~Case Studies and Accident Analysis~

JTSB Digests

JTSB (Japan Transport Safety Board) DIGESTS

No. 40 (Issued in February 2023)

Digest of Marine Accident Analyses

For Prevention of Accidents Caused by Dozing Watchkeepers on Cargo ships and Tankers

1. Preface

40% of annual accidents occur in March and April

Dozing at navigations with neglect of watchkeeping is likely to immediately lead to dangerous marine accidents such as grounding and collisions, which, once they occur, can lead to serious accidents that can cause damage to coastal areas due to oil spills from cargo ships and tankers.

Of the accidents for which the Japan Transport Safety Board (JTSB) published accident investigation reports during the five years from January 2018 to December 2022, 45 accidents (at 45 vessels) were caused by operators dozing on cargo ships and tankers. Nine accidents (20%) occurred in April, the highest, followed by 8 (18%) in March, with both months alone accounting for approximately 40% of the annual total. (See Figure 1)

For preventing marine accidents caused by dozing on cargo ships and tankers in early spring, this digest summarises the 45 accidents (45 vessels) with their case studies and pointers for marine accident prevention.

The change of season can cause fatigue. Prominent are accidents related to the drowsiness caused by work-related fatigue.

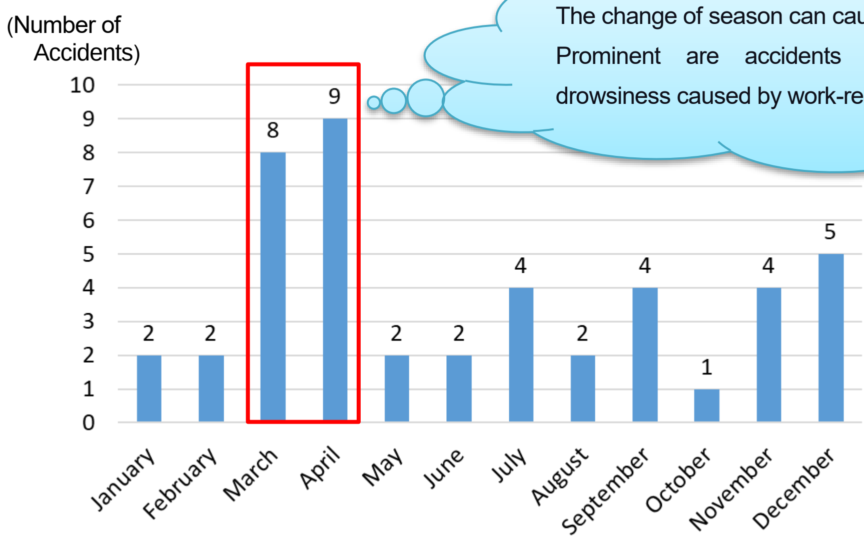


Figure 1. Accidents by month

2. Statistics on accidents caused by dozing

By accident type

By accident type, 35 (78%), or approximately 80%, were grounding, followed by 9 (20%) collisions between vessels and 1 (2%) contact with a breakwater. (See Figure 2)

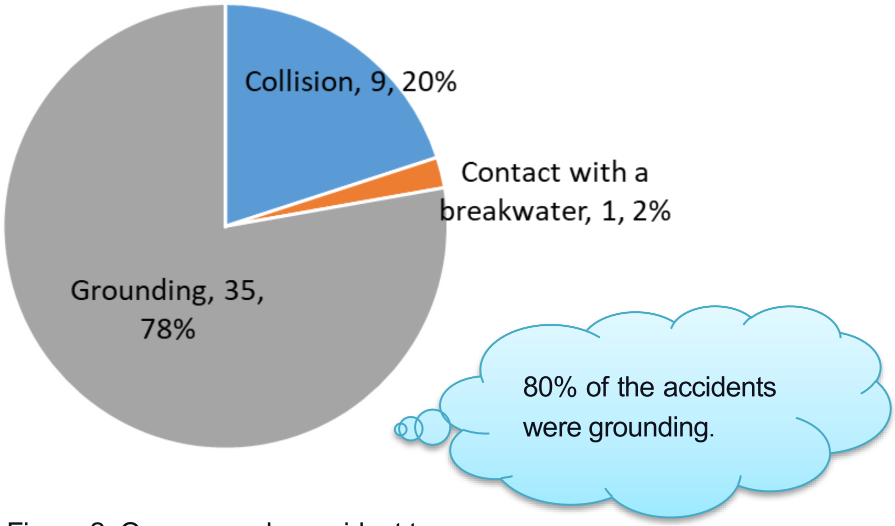


Figure 2. Occurrence by accident type

By vessel type and the gross tonnage

By vessel type, 38 (84%), or more than 80%, were cargo ships. (See Figure 3)

