The 'traditional' schedule means that neither the OIC nor the Master has an eight-hour rest period, which is the case in the shift system as suggested.

In the suggested 4-8 – 8-4 watch system the following pattern exists:

Master	OIC
Work 4 hrs	Rest 4 hrs
Rest 8 hrs	Work 8 hrs
Work 8 hrs	Rest 8 hrs
Rest 4 hrs	Work 4 hrs etc

The advantages of the suggested 4-8 / 8-4 shift system are:

- The eight-hour rest period.
- There will still be only two people carrying out the watch, so the change in shift system has no financial implication.

The Working Time Directive is no obstacle for the 4-8 / 8-4 shift system, since it prescribes at least a 30-minutes rest after 6 hours work, but longer working periods up till 9 hours (and in exceptional cases 10 hours) are permitted. In the latter case the rest-period should, however be longer (at least 45 minutes), which is no problem within the suggested shift system. For the Dutch shipping industry, specific agreements on working times are prescribed in a so-called 'Arbeidstijdenbesluit' (www.arbeidsinspectie.szw.nl; next: 'arbeidstijden'). These agreements are in line with the European Working Time Directive (Directive 2002/15/EC).

As mentioned before, this change in shift system has no direct financial implication, and thus a calculation cannot be made. Neither does this change in shift system affects the maritime training and education.

4.4.3.4 *Fatigue Management Programme or Tool*

In addition to the before mentioned measures the Dutch Ministry of Transport, Public Works and Water Management suggested to set up a framework for a “Fatigue Management Programme or Tool”. Such a programme or tool should enable and support shipping companies to take measures to manage fatigue and thus (further) improve safety onboard ships (IMO, 2001 b). Although the concept of 'programme' suggests that it should be something in itself, it should be seen as an integral part of safety management, and could thus be seen as part of the ISM-Code with specific attention to fatigue. The concept of 'Tool' appears to fit better in that respect, although it may suggest that this measure is comparable to a tool box. In other (road) transport sectors considerable experience is already available with these FMS's (e.g. Dawson & McCullough, 2005). The specific way in which these systems and tools have been developed and implemented in e.g. road transport may provide useful information about the way fatigue could (properly) be implemented as part of the ISM-Code in organisations. As described earlier in the introduction of 4.4.2, the implementation of the ISM-Code itself is, although it is potentially a measure that can help reduce fatigue, at present not fully grown yet, and still results in a lot of administrative burden.

The ISM-Code is 'the' International Management Code for the Safe operation of ships and for Pollution Prevention and aims to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, particularly the marine environment, and to the property. ISM puts emphasis on the essential ingredient of Shipping Management that every company should develop, implement and maintain a Safety Management System (SMS) to the Code. This does not mean that the code is telling the company how to go about running their business. It is up to the company how to go about implementing the codes.
The link between the ISM Code and the indication of fatigue is that the Ship’s Master, Chief Officer(s), Officers in Charge and other seafarers have the obligation to report (preferably written) problems on e.g. long working hours and pro's and con's of shift systems on certain trades, without counter measures to be expected from the organisation, in order to improve the system. This active participation of the crew in the safety management of the ship is for sure a favourable and positive aspect of the ISM Code.
Despite the active participation, the ISM Code also puts quite a heavy clerical burden for the ship's staff; it must be done besides other administration needed under the new ISPS Code, the Paris MOU and the organisation ashore.
However, the question remains how the companies perceive the ISM philosophy. Under the Code, companies are required to perform frequent audits. Audits are mandated before the issuance or renewal of a Document of Compliance certificate or a Safety Management Certificate.
In addition, periodic audits, including annual and intermediate verification audits, are necessary to maintain the validity of a company's safety management system. Their purpose is to verify that a vessel and its owner or operator is complying with the company's safety management system. Specifically, audits review the procedures and documents of a safety management system to ensure that they are consistent with flag state, port state and International Maritime Organisation (IMO) requirements.
In the Netherlands it is the Shipping Inspectorate that has the final responsibility for ISM-certification. The audits are carried out by the classification bureaus, e.g. Lloyds Register, Det Norske Veritas or Germanischer Lloyd.

When an audit is conducted, the possibility exists that a "non-conformity" will be detected. A "simple non-conformity" is an observed situation, which indicates the non-fulfilment of a specific safety or environmental requirement. A "major non-conformity" is an identifiable deviation from applicable requirements, which poses a serious threat to personnel or vessel safety or a serious risk to the environment. Major non-conformities require immediate corrective action.
When a non-conformity is found, it must be reported in writing to the company's owner or operator as well as to the vessel's master. This ensures that the owner or operator and the master are made aware of a problem and steps are taken to correct the deficiency.
This process encourages improved efforts at future compliance with applicable safety and environmental standards. However, it also leaves (again) a "paper trail" document-

ing non-conformity problem for future auditors, including flag state and port state control inspectors. It may also provide evidence in litigation that arises after a mishap.

It is suggested to first investigate in more detail whether the ISM-Code does not cover or even show any shortcomings. However, one should also bear in mind that the ISM Code has only become obligatory for the short sea shipping (excluding short sea tanker operations) since 3 years. This means that its contribution to increased safety in work processes and their potential assets to an improved fatigue management are still taking shape. On the other hand, it may be interesting to see how 'fatigue management' may be improved within this ISM-context.

5 Literature

Akerstedt, T. & Folkard, S. A model of human sleepiness. In: J.A. Horne (Ed). Sleep '90. Bochum: Pontenagel Press, 1990:310-313.

Akerstedt, T. & Folkard, S. Prediction of intentional and unintentional sleep onset. In: R.D. Ogilvie and J.R. Harsh (Eds). Sleep Onset: Normal and Abnormal Processes. Washington: American Psychological Association. 1994:73-87.

Akerstedt, T., Knutsson, A., Westerholm, P., Theorell, T., Alfredsson, L., Kecklund, G. Mental fatigue, work and sleep. Journal of Psychosomatic Research 2004; 57:427-433.

Baker, C.C., McCafferty, D.B. Accident database review of human-element concerns: what do the results mean for classification? American Bureau of Shipping, USA. February, 2005.

Belenky, G., Balkin, T.J., Redmond, D.P., Sing, H.P., Thomas, M.L., Thorne, D.R. & Wesensten, N.J. Sustaining Performance during Continuous Operations: The US Army's Sleep Management System. In: L. Hartley (Ed). Managing Fatigue in Transportation; Proceedings of the 3rd Fatigue in Transportation Conferences, Fremantle, Western Australia, 1998. Oxford: Elsevier, 1998: 77-85.

Bohnen, H.G.M. & Gaillard, A.W.K. The Effects of Sleep Loss in a Combined Tracking and Time Estimation Task. Ergonomics, 1994;37(6):1021-1030.

Broughton, R.J. Vigilance and Sleepiness: A Laboratory Analysis. In: Vigilance and Performance in Automated Systems. A. Coblenz (Ed), Dordrecht: Kluwer, 1988.

Brown, I.D. Study into the Hours of Work, Fatigue and Safety at Sea. Medical Research Council, Cambridge, England, 1989.

Bryant, D.T. The Human Element in Shipping Casualties. HMSO, London, 1991.

Colquhoun, W.P., Rutenfranz, J., Goethe, H., Neidhart, B., Condon, R., Plett, R., Knauth, P. Work at sea: a study of sleep, and of circadian rhythms in physiological and psychological functions, in watchkeepers on merchant vessels. I. Watchkeeping on board ships: a methodological approach. Int. Arch. Occup. Environ Health 1988;60:321-329.

Condon, R., Colquhoun, W.P., Plett, R., DeVol, D. & Fletcher, N. Work at Sea: A Study of Sleep, and of Circadian Rhythms in Physiological and Psychological Functions in Watchkeepers on Merchant Vessels; Part IV - Rhythms in Performance and Alertness. International Archives of Occupational and Environmental Health, 1988;60:405-411.

Davis, S.C., Cameron, B.J., Heslegrave, R.J. Study on extended coast guard crewing periods. Vancouver, march, 1999.

Dawson, D. & McCullough, K. Managing fatigue: It's about sleep. Sleep Medicine Reviews 2005,9:365-380.

Dinges, D.F. Probing the limits of functional capability: the effects of sleep loss on short-duration tasks. In: R.J. Broughton & R. Ogilvie (Eds). Sleep, Arousal and Performance. Boston: Birkhauser-Boston Inc., 1992: 176-188.

Dinges, D.F. An overview of sleepiness and accidents. J Sleep Res 1995;4(Suppl. 2):4-14.

Dinges, D.F., Pack, F., Williams, K., Gillen, K.A., Powell, J.W., Ott, G.E. et al. Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. Sleep 1997;20(4):276-77.

European agreement on the organisation of working time of seafarers. Merchant Shipping Regulations, 2002.

European Transport Safety Council. The role of driver fatigue in commercial road transport crashes. Brussels: European Transport Safety Council, 2001.

Folkard, S. & Monk, T.H. Shiftwork and Performance. Human Factors, 1979;21(4): 483-492.

Froberg, J.E., Karlsson, C.G., Levi, L. & Lidberg, L. Circadian rhythms of catecholamines excretion, shooting range performance and self-ratings of fatigue during sleep. Biol. Psychol., 1975;2:175-188.

FSI 9/10. Casualty statistics and investigations, November 24th, 2000.

FSI 10/9. Casualty statistics and investigations, January 4th, 2002.

FSI 11/4. Casualty statistics and investigations. January 13th, 2003.

FSI 13/WP.2. Casualty statistics and investigations. March10th, 2005.

Gaffney, M.E. Bridge simulation: trends and comparisons (unpublished manuscript, Maritime Transportation Research Board, National Academy of Sciences, Washington, D.C., 1982.

Gaillard, A.W.K. & Steyvers, F.J.J.M. Sleep Loss and Sustained Performance. In: Vigilance and Performance in Automated Systems. A. Coblenz (Ed), Dordrecht: Kluwer, 1988.

Graeber, R.C. Long-Range Operations in the Glass Cockpit: Vigilance, Boredom and Sleepless Nights. In: Vigilance and Performance in Automated Systems. A. Coblenz (Ed), Dordrecht: Kluwer, 1988.

Grandjean, E.P. Fatigue. American Industrial Hygiene Association Journal. 1970: 401-411.

Hachmang, F.P. Tussenrapportage Vervolg 'Toezicht Bemanning'. Rotterdam: IVW, Toezichteenheid Zeevaart Unit Vlaggenstaat, oktober 2005.

Hanecke, K., Tiedemann, S., Nachreiner, F., Grzech-Sukalo, H. Accident risk as a function of hour at work and time of day as determined from accident data and exposure models for the German working population. Scand J Work Environ Health 1998;24 suppl. 3:43-48.

Haworth, N.L., Triggs, T.J. & Grey, E.M. Driver fatigue: Concepts, Measurement and Crash Countermeasures, Federal Office of Road Safety, Canberra, 1988.

Hockey, G. Changes in Operator Efficiency as a Function of Environmental Stress, Fatigue and Circadian Rhythms, in Handbook of Perception and Human Performance, K. Boff, L. Kaufman, & J.P. Thomas (Eds.), New York: John Wiley and Sons. 1986.

IMO. Guidelines on fatigue. International Maritime Organization, London, 2001 a.

IMO. Guidance on fatigue mitigation and management. MSC/Circ.1014, 2001 b.

Inspectie Verkeer en Waterstaat, Divisie Scheepvaart (Netherlands Shipping Inspectorate). Eindrapportage “Toezicht Bemanningen”. Januari 2005.

Krueger, G.P. Sustained Work, Fatigue, Sleep Loss and Performance: A Review of the Issues. Work and Stress, 1989; 3(2): 129-141.

Lang, J.S. The Marine Accident Investigator’s Perspective. “The changing scene of passenger travel by sea – new risks, new challenges, new solutions”. International union of marine insurance conference, London 2000.

Lindquist, C. Ships with only two navigators onboard. Stockholm: Swedish Maritime Safety Inspectorate, September 2004.

Luczak, H. Work under Extreme Conditions. Ergonomics, 1991;34(6):687-720.

Mackworth, N.H. Researches on the Measurement of Human Performance. His Majesty's Stationary Office, London, 1950.

MAIB, Bridge Watchkeeping Safety Study. Marine Accident Investigation Branch (MAIB). July 2004.

MAIB. Annual Report 2004. May 2005.

MAIB. Department of Transport. Safety digest. Lessons from Marine Accident Reports 1/2005.

Maritime Simulation Rotterdam (BSR), Assessment of the effectiveness of bridge resource management training. Final report. DGG Number 13722/GV00325. (Project no. R&D/01/5501).

McFarland, R.A. Understanding Fatigue in Modern Life. In: Methodology in Human Fatigue Assessment. K. Hashimoto, K. Kogi & E. Grandjean. London: Taylor and Francis, 1971.

McNamara, R., Collins, A., Matthews, V. A review of research into fatigue in offshore shipping. Maritime review, pp. 118-122, London: Pacific Press, 2000.

National Research Council. Crew size and maritime safety. National academy press, Washington, DC, 1990.

Neri, D.F., Shappell, S.A. & DeJohn, C.A. Simulated sustained flight operations and performance. Part 1. Effects if fatigue. Mil Psychol 1992;4(3):137-55.

Ohashi, N. & Morikiyo, Y. Differences in Human Information Processing for a Ship Manoeuvring in the Daytime and at Night. Journal of Human Ergology, 1974, 3: 29-43.

Parasuraman, R. Vigilance, Monitoring and Search. In: Handbook of Perception and Human performance. K. Boff, L. Kaufman and J.P. Thomas (Eds.). New York: Wiley & Sons, 1986.

Perrow, C. Normal accidents. Living with high-risk technologies. Princeton: University Press, 1999.

Philip, P., Sagaspe, P., Moore, N., Taillard, J., Charles, A., Guilleminault, C., Bioulac, B. Fatigue, sleep restriction, and driving performance. Accident Analysis and Prevention, 2005; 37, 473-478.

Philips, R. Fatigue Among Ship's Watchkeepers: A Qualitative Study Of Incident At Sea Reports. In: L. Hartley (Ed). Managing Fatigue in Transportation; Proceedings of the 3rd Fatigue in Transportation Conferences, Fremantle, Western Australia, 1998. Oxford: Elsevier, 1998: 315-337.

Plett, R. Colquhoun, W.P., Condon, R., Knauth, P., Rutenfranz, J. & Eickhoff, S. Work at sea: a study of sleep, and of circadian rhythms and physiological functions, in watchkeepers on merchant vessels: III. Rhythms in physiological functions. Int. Arch. Occup. Environ Health, 1988;60:395-403.

Pollard, J.K., Sussman, E.D., Stearns, M. Shipboard Crew Fatigue, Safety and Reduced Manning. Report No. DOT-MA-RD-840-90014. John A. Volpe National Transportation Systems Center – Massachusetts, United States, 1990.

Rothman, K.J. Modern epidemiology. Boston/Toronto: Little, Brown and Company, 1986.

Rutenfranz, J., Plett, R., Knauth, P., Condon, R., DeVol, D., Fletcher, N., Eickhoff, S., Schmidt, K-H., Donis, R. & Colquhoun, W.P. Work at sea: a study of sleep, and of circadian rhythms and physiological functions, in watchkeepers on merchant vessels: II. Sleep duration, and subjective ratings of sleep quality. Int. Arch. Occup. Environ Health, 1988;60:331-339.

Sablowski, N. Effects of Bridge Automation on Mariner's Performance. In: Vigilance and Performance in Automated Systems. A. Coblenz (Ed), Dordrecht: Kluwer, 1988.

Sanquist, T.F., Raby, M., Forsythe, A., Carvalhais, A.B. Work hours, sleep patterns and fatigue among merchant marine personnel. J. Sleep Res 1997;6:245-251.

Schagen, I.N.G.L van. Vermoeidheid achter het stuur. Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV), 2002. http://www.swov.nl/nl/publicaties/index.htm

Simons, R.A.C.J., Prins, T., van Waesberghe, J. Risk Based Inspection. In ontwikkeling. Rotterdam, mei 2003.

Simons, R.A.C.J. Expert meetings. Risico's op de Nederlandse Koopvaardij. Rotterdam: Inspectie Verkeer en Waterstaat, Divisie Scheepvaart, mei 2004.

Smith, A., Lane, T. & Bloor, M. Fatigue Offshore: A comparison of offshore oil support ship-ping and the offshore oil industry. http://www.mcga.gov.uk/c4mca/research_report_464_phase_1.pdf

Stokes, A. & Kite, K. Flight Stress: Stress, Fatigue, and Performance in Aviation. Aldershot: Avebury Aviation, 1994.

The Parliament of the Commonwealth of Australia. Beyond the Mid-night Oil. An inquiry into managing fatigue in transport. October 2000.

Tipton, M., Eglin, C., Golden, F. & David, G. The performance capabilities of crews of daughter craft involved in offshore operations in the oil and gas industries. HSE-report on 'Fatigue, Health and Injury Offshore: a Survey, 2003. http://www.hse.gov.uk/research/rrpdf/rr108.pdf

Transport Canada, transportation development centre (R&D). Development of a fatigue management program for Canadian marine pilots (TP 13958E). November 2002.

USCG. Crew fatigue and performance on U.S. Coast Guard Cutters. US Coast Guard Research and Development Center. Report No. CG-D-10-99, October 1998.

USCG. Crew Endurance Management Practices. January 2003.

Vidacek, S., Radosevic-Vidacek, B., Kaliterna, L. & Prizmic, Z. Individual Differences in Circadian Rhythm Parameters and Short-Term Tolerance to Shiftwork: A Follow-up Study. Ergonomics, 1993; 36 (1-3): 117-123.

Zieverink, H.J.A., Kluytenaar, P.A. Werkdrukonderzoek op schepen met een voortstuwingsvermogen van minder dan 750 kW. DGSM nr. 6862, 1997.

Annexes

Annex 1: The questionnaire on measures to manage fatigue as sent to the stakeholders

Measures to prevent and reduce fatigue in the shipping industry

TNO/ MSR, Mathilde Miedema, 14 september 2005

Study on fatigue

The Ministry of Transport, Public Works and Water Management, and more specifically the Directorate-General for Civil Aviation and Freight Transport (hereafter called the Ministry) commissioned TNO Work & Employment (TNO) and Maritime Simulation Rotterdam b.v. (MSR) to perform a study on 'fatigue' in the shipping industry. Central to this study is the relation between 'fatigue' and the occurrence of collisions and groundings. One of the aims of this project is to assess the relationship between fatigue and collisions and groundings, to inventory measures to manage fatigue, and to map the consequences of these measures for the competitiveness of the sector as well as for the maritime education.

Workshop

Within the context of this study, in July and August accident reports on groundings and collisions were analyzed, literature is studied, and stakeholders from the sector were interviewed. On August 30th a workshop was held with these stakeholders. The goal was to identify effective measures to prevent fatigue in the (short sea) shipping industry. It was an informative and interesting workshop during which we talked about definitions, about causes of fatigue, and about measures. However, no time was left to select the most important and feasible measures, and discuss their expected effectiveness. We would like to obtain this information and are now trying to do this by mail. In this document you will find a short summary of the workshop with a few questions addressed to you. The document is organized as follows:

- Part A gives a review of causes of fatigue.
- Part B reviews the solutions to these causes.
- Part C asks you to select the most important and feasible solutions and to elaborate on these. You can do that by rating the solutions, and answering the consecutive five open questions.

We kindly ask you to read through Part A and B and rate the solutions in Part C. Would you please also answer the open questions in Part C?

Finally, would you send the completed form to m.miedema@arbeid.tno.nl?

Thank you for your cooperation!

A. Causes of fatigue and optimizing fatigue management

In this project we define fatigue as either acute or chronic. Acute fatigue restricts itself to a single shift, and is synonymous with sleepiness. Chronic or cumulative fatigue occurs as a consequence of incomplete recovery between shifts. Fatigue is multidimensional and relates to a state of being exhausted, mentally fatigued, physically fatigued, feeling tired and lack of motivation.

Six areas of causes for fatigue did arise from the literature study, accident analyses and interviews.

1. Work and resting times

- Long working days – 2 shift-system (6 hours on.6 hours off).
- Broken shifts (shift is split by several short resting periods).
- Long work periods alternated with long periods of rest. At 2 shift-system about four weeks to four months on board of a vessel are followed by about four weeks to 2 months of rest.
- Disturbance of the rest period / temporary shift between work and resting periods (e.g. with over work, unplanned and unexpected activities, entering or leaving the harbor, short stay in the harbor, inspections, audits by contractor).
- Bad quality of the resting period – noise vibrations at loading and unloading.
- Individual time management – not able to do one’s work, low on self-discipline.

2. Manning issues – culture

- Sub optimal/minimal manning:
  - distribution of tasks amongst the crew members;
  - crew number;
  - competencies – education, training, experience;
  - social cohesion – click amongst workers, officers, atmosphere and morale;
  - management - Officers with few management qualities;
  - communication;
  - nationalities and cultures.
- Manning plans are mainly based on sailing from A to B; underestimating the number of (additional administrative) tasks.
- Relationship Master and the shipping company/ personnel management – it is a good policy to have shared responsibilities between the ship and ashore. There still are shipping companies where there is a culture of settings scores, or seafarers put forward unfunded complaints about matters without any intention of solving things in a structural manner.
- Seafarers work in an isolated environment, which may lead to the perception that ashore things are always better (insufficient consciousness of the positive aspects of working on board and too much attention to negative aspects).

3. Time pressure, mental work load

- High administrative load - because of many procedures, no nice tasks (no affinity with this kind of work), danger for ones own and one's colleagues' safety because one has to combine administrative tasks with watch keeping.
- Extra work - many and unexpected inspections and audits, unexpected, delayed or overrun activities.

- Again and again showing things on board are as they should be during the many inspections and visits of authorities and auditing organizations.
- Inefficient distribution of work on board, insufficient anticipation of work to be expected.
- Insufficient skills and competencies to do the tasks that have to be done.
- Overwork – problems with time management, financial incentives. Some ship owners use a set pay, resulting in a reduced incentive to do overtime.
- Economic pressure – competition. Operations ashore stimulate the ship to make optimal profit. The Master has to set the standards. This game is not always being played well.

4. Health and coping capacity
- Lifestyle crew – unhealthy behavior: overweight, exercise, use of alcohol, smoking.
- Discipline on resting times is not always maintained (go to bed when one can or should).
- Do not recognize fatigue or underestimate it.
- Stress caused by personal reasons (problems at home etc.).

5. Cognitive or mental work load
- Work by night, at bad weather or at bad sight.
- A lot of information to handle – radar, telephone, fax, computer screens, intercom, sight, dashboard.
- Not trained well enough to handle the apparatus at hand (particularly the older seafarers).
- Little alternation in the environment/monotony (rest at work, close living community with colleagues).

6. Data management
- Content of the reports on accidents is sober, too few human error factors, like fatigue, are looked at/indicated.
- Analyses per country – small numbers, an international data base should be installed.
- Data collection should be expanded with:
  - frequency and near misses;
  - the entire performance of the sector (as far as safety is concerned);
  - information on the health of the crew. Two yearly assessments ordered by the ship owners could be the input here. A privacy aspect may be at stake here…

B. **Measures to prevent/reduce fatigue**

We would like to be ahead of fatigue. From the literature, the interviews with stakeholders and the workshop the 48 measures presented next are identified to manage fatigue. Not all of these measures are feasible in every situation, and there probably are more measures that are potentially effective. We therefore clustered the 48 measures in 12 main types of measures… the 12 main directions are leading, and the 48 measures are just put there as an illustration.
In the table below the first column provides the 12 main directions to help solving the fatigue problem. The 28 measures, numbered as a, b, c… are presented as illustrations. In the other columns we see the causes of fatigue. With a cross you can mark that you think the measure may influence fatigue risk positively.

Measure	Working times	Constitution of the crew	Work pressure	Health	Perceptive-mental load	Monitoring
1. Lengthening of the rest period:						
a. More flexible schedule: e.g. 4-8-8-4	x					
b. At least 24 hours between two harbors: staying in harbor	x		x			
c. More crew, different watch systems	x	x	x			
2. Optimizing the organization of work on board:						
a. Type and size of work should be in line with the qualities of the crew	x	x	x			
b. Optimizing the distribution on board						
c. Attune necessary competencies to what has to be done	x	x	x			
d. Attune the necessary number of people to the tasks and organi-	x	x	x			
zation at work	x	x	x			
e. Distribution of work. Shift of responsibilities on board. Main engi-	x		x			
neer can for example for 4 hours work in the engine room and the do a 4 hours watch (when properly trained; e.g. MARON). This would help the officers on watch. Modern machine rooms makes this possible	x	x	x		x	
f. Communication and taking responsibility. Learning to counteract demands/requests from ashore or third parties may be part of		x	x		x	
this		x			x	
g. Optimizing team functioning - BRM		x			x	
h. Careful choice of manning in order to secure an optimal collaboration and atmosphere						
i. Better fit regarding nationality and cultures						
3. Reduction of administrative tasks (from Masters and OIC's)						
a. Support by the organization ashore, e.g. more preparatory work	x	x	x		x	
b. Expansion of the crew with an administrative employee	x	x	x		x	
c. Flying team in every harbor support e.g. from local agent who	x	x	x		x	

Measure	Working times	Constitution of the crew	Work pressure	Health	Perceptive-mental load	Monitoring
puts e.g. an extra employee on board (e.g. 3e officer)						
d. Automatization	x		x		x	
e. Regulation/reducing inspection pressure	x		x			
4. Less inspectors, auditors/visitors in the harbor:	x		x		x	
a. Coordination of inspections – private, flag state or port state control						
b. Better attuning this with the work-rest schedule of the Master						
5. Limit overwork:						
a. More, and more directed inspections; reduction of double bookkeeping. Selecting out shipping companies that do not obey international laws in order to have lawful companies less additional costs	X		x			
b. Reduce financial incentives for over work – e.g. set fixed wages	x		x			
6. Proper personnel policies:						
a. Recruitment and selection: proper competencies. The sailing licence is a first one, but performances on board an important second one		x	x			
b. Individuals match with the team	x	x				
c. Predetermined schedule			x			
d. Increasing commitment – a lot of contact with ship and at home, ship owner is known and accessible to the ship		x	x			
e. Providing responsibility to the crew – respect		x	x			
f. Support of the ship from ashore on communication	x	x	x			
g. Restrict variation in ship manning	x	x	x			
h. Broad education for manning – flexible usability		x	x			
i. Use the Foundation for Family Contact				x		
j. Increase knowledge and understanding on how to increase self discipline regarding alcohol consumption etc.	x					
7. Education, training and schooling:						
a. Team training regarding cultures		x				
b. Master is a people manager		x	x			
c. New ICT – modern bridge					x	
d. Recognizing perceptive mental load				x	x	
e. Attitude on board: delegating				x		

Measure	Working times	Constitution of the crew	Work pressure	Health	Perceptive-mental load	Monitoring
f. Training new apparatus					x	
8. Development of a Fatigue Management Tool – IMO Guidelines for Fatigue specify such a tool. At present, shipping companies don't know when causes for fatigue are present, because there are many of such causes, and for each ship /cargo/environment the factors that determine fatigue will differ. A checklist should become available to identify these risks and in the basis of which measures are suggested	x	x	X	x	x	x
9. Proper implementation of the ISM-code – better communication, safety:			x		x	
a. Expand on the topic of fatigue						
10. Healthy design shop:						
a. Presence of ergonomic tools/equipment				x	x	
b. Integrated bridge system			x		x	
c. Reliable alarm			x		x	
d. Reduction of noise and vibrations					x	
e. Standardization of equipment/ apparatus					x	
11. Workplace health promotion:						
a. Provision of information on life style and fatigue (stimulating own responsibility regarding eating, drinking and resting)				x		
b. Even stricter alcohol policy of shipping companies, no alcohol on board, or directions for proper alcohol use				x	x	
c. Exercise facilities on board and in harbors				x		
12. Shortage on (monitoring) information:						
a. Accident reports should make use of fatigue/human error related causes and behaviours						X
b. Combining databases on accidents at international level						X
c. Constructing databases on near misses/ mistakes						X
d. Expand databases on fatigue with accidents at work, safety and company performance						X

C. **Effectiveness of measures**

We would like to know which measures are most necessary and most feasible to prevent or reduce fatigue from the participants in the workshop. All measures will be assessed on the next 6 characteristics:

- Prevention of fatigue; to what degree is the measure responsible for prevention or reduction of fatigue?
- Feasibility; what are the chances that this measure will actually be implemented? Feasibility may be determined by several factors. You may weigh them as you please.
- Practical usefulness; to what degree is the measure easy to use in the workplace?
- Time elapsed before full implementation; when is it possible for the measure to be fully implemented and 'active'? This has to do with the simplicity of the measure, availability and support from stakeholders and time needed for development.
- Costs; what are the costs of investment as well as other additional costs to make the measure operational?
- Expected benefits; to what extent does the measure result in less costs, extra income, lower absenteeism/disability, more motivation/commitment, higher productivity, better image of the shipping company/sector/country etc.

We would like to inventory your opinion in two steps:

Step 1. Please, complete the table below, and rate all 12 measures as to their necessity and feasibility. The seven characteristics can be rated on a 5-point scale, where 1 is a low score, and 5 a high score. Please pay attention to the fact that at 'Time to full implementation' and 'Costs' the rating is reversed (so here score 1 is the 'high' score and 5 is the 'low' score). Please, put in a rating at every cell.

Measure	Necessity to manage 1- 2- 3- 4- 5 Low - high	Effective of fatigue reduction 1- 2- 3- 4- 5 Low - high	Feasibility 1- 2- 3- 4- 5 Low - high	Practical usefulness 1- 2- 3- 4- 5 Low - high	Time to full implementation 1- 2- 3- 4- 5 High - Low	Costs 1- 2- 3- 4- 5 high - low	Benefits 1- 2- 3- 4- 5 Low - high
1. Lengthening of the resting period							
2. Optimizing the organization of work							
3. Reduction of administrative tasks							
4. Less visits/inspectors in the harbor/better coordination of inspections							
5. Reduce overtime							
6. Proper Human Resource Management							
7. Education and training							
8. Development of a 'Management tool for fatigue							
9. Proper implementation of the ISM-Code							
10. Healthy design of the ship							
11. Workplace health promotion							
12. Expand monitoring of fatigue causes, behaviours or consequences, including near misses							

Step 2. Description of most feasible, most important measure
The measure with the highest scores is the most feasible. Is this the case?
When no, which measure(s) do you rate as most important and most feasible?

Can you describe here how this measure/these measures should best be made more concrete (which of the 48 measures do you choose)?

Is the effectiveness of the measures you choose bigger when it is implemented together with other measures?
If yes, which?

Who/which stakeholder should play a role in the development and implementation of the measure?

What are potential problems when implementing this measure (these measures)?

Annex 2: The questionnaire elaborating on shifts and tasks at sea

A short questionnaire was completed by 22 Masters, Chief Officers, Officers in Charge and some others to obtain a better insight into the prevalence of the different shift-systems, the activities and tasks that are now performed at sea, on the time involved in performing these activities and on the possibility to delegate these activities to someone lower in rank, or ashore.

The questions were:

1. Does fatigue occur onboard ships you sail on?

2. Are measures taken to prevent fatigue from occurring?
   a. If so, what measures are taken?

3. What shift-system is used at the ships you sail?

4. What position do you hold inboard ships?

5. Do you carry out administrative tasks onboard ships?
   a. If yes, please describe your tasks

6. In case a vessel would have a high-speed Internet connection with the organisation ashore, which of the before-mentioned tasks could be transferred to the organisation ashore?

7. When do you do your administrative task(s); during or after the shift?
   a. Percentage of time during or after the shift?

8. How long (in hours) do you spend on administration per day?

9. Which of the following measures would help managing fatigue? (very effective - impossible):
   a. Always preserver a three-shift system.
   b. Add an extra crew member to carry out certain administrative tasks only.
   c. Adjust the work schedule from e.g. '6 on 6 off' to '4 on 4 off, 8 on, 8 off' in order to create the possibility of having 8 hours sleep.
   d. Have the administrative tasks carried out by the organization onshore through a fast Internet connection between ship and shore.
   e. The Master should be better trained in recognizing fatigue, and he should be told to take certain measures to prevent fatigue from occurring.
   f. Should the organization onshore be equipped with a planning tool to prevent working conditions having a positive effect on fatigue from occurring.

10. Do you have any idea/suggestion to prevent fatigue from occurring?

Answers to the questionnaire:

Question 1 Does fatigue occur onboard ships you sail on?

- Yes : 6
- No : 16

Question 2a Are measures taken to prevent fatigue from occurring?

- Yes : 13
- No : 9

Question 2b What measures are taken?

- Registration, extra personnel
- Rest-hours administration
- Improved shift system
- Tied work-rest schedule
- Rest-hour administration and observing the regulations
- Forced rest after eight hours duty
- Depends on the Master
- Short sailing-leave schedule
- Thorough working schedule
- Sharing the work properly
- Comply with the sailing times
- 2-shift system.

Question 3 From the completed questionnaires the following answers were provided related to the shift system

- Two-shift system : 8
- Three-shift system : 10
- Both shift systems : 4

Question 4 What position do you hold onboard ships?

- MAROF : 2
- Master: 3
- Chief Officer : 3
- Officer in Charge : 11
- Maritime Engineer : 2
- Pilot certificate : 1

Question 5a Do you carry out administrative tasks onboard ships?

- Yes : 21
- No : 1

Question 5b If yes, please describe your tasks

Officer in Charge:

- Maintenance/ lubricating
- Safety equipment registration
- ISM (International Safety Management – Safety & Environment)
- UTM (Universal Transverse Mercator = maps of the sea)
- NTM (Notices to Mariners = updating charts and books)
- Ship's log
- Preparation voyage
- Voyage reporting
- Keeping up the cargo administration

Master/Chief Officer:

- Keeping up the crew list
- Check/ decide on ship stability
- Bookkeeping
- ISM (Safety & Environment)
- ISPS (International Ship and Port Facility Security Code)

Question 6 — In case a vessel would have a high-speed internet connection with the organisation ashore, which of the before-mentioned tasks could be transferred to the organisation ashore?

- None (6 x)
- Notices to the Master
- NA (3 x)
- Time registration and invoicing

Question 7a — When do you do your administrative task(s); during or after the shift?

- After the shift : 3
- During the shift : 7
- Both : 12

Question 7b — Percentage of time during or after the shift

- 5% : 1
- 10% : 3
- 15% : 1
- 20% : 2
- 25% : -
- 30% : 2
- 35% : -
- 40% : 1
- 45% : -
- 50% : 1
- 100% : 1
- Blank : 10

Question 8 — How long (in hours) do you spend on administration per day?

- 0.50 : 1
- 0.67 : 1
- 1.25 : 4
- 1.50 : 3
- 2.00 : 1
- 3.00 : 2

- 4.00 : 4
- Blank : 6

Question 9 Which of the following measures would help managing fatigue:
Question 9 A Always preserve a three-shift system.

Very effective	Effective	Neutral	Not effective	Impossible
5	9	2	0	3
26%	47%	11%	0%	16%

Question 9 B Add an extra crew member to carry out certain administrative tasks only.

Very effective	Effective	Neutral	Not effective	Impossible
5	5	6	5	1
23%	23%	27%	23%	5%

Question 9 C To adjust the work schedule from f.e. “6 on 6 off” to “4 on 4 off, 8 on, 8 off” in order to create the possibility of having 8 hours sleep.

Very effective	Effective	Neutral	Not effective	Impossible
2	5	6	9	0
9%	23%	27%	41%	0%

Question 9 D Have the administrative tasks carried out by the organisation onshore through a fast internet connection between ship and shore.

Very effective	Effective	Neutral	Not effective	Impossible
1	4	7	7	2
5%	19%	33%	33%	10%

Question 9 E The Master should be better trained in recognising fatigue, and he should be told to take certain measures to prevent fatigue from occurring.

Very effective	Effective	Neutral	Not effective	Impossible
1	5	11	4	0
5%	24%	52%	19%	0%

Question 9 F Should the organisation onshore be equipped with a planning tool the prevent working conditions having a positive effect on fatigue from occurring?

Very effective	Effective	Neutral	Not effective	Impossible
2	1	11	5	0
11%	5%	58%	26%	0%

Question 9 G Do you have any idea/suggestion to prevent fatigue from occurring?

The following ideas/ suggestions were noted down (quote/ unquote):

- Make sure that there is enough personnel onboard ships.
- Make demands on the minimum number of seafarers needed to operate the three-shift system; the Master excluded.
- Organise a course for Masters to recognise fatigue in early stage.
- Revise and reduce the number of administrative tasks.
- Add an Officer in Charge (2de stuurman)/ MAROF to ships operating a two-shift system with the aim to support the deck and engine room.
- Reduce the number of crew to an absolute minimum in order to take an administrator onboard.
- “Do not bite off more than one can chew”.
- Assure a descent planning onboard.
- Make sure that there is enough possibility for relaxation.
- Fine-tune the crew composition.

Annex 3: Extensive analyses of accidents in the Dutch shipping industry

Cases studied:

	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Number of accident reports	33	26	23	26	27	23	16	9	8	191
Selected number of cases	6	6	5	7	10	6	9	7	3	58
Cases with fatigue	2	0	1	3	2	2	0	2	1	13

In the Table are only selected cases, in **bold** cases where 'fatigue' plays a role.

Cases selected on:
1. short sea (so no shipping or passenger vessels involved);
2. human factors play a role in the accident;
3. collisions and groundings (so no occupational hazards on board, no fires).

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
2-1997	Oxelösund-Antwerp	Dutch cargo ship ran on a rock near Hävringe island while sailing in Swedish waters (narrow passage + hard rocky sea-floor).	• Master did not study the sailing directions of the area and exceeded the recommended speed of 5 miles per hour. • Master did not use all available aids to sail through the narrow passage as safe as possible (sailing on buoys, not marking the ship's position on the chart, no optimal use of radar, using auto-pilot instead of hand steering). • Master did not use the assistance of a second watch keeper.	• Master mixed up a red buoy and a green buoy. • Ship ran on a rock.	?
4-1997	Beverwijk-English Continental Shelf the Lancelot Field	Collision of a Dutch supply ship sailing on the North Sea with the platform 'NSR-M1'.	• Master planned a route close to the platform and thought the officer in charge could safely pass this platform. • Watch keeping duties were neglected by the master and watch keeper in charge (master was doing his administrative tasks and watch keeper focussed on the afterdeck and was considering his duties for the next day). • Trainee was not alarmed when marking the ship's position on the chart on only a few cable lengths from the platform. • Master should have been aware of the limitations of a magnetic	• Collision with a platform.	2

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			compass (large deviations when passing underwater cables) that was connected to the automatic pilot because the defect gyro-compass, and should have checked the ship's position regularly.		
5-1997	**Elleholm (Swe-den) –Rostock (Germany)**	**A Dutch cargo ship grounding on the German coast near Bör-gerende.**	• **Master kept watch alone.** • **Master did not take any measures to alarm him in case of falling asleep (watch alarm and radar alarm were off, the volume of the GPS and VHF alarm was turned down.** • **Master had been drinking alcohol during his watch.** • **Master did not mark the ship's position on the chart, and only used GPS and radar.** • **The crewmembers had an intensive working schedule visit-ing a harbour every day, but the master did not register the crew's working hours.** • **Master fell asleep on the bridge during his watch keeping duties at night.**	• **The radar post Warnemünde noticed the ship and tried to get in contact with it several times in vain using the local channel.** • **The ship sailed closely passed an anchored ship (near miss).** • **Ship grounded near a camp-ing site.**	**3**
18-1997	Rotterdam - ?	Collision between a Portuguese chemical tanker sailing at the North Sea and and an oil tanker from Malta near Hoek van Hol-land.	• Meeting vessel should have chosen another route (the current route should have been avoided according to the sailing direc-tions; through vessels should avoid the precaution area). • Traffic control should have advised the meeting vessel regarding the course of navigation and should have kept an eye on the vessel and provide the vessel with information. • The meeting vessel should have changed its course drastically and should have reduced its speed. • Pilot of the ship assumed that the meeting vessel would pass along the back and that traffic control agreed on this with the meeting vessel. Pilot should have realised that the meeting ves-sel deviated from the common and expected sail direction. • Traffic control should have provided both ships with information sooner. • Traffic control and Pilot should have used the English language (instead of the Dutch language) so the meeting vessel could have listened to (and understand) their conversation.	• Collision.	?
20-1997	IJmuiden – Kold-ing (Denmark)	Collision between a Dutch Coaster sailing on Danish waters	• Master slightly deviated from the recommended course (because of expected floating ice), which made the ship sail even closer to	• Collision.	2

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
		(Langelands Belt) and a German naval vessel.	another nearby nearly parallel route, and this might cause uncertainty with other ships regarding the ship's course. • The officer's poor navigation (only marked some positions of the ship on the chart and important passages and changes were not registered in the ship's logbook). • No watch keeper during the night. • Contrary tot regulations no mist signal was given. • Watch alarm was not on standby. • Officer recorded a passing distance that was unsafe in foggy weather, but did not do anything to increase the passing distance (only then when the meeting vessel had approached up to 2 miles the ship made a small change of course). • Watch keeping officer of the meeting vessel should have used a larger reach of the radar and made a wrong interpretation of the other ship's movements. • The watch keeping officers of both vessels neglected their duty to warn their master about the problematic situation with a meeting vessel that had developed due to the misty weather. • None of the vessels reduced their speed nor did anything to avoid the situation. • None of the vessels used the VHF.		
30-1997	**Stettin (Poland) – Youghal (Ireland)**	**Dutch cargo ship grounded in the Drogden Channel near the Smaagrundene buoy.**	• **Master did not draw the route on the chart and the navigating officers decided on the course of navigation themselves.** • **Navigating officer sailed on an unnecessary short and unsafe distance past the buoy with behind it a bar.** • **Navigating officer navigated on the buoys and lighthouses and did not mark the ship's position on the chart. This can be dangerous because buoys can be out of position.** • **Navigating officer was alone on the bridge by night and dense fog (no extra watch keeper).** • **No use of watch alarm.** • **It is likely that the navigating officer was absent-minded and therefore could not change the ship's course in time.**	• **Grounding at the Smaagrundene reef.**	**3**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
5_1998	Guness - Van-ersborg	Getting outside the channel and grounding of a Dutch cargo ship sailing on the Humber river (England).	• Pilot and master heavily underestimated the ebb tide. • The ship travelled with too high speed. • Not in the right position to navigate on the line between keel and stems/sterns (get a distorted picture with respect to this line). • Master should have studied the pilot's charts more thoroughly and should have asked for information regarding the pilot's planned course.	• Grounding.	?
6-1998	Hamburg (Duitsland) Göteborg (Zweden)	Grounding of a Dutch cargo ship sailing under the instruction of a pilot near Vinga island (Sweden).	• Because of the dark (at night), the crosswind and current, the master should have taken a longer but more familiar and less difficult course, instead of the narrow passage. • The pilot should have alerted the master on this. • Master and pilot should have discussed the course and division of tasks with one another. • Pilot navigated by using the radar and did not use the visual signs/features or did not read them correctly, lost his orientation and put the helm to the port too soon. • Master's organisation on the bridge was insufficient (e.g. no positions were marked on the chart, did not use second radar to check the pilot's navigation, did not assess the compass error properly)	• Grounding.	3
8-1998	Antwerpen - Rotterdam	Collision between Dutch chemical tanker sailing at the Westerschelde and Norwegian chemical tanker.	• Irresponsible sailing behaviour by the Norwegian tanker (high speed while view was poor, sailing in the opposite direction, not keeping starboard side/shore, passing other ships without making clear agreements about it). • Several ships sailing at high speed while view is poor and shipping is busy, therefore not having enough time to get a clear view of the situation. • Due to poor discipline on the VHF no clear agreements were made about passing, reducing speed in time and giving clear traffic information.	• one near miss. • two collisions.	?
9-1998	Flixborough - Vlissingen	Getting outside the channel and grounding of a Dutch tanker sailing at the Humber (England).	• Master and pilot underestimated the ebb tide. • Master relied on the pilot too much and did not obtain all possible information regarding the pilot's course to be able to check and correct the pilot.	• Grounded due to strong ebb tide.	?

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			• Pilot did not possess the proper charts.		
20-1998	Nordenham_ Douglas (Isle of Man)	Dutch cargo ship sailing at the German Bend collided with buoy.	• Navigating officer sailed by night for the first time on a ship that was new to him, and was getting familiar with the new bridge and some of the devices/appliances that were new to him. Therefore he did not fulfil his watch keeping duties properly. • Master did not check properly if navigating officer was familiar with the bridge and the standard watch keeping orders. • Navigating officer left on the light above the Table with the charts even when not studying the charts, this might have deteriorated his night vision for a while after looking in the light. • There was no extra watch keeper during the night (navigating officer should have asked for one).	• Ship collided with buoy.	2
25-1998	Amsterdam – Treguier (France) Arklow (England) - Moerdijk	Collision between a Dutch cargo ship sailing at the English Channel and another Dutch cargo ship.	• On one of the ships the extra watch keeper was making some coffee, while on the other ship there was no (extra) watch keeper. • None of the vessels used the obligated sound signals. • None of the vessels had ARPA or the possibility to plot contacts on the radar screen with a wax pencil. • Master of one of the vessels did not prepare the journey. He failed to give any instruction to the navigating officer, regarding the course, and how to cross the stream of traffic. • Navigating officer opposed to the traffic stream and did not adjust his course after he spotted two other vessels on his radar and did not warn the master. • Navigating officer used the radar incorrectly (as is usually used in inland navigation, but having severe restrictions at sea, increasing the risk of mistakes). • Navigating officer of the other vessel assumed he was overtaking the other ship (while he was actually meeting the other ship) and did not check this assumption and took insufficient measures to prevent the collision (e.g. reduce speed, drastically change course). • Master of the other ship did not check properly if navigating officer had enough experience regarding sailing with poor view.	• Collision.	2

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
2_1999	Jacobstad (Finland) – Hull en Dundee (England)	Collision between Dutch cargo ship sailing at the North Sea and a survey vessel from the Bahamas.	• On board of the cargo ship the steering position was not registered. • Master of the cargo vessel should have passed the platform with a greater distance because of the fog and knowing there could be vessels in the immediate surrounding of the platform. • Master did not have the chart with the largest scale indicating buoys and (sometimes) safety areas • No proper use of (extra) watch keeper. • Survey vessel did not plot it's course on the chart and did not make a radar plot before leaving the platform. • Survey vessel did not have an (extra) watch keeper. • Both vessels did not give enough sound signals, while this was obligatory due to the fog. • None of the vessels reduced its speed when they spotted each other on the radar.	• Collision.	?
5-1999	Rotterdam Eemshaven – in the direction of the sea	Grounding and then collision of a Swedish vessel sailing at the New Waterway (near Maassluis) with a pilot on board with a Norwegian cargo ship.	• Both vessels sailed with high speed considering the weather conditions (fog). • Considering the situation (fog, meeting vessel) it would have been wise to give up the overtaking/passing manoeuvre. • Poor navigation (not plotting the ship's position, rarely checking the radar, pass on the wrong course corrections) • Bad organisation of the bridge (did not discuss the ship's details/particulars, overtaking/passing manoeuvre, view (fog), travel speed and information received from sector post, relied on the pilot's navigation, pilot's communication on marine telephone was in Dutch which the master could not understand) • Lack of communication between master and pilot.	• Grounding and then collision.	?
9-1999		Collision between French container ship sailing at the Westerschelde and a tanker from Bermuda.	• Insufficient information supply and exchange and a poor VHF procedure by both pilots. • In line with the rules the ship should have avoided to pass/overtake the other ship in a precaution area and when changing pilots, or at least the ship should have informed of the headquarter and the other ships. • Pilot should have chosen a safer starting position for changing	• Collision.	?

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			pilots. • Pilots were preoccupied with changing places because they assumed that they were a limited manoeuvrable ship when changing pilots and that other ships would steer away, but that was not the case. • No compulsory outlook and no proper outlook. • Other ship did not inform other parties regarding their plan to pass the roadstead and heading towards the Oostgat without changing pilots. • Other ship did not sail with the obligatory green light meaning it would not stop for changing pilots and immediately heading towards the Oostgat. • Other ship expected the first ship to come over starboard in time, and reduced its speed too late and did not take enough measures in time.		
11-1999	**Gdansk - Nantes**	**Grounding of a Dutch cargo ship sailing at the Baltic Sea.**	• **Navigating officer did not follow the master's instructions and changed course immediately after the master left the bridge.** • **Navigating officer did not plot its positions on the chart to check his course.** • **During the period of the grounding the navigating officer did not take notice of his navigation duties.** • **Navigating officer did not have the watch alarm standby.** • **Navigating officer did not call for an (extra) watch keeper when it became increasingly foggy.**	• **Grounding.**	**2**
17-1999	Newhaven - Oostende	A three-master grounding and running ashore immediately after departure from Newhaven.	• The master of the ship should have decided to leave later on at high tide, taking in consideration the weather, small channel, tide, the ship's draught and engine power. • No proper preparation the navigation for sailing out of the harbour. • Nobody plotted the positions of the ship nor checked the pilot. • None of the available aids (e.g. radar and compass) were used. • No attention was paid to echo-sounder.	• Grounding.	3?

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
5-2000		Collision between Dutch cargo ship sailing at the Oostgat with a Swedish vessel.	• Both ships travelled with high speed while the view was poor, their navigation was poor, and there was no proper lookout and the ships did not keep enough to starboard side. • On both ships the pilot was sailing/navigating the ship alone en they were not checked or supported by the crewmembers. • Neither of the ships gave the obligatory sound signals with poor view nor the obligatory manoeuvre signs to prevent collisions. • VTS operator did not warn for the imminent dangerous situation and did not provide important information to both vessels and the pilots did not check for meeting vessels with the traffic control system. • The rules for an oversized ship were not complied with.	• Collision.	?
11-2000	Amsterdam _ Perth	Collision between a Dutch cargo ship sailing at the river Tay with a pilot on board and a pier.	• Pilot should not have been at the rudder himself that provides fewer opportunities to keep a proper overview, to use the radar and advise the master about safe navigation of the ship. • Pilot made a wrong assessment of the manoeuvre characteristics of the ship, and the turn was set in too late. • Pilot should have given his instructions verbally, in order for the master to be able to respond immediately. • Master was too confident of the skills of the pilot, the course and bridge manning were not discussed in advance, insufficient check if his ship had a safe course.	• Collision with pier of bridge.	?
14-2000	**Home (Denmark) – Olda (Norway)**	**Grounding of a Dutch cargo ship sailing in the Skudenes Fjord.**	• **Master feared to be declared unfit for duty because of his alcohol consumption and signed up despite his expired medical certificate.** • **Master had prepared the journey and his watch keeping insufficiently.** • **Sailed on a map that had lapsed and was not updated.** • **Use of alcohol during watch keeping.** • **Master navigated poorly, kept watch in an incompetent way and did not keep a proper lookout.** • **Master fell asleep in his chair on the bridge.**	• **Grounding.**	**2?**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
16-2000	Pohang (Korea) – Kinuura (Japan)	Grounding of a Dutch cargo ship sailing towards Kanmon Fairway.	• The master insufficiently made demands and failed to exert control over the preparation of the journey, watch keeping, navigating and the lookout on the bridge, did not prepare for docking at the next harbor properly and poorly orientated himself navigation wise. • Officer in Charge's navigational orientation was poor and he did not use all available navigational tools, changed course too late, and kept a poor lookout. Therefore the other anchored vessel was spotted too late and the ship was in a difficult position. The Master offered insufficient support regarding navigation, lookout, and using all available tools/aids. • The traffic control's warning that the ship was sailing too much eastward was ignored. • The Master thought that the Officer in Charge was navigating and vice versa.	• Grounding.	3?
18-2000	**Nakskov (Denmark) – Grena (Denmark) - Amsterdam**	**Grounding of a Dutch cargo vessel sailing in Danish waters on a bar.**	**• Crew on board did not meet the requirements (not enough and insufficient qualified crew, no Officer in Charge, Master kept watch for long periods).** **• Master was alone on the bridge (no lookout or navigating officer) and watch alarm was switched off (master was accompanied by his brother who had to keep him awake).** **• Master did not record the ship's positions and times on the map, and did not have a suitable detailed map of the area.** **• Master fell asleep just before running aground (fatigued due to under manning), while the Master's brother was making coffee and having something to eat.**	**• Grounding.** **• After the grounding nobody was informed and the vessel continued its journey while the master knew the vessel was leaking.**	**?**
22-2000	**Fowey (UK?)-Oulo (Finland)**	**Dutch cargo vessel ''Sylvia'' struck the rocks, while sailing on the (English) Channel.**	**• Towards the evening the Officer in Charge received bad news by phone and then drank 2 glasses of whisky and watched some television until the ship departed at 02.00 a.m. with a pilot on board. The Officer in Charge's watch started at 04.00 a.m. The second officer tried to wake him, but did not succeed. When the Officer in Charge appeared he smelled after alcohol and looked tired. The second officer did not like the idea to go below deck, but did not warn**	**• Damage to vessel (€ 150.000,-)**	**?**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			the Master. At 05.00 a.m. the ship stranded well off course against a cliff. When the Master woke up the door to the bridge was closed, but the Master succeeded in opening the door and steered away. The Officer in Charge seemed distracted. Provisional tests indicated that the Officer had been drinking. • **Master did not arrange a lookout because dawn would set in within 30 minutes.**		
26-2000	Kotka - Lissabon	Collision of Dutch cargo vessel sailing in the Golf of Finland with a light buoy after leaving the harbor.	• Poor communication (pilot assumed that meeting vessel would make way, but did not contact the meeting vessel to check it out; Officer assumed that the pilot contacted the meeting vessel and discussed the situation in Finish, while the pilot actually contacted traffic control). • Meeting vessel may have kept not enough starboard and the pilot did not anticipate this situation. He also did not sail according to the recommended routes on the map. • Officer did not recognize the danger of the situation, took a passive attitude towards the pilot, and should have warned the master. • Master should not have left the bridge, did not instruct the Officer, did not station a lookout (sailors were not used as extra lookout because it interfered with their working activities), and had been using alcohol before departure.	• Collision with light buoy	Officer 2 and Master 3?
4-2001	from Houston to Venezuela sailing	Makiri Green grounded near an island while sailing in the Caribian Sea and changing course in coastal waters.	• No proper lookout by night and wrong assessment of the fishing boats. • No lookout and alone on the bridge, while navigating, keeping a proper lookout, and checking positions of fishing boats was too much for one person. Additionally the ship sailed at too high a speed, was not well prepared, sailed too close along lightless islands, and did not use radar properly. He was quite familiar with the route (it seems as if he overestimated his own capacities). • Pilot was only a formality (was on board for a very short period). • It was planned to stay over in the harbor for the night, but the port master told them to leave the harbor as soon as possible.	• Considerable damage to the ship	8/4 at sea 6/6 in the harbour

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			• Crew had to unload and prepare for departure in the evening, while the day before everybody had been working as well. • GPS equipment was rather user-unfriendly. • Lloyds certificate for one-man bridge keeping was present, but the attached conditions were unknown. • Master felt rested. • The Master preferred sailing along the islands during the day. • According to the Master's statement another Officer was not necessary in this situation.		
5 - 2001	Port Kelang - Suez	Nedlloyd Honshu had containers with fireworks at the front of the ship and almost collided with the shore/coast. Master came into action in time and shifted the ship astern, and by doing so touched the side of another ship.	It is questionable weather or not fatigue is an issue here. • The MO3 made a distracted, absent-minded impression and did not take action: - He did not wake the Master (in time). - he did not prepare the arrival. • 3 maritime officers changed watch and the Master occasionally took over watch keeping.	• Damage to the ship. The Master has prevented a disaster.	3
7- 2001	From Finland to Copenhagen (Geulborg)	Grounding at night; blinded by the moonlight	• Master was 68 years old, had not been sailing for 25 years, and had a temporary but expired license to sail. ISM certified shipping company presumably permits this. • By night, no watch alarm and outlook, because he did not think that to be necessary. Did not report to VTS (while this is the procedure). After grounding all procedures were ignored. • Available tools/aids were not used: according to a statement the Master could not handle these tools/aids very well. • According to the Master his view was influenced/dazzled by the moonlight.	• Damage to the ship	3
8 - 2001	From Riga to Sweden	Balticborg grounded into floating ice.	• Voluntary requested a pilot (was sailing this route for the first time and there was ice). Pilot visited the ship for a very short period and came on board later than expected. The pilot had trouble with the ice himself and asked this ship to help him with making a lane. • Darkness, sailors had been busy with making the ship free of ice. • Master previously worked for the inland navigation and did not think a second man on the bridge was necessary. He wanted to	• Damage to the ship.	2

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			spare his crew's strengths for their arrival in the harbor because of the dangerous weather conditions. • Master ignored rules (one man on the bridge and no watch alarm). He complained about too much rules (ship was not yet ISM certified). • Master relied too strongly on the pilot's instructions and this made him lose track of the situation. • Master thought there was enough crew on board and had not handed in a manning plan.		
10 - 2001	From Talinn to Poland near Ronskar	Ice Star ran aground on a familiar route. Normally a pilot is not compulsory on this route, but at that time there was because of work in the harbour, busy/active sailing area near Ronsskar	• The Master thought that the number of crew members (7) was too low, despite the fact this number met the safe manning document. • There always were two navigating officers on board. The crew members enjoyed their work, however work pressure was high. • The ship was ISM certified, which according to the Master results in good rules, but also extra effort. • Crew had been busy all day unloading the ship. There always was one navigating officer on watch (6 hours on 6 hours off). During the loading of the ship they got a problem with a broken bulkhead. As a result they were delayed. Pressure increased because of a next ship. During departure the Master let the first navigating officer go to sleep because he made a fatigued impression and was completely covered with dust from the load. Additionally, within a short period of time the second navigating officer would start his watch. During departure the Master was alone. Looking backwards it would have been better to be accompanied by the first navigating officer during the 15 minutes of departure (according to the Council). • Just before the accident the Master was tense because of a phone call from the harbor agent who told the Master that due to the delay he was no longer welcome in the harbor anymore. The Master was angry about that. Shortly thereafter he oversaw a second buoy due to the blinding sun and grounded.	• Damage to the ship.	2 (at least during unloading and loading in the harbor)

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
7 - 2001			In Indonesia: • Misinterpreted the danger of the rocks. First navigating officer acted uncritically while on watch and the journey was poorly prepared.		?
18-2001	**Drogheda (Ireland) – Kampen (through IJmuiden and Amsterdam)**	**Change of Master in IJmuiden. While sailing from IJmuiden to Kampen collision with the Sumatra quay/wharf in Amsterdam**	• **The Master had been drinking alcohol (0,8 permillage)** • **Four crew members on board instead of five (1 navigating officer short and nobody with an engine room certificate on board)** • **Master was alone on the bridge, no navigating officer nor lookout (the other crew members were having a meal)** • **It is likely that alcohol together with fatigue were the main contributing factors to the grounding.**	• **Strange sailing behavior (problems with lying still at the lock, sailing at the wrong side of the water)** • **Not reporting oneself and not listening to the compulsory frequencies.** • **Collision with the Sumatra quay/wharf in Amsterdam (damage to ship and quay/wharf)**	**?**
19- 2001			5 crew members: Master, navigating officer and 3 workmen. Navigating officer finished his daily activities, and therefore the Master took over the rudder. When a heavy piece of equipment dropped in the engine room, the Master went to take a look. According to the Master he only left for one minute, but he must have left for at least 6 minutes leaving the bridge unmanned. Thereafter they were so close to land that they could not steer away anymore and grounded.	• Grounding	?
22-2001	**Hull - Rotterdam**	**Dutch cargo vessel stranded on the Zuiderdam near the Maasmond (a river mouth) while docking at Rotterdam.**	• **Poor sleep due to a broken relationship.** • **Lack of sleep before standing (in the 10 hours before departure hardly any to no sleep, amongst other things due to noise during loading and unloading and delayed departure due to organizational problems of the harbor authorities/pilot)** • **After first watch use of alcohol to be able to fall asleep (11 hours after consumption 0,998 permillage).** • **Did not use watch alarm (because of daytime), while alone on the bridge.**	• **Master fell asleep on the bridge during his second watch.** • **No lookout and navigation (sailed a straight course through active sailing area using the autopilot).** • **Stranded on the Zuiderdam.**	**2**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
24- 2001	From Rotterdam through Sweden sailing on the North Sea, ran aground at height of Boston, near Great Britain.	Dutch cargo vessel ''Lys Ranger'' grounded because the wrong course was set in the automatic pilot. - Master was working as freelancer for this shipping company. During the change of Masters the replacement Master shortly spoke with his predecessor. - After grounding the Master was discharged from office. In 2000 a medical examiner declared the Master was unfit for this profession.	• Grounded in narrow waters without second watch while second navigating officer was awake. According to the Master there was no time for a lookout on the bridge. The crew had to lash down the load themselves. "Nowadays there usually is no lookout on the bridge at night. The hours are fitted to the regulations afterwards. " • Experienced crew. However, due to the work pressure during the journey they did not have time for certain administrative tasks (sign on, recording work and resting times). Docked at a lot of harbors/ports and worked many hours (not more than laying down on the couch for an hour every now and then) . Second navigating officer had been working for 16 hours, and the Master as well. That morning they slept well. • Did not use the available tools/aids, such as the watch alarm. • Master told he previously had fallen in his cabin and therefore was dizzy/had a headache. Master has had drinking problems before. • Master did not inform anyone after the grounding (Master complained a lot, but had a passive attitude).	• Damage to the ship due to the grounding	2
5-2002	**From Aberdeen on its way to Norway, north-east of Kristiansund (in fjord)**	**Dutch cargo ship ''Frisiana'' struck the rocks, because the Master had fallen asleep during his watch.**	• **After working 9,5 hours (enter fjord, loading/unloading, leave fjord at night) fell asleep.** • **Recently 4 people on board. Even though it was possible (and customary) to set a sailor on watch the Master did not do that. The Master let them rest/sleep after the busy loading and unloading.** • **The Master was the only one on board who was exempted from sailing with a pilot. Therefore he continued watch keeping on the bridge himself. Fifteen minutes after the accident the Master would hand over the watch to the navigating officer.** • **The Master has sailed this track before and does not find it difficult (possibly overestimation of himself?)** • **The (compulsory) Norwegian maps were not up to date.** • **Besides the 'normal time pressure' there was extra time**	• **The ''Frisiana'' struck the rocks, because the Master had fallen asleep on the bridge.** • **Material damage. After grounding the Master acted in a proper way.**	**2**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
			pressure due to the bad weather forecast. • **According to the report there was no relationship between number of crew members and the grounding.** • **Watch alarm partly worked; it buzzed, but did not give a general alarm after not responding for one minute.** • **The collision presumably occurred at a moment the Master thought he could lean back, because the situation became orderly and the change of the watch was expected.** • **Late at night is an extra risk.** • **During the day you do not need an extra watch when the watch alarm is switched on and the weather is good, but that does not apply at night (misinterpretation of the rules).** • **It is social minded to let the sailors sleep, because of the hard work on deck earlier that day.**		
6 – 2002	On its way from Finland to Bremen (Germany) ran aground in the Drogden Channel nearby Copenhagen (Denmark).	Grounding of the “Inger” sailing on a straightforward channel at dawn with 10 crew members on board.	Fatigue was not mentioned as a cause, but the shift system was: • In the morning the Master was steering the ship manually while sailing on a straightforward channel with poor weather conditions and without the mandatory second lookout. The Master should not be steering himself (good opportunity for another workman to keep up his sailing ability). By steering himself he was limited in his actions, for example he could not have a proper look at the map and check the ship’s position. At the time the Master switched to the automatic pilot the vessel ran aground. • After changing to the automatic pilot one could theoretically do with one person on the bridge. Given the poor view and the nature of the waters it would have been wise of the Master to be on the bridge with two people (the Master and the first navigating officer). In short: no proper lookout and overseeing a red buoy. • According to the Council: Poor conscientious navigation (route in the map was outlined unnecessarily close to the waterside) with only a few other tools and aids available, while it was known that the ship was more difficult to steer in shallow waters. Furthermore, the journey was poorly prepared.	• Two leaking tanks due to the grounding.	?

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
14- 2002	Singapore waterway	Collision in a busy waterway Singapore of Volvox Delta with Hikari II	Fatigue was not mentioned, but shift system was: • Theoretically the bridge was manned by 4 crew members: the Officer in Charge, the second officer, a workman and a trainee. At the time of the accident the Officer in Charge was alone, while the second officer and the trainee were on their way to the beacon. The workman was on the bridge but, but was not involved/called in navigating the ship. They did not comply with the rules regarding bridge manning at night. The Officer in Charge was steering himself and therefore was not able to safely navigate the ship. The Master had gone to sleep and was not warned in time. The Officer in Charge should not have been steering himself and should have relied more on the Master. • According tot the Council: A proper navigation, keeping track of other ships, keeping a proper lookout, communicate with traffic control and other vessels, maneuvering the ship and steering in these waters are too many tasks for one person, even for a very experienced person. In the Singapore waters it is very busy with other ships and the navigation also asks for proper attention.	• Collision, damage to the ship and confused Master.	The chief and second officer 8 hours on/ 8 hours off duty
10 - 2002	**Cargo vessel ''Bernice'', sailing from Belfast to Liverpool. Grounded at Belfast Lough at the level of Grey Point (Northern Ireland).**	**• Left Belfast without a pilot on board. The vessel was not obligated to sail with a pilot on board. • Master was familiar with the water. He was not put under pressure by the owner of the ship to sail without a pilot. • Master was on the bridge and another crew member was in the engine room. • Automatic pilot. • Well equipped /no alcohol or other stimulant drugs.**	**• Direct cause: Failure of tuning the radar with a special technique (the Master was seen as an expert on this area). • Master had been on sickness leave because of previous grounding due to fatigue (mental health complaints). At the moment the Master had returned to work, but he still felt very tired. • Master intended to stick to the rules after the previous accident, but the shipping company confronted him with an officer who was not in the possession of the necessary qualifications. The Master was worrying about it. • The Master was alone on the bridge during departure. Master felt fatigued due to extra activities but there was no other Master to take his turn, which made sailing for a long period of time necessary. • Master advised the shipping company not to make the jour-**	**• Material damage (ship was making water) • Master got overstrained (again).**	**?**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
		• **All necessary equipment was set and was functioning properly. The echo sounder and watch alarm were not set.** • **Weather was unstable with regular showers, and therefore the view varied.** • **The vessel was calm.** • **There were 2 radars on board; one was functioning fine and the other one was functioning less. During the showers the radar picture became less sharp.** • **Before the accident they had a few breakdowns (fuses had gone, causing the radar to break down).**	**ney with him as Master because of his fatigue. Besides he did not get over his previous grounding in Denmark yet. However, the shipping company talked the Master into it in a way that he felt he was forced to make the journey anyway.** • **Master did not mark the route in the map in a way to prepare the journey because he knew the area very well.** • **Watch alarm was not set.** • **After departure it was not possible to have a second lookout on the bridge. All crew members were heavily loaded and the Master thought they should go to sleep. The navigating officer had been on deck all day.** **According to the Inspectorate:** **Grounding could have been prevented if the Master:** • **Kept a better lookout;** • **Navigated in a better and safer way;** • **Prepared his journey according to the rules;** • **Realized that routine work could lead to dangerous situations.**		
18-2002	Eems-Dollard	Vessel on the wrong side of the water.	• No communication between vessels due to different communication systems (simplex/semi-simplex).	• Collision between two vessels.	?
21-2002	East Chinese Sea	Container ship sailing at high speed collides with small fishing vessel on rough/choppy sea.	• Poor lookout.	• Container ship collided with a fishing vessel.	3
1-2003	Dover Strait	Ferry crosses a sea way out of the vertical, but approached from starboard site with respect to the fishing vessel (not fishing).	• Uncertainty about the ferry's plans/intentions. • Fishing vessel did not follow the rules regarding giving way/sheer away.	• Ferry collided with fishing vessel.	?
2-2003	Baltic Sea	Train of boats with restricted /limited freedom of movement crosses a cargo ship while view is good.	• Rather passive navigation by the navigating officer of the cargo ship.	• Cargo ship collided with a train of boats.	3

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
3-2003	Westerschelde	Three meeting vessels in narrow waters, of which one overtaking vessel.	• Pilot does not navigate in a safe manner and turns sail too late.	• Collision with meeting vessel and vessel that had overtaken.	?
7-2003	Japan	Bad weather, fishing vessels were hardly visible.	• No proper lookout.	• Collision of merchant ship with fishing vessel.	3
9-2003	Drogheda (Ire-land)	Vessel left a shallow harbour by night.	• Master had a passive attitude towards the pilot (who was steer-ing the vessel) and therefore navigation was poor.	• Grounding	3
13-2003	New Waterway	Overtaking vessel collides with vessel that had overtaken.	• Poor situational awareness. • Poor communication.	• Collision.	?
12-2003	Dover Strait	Overtaking vessel collides with vessel that had overtaken.	• No lookout. • Poor situational awareness.	• Vessel sank.	2
15-2003	North Sea	Vessels crossing each other's course, while being in each other's view.	• Navigating officer was not assertive towards Master. • Did not act according to the rules on how to avoid collisions.	• Collision.	3
16-2003	Poland	Cargo ship approaches a harbor with many anchored ships.	• No lookout despite bad weather conditions. • No situational awareness / sense of urgency • Doing other tasks besides watch keeping. • Did not continue to navigate safely.	• Cargo ship collided with an anchored vessel.	?
1-2004	Strait of Singa-pore	Navy vessel is having a military exercise, but does not follow the rules and makes unexpected maneuvers.	• Unexpected maneuvers by the navy vessel. • Container ship does not do everything possible to avoid a colli-sion.	• Collision of navy vessel with container ship.	3
4-2004	Banda Sea/ In-donesia	Ship sailing in quiet waters has to pass one island. Navigating offi-cer navigated passively.	• Rather passive navigation by the navigating officer. • No directions from Master	• Grounded while passing an island.	3
5-2004	**The Bay of Bis-cay**	**Ship in transit through fishing area. Only one navigating offi-cer on board. High pressure placed on crew members due to an audit for the shipping company being at hand.**	• **No proper lookout by the Master who was doing some ad-ministrative tasks.** • **Ship sails in accordance with the manning certificate, how-ever seems undermanned (work pressure).**	• **Collision with fishing vessel.**	**2**

Casenr	Trajectory	Situation	Causes	Consequences	2 or 3 shift system
7-2004	South Korea	Ship leaves its anchored position.	• Pilot only communicates in Korean language with other vessels and traffic control, and therefore the Master can not get a grip on the situation (no situational awareness). • Master does press/urge the pilot to communicate in English.	• Collision with vessel that suddenly appeared from behind the other anchored vessels.	?
9-2004	North Sea	Fishing vessels were sailing straight following each other. The first fishing vessel reduced speed in order to put out its fishing gear.	• Poor outlook/situational awareness of both vessels and therefore not aware of the fact that they were sailing so close at each other and no awareness that the first ship reduced speed.	• Collision with the first vessel.	?
11-2004	**North Sea**	**Two crossing ships with clear view / good weather.**	• **Passive and indifferent way of watch keeping.** • **No lookout on the bridge because of rest crew members.** • **Master stood watch for 7 hours already.**	• **Collision**	**?**
2-2005	**China**	**Leaving vessel on a busy river with a Chinese pilot.**	• **Master completely trusts the Chinese pilot – who is not keeping a proper lookout – and is doing administrative tasks.** • **High workload for Master due to pressure from port authorities and shipping agents/charters**	• **Collision with Chinese fishing vessel that suddenly crosses in front of the bow.**	**?**
6-2005	Turkey	Simple sailing towards the harbor.	• Very passive way of navigation.	• Grounding	3
8-2005	North Sea	Fishing vessel is fishing in the traffic separation system, by doing that it hampers the other ships.	• No knowledge regarding fishing in traffic separation system • Poor lookout / situational awareness • Merchant ship also has a poor lookout and takes insufficient measures to prevent the collision.	• Collision of merchant ship with fishing vessel.	?

seafarers in the industry. As shipping has become. increasingly intensive, with smaller. crews and shorter time in port, seafarers can be working long and irregular hours. There are many reasons why they can be short of sleep, which could include the noise and vibration on the ship and the number of port calls and cargo handling operations.Â P&I incident reports frequently make a causal connection between fatigue in the individual involved in the accident and the events leading up to the accident. Fatigue management needs to be high on the agenda of everyone involved in the adventure. For the seafarer, it means being able to identify the causes of fatigue and to work towards taking appropriate and early measures to prevent it. â€œShipping is perhaps the most international of all the world's great industries, and also one of the most dangerousâ€ (International Maritime Organisations [IMO], 2011). A range of approaches have been introduced to enhance maritime transport safety, such as developing new methods of transportation, introducing numerous technical innovations, increasing traffic surveillance and control, etc.Â In the maritime Industry many factors are present which may cause work related fatigue. For example, it is suggested that long and unsociable working hours, lack of training, poor communication between office staff and sea personnel, job insecurity, and physical health problems may all cause work related fatigue. Fatigue has negative impacts on the general working population as well as on seafarers. In order to study seafarersâ€™ fatigue, a questionnaire-base survey was conducted to gain information about potential risk factors for fatigue and construct indexes indicating fatigue. The study applies T-test to compare strata of seafarers to analyse work and sleep patterns in global seafaring. Qualitative analysis are also employed to explore the impacts of fatigue on seafarerâ€™s occupational health and safety.Â Smith, A.P., Lane, T. and Bloor, M. (2001) Fatigue Offshore: A Comparison of Offshore Oil Support Shipping and the Offshore Oil Industry. Seafarers International Research Centre (SIRC)/Centre for Occupational and Health Psychology, Cardiff University, Cardiff. [10].

Fatigue-induced human errors have been identified as major contributing factors in most maritime accidents. This paper attempts to explore an approach to evaluate the degree of seafarersâ€™ fatigue and to propose some suggestions on fatigue prevention and management.Â The complexity and difficulty posed by the fatigue issue today in the shipping industry reveal the need for further research. Considering also the permanent effect and the potential hazard that fatigue factors are posing to seafarers, additional studies need to be undertaken in order to find more effective solutions to the problem. The cause - fatigue. None of the three crew members on the bridge had been allowed to take their mandatory six hours off duty before their next 12-hour shift for many weeks. Despite the inevitable findings, reduced staffing is one of the most widely used methods of reducing crewing costs and raising efficiency.Â A Guide to the Human Element by the UK MCA Human Behaviour in the Shipping Industry: Risk Taking The Human Element in Shipping: Making Mistakes. Like This. Tweet.