By gross tonnage, 28 vessels (62%), or more than 60%, were between 200 and 500 tons, followed by 11 vessels (25%) between 100 and 200 tons and 6 vessels (14%) between 500 and 1600 tons. (See Figure 4)

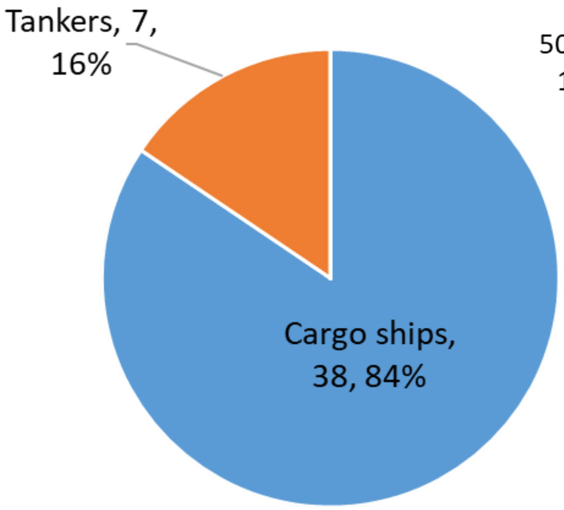


Figure 3. Occurrence by vessel type

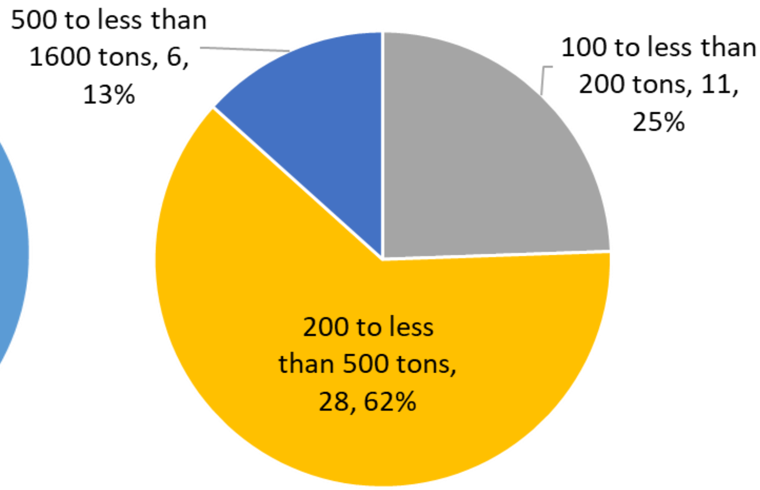
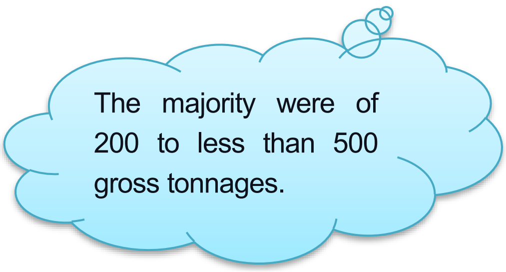


Figure 4. Occurrence by gross tonnage



By area

By area, 25 (56%), or approximately 60%, were accidents in the Seto Inland Sea and around (Osaka Bay to the Kanmon Strait), followed by 6 (13%) in the central part of the south coast of Honshu (Tokyo Bay to the coast of Wakayama Prefecture) and 4 (9%) in the north and west coast of Kyushu (northern coast of Fukuoka Prefecture to western coast of Kagoshima Prefecture). (See Figure 5)

The "Japan-Marine Accident Risk and Safety Information System (J-MARISIS)" developed by JTSB in its Seto Inland Sea area shows four groundings near Kudako Island, Matsuyama City, indicating many groundings in the vicinity of the narrow waterway. (See Figure 6)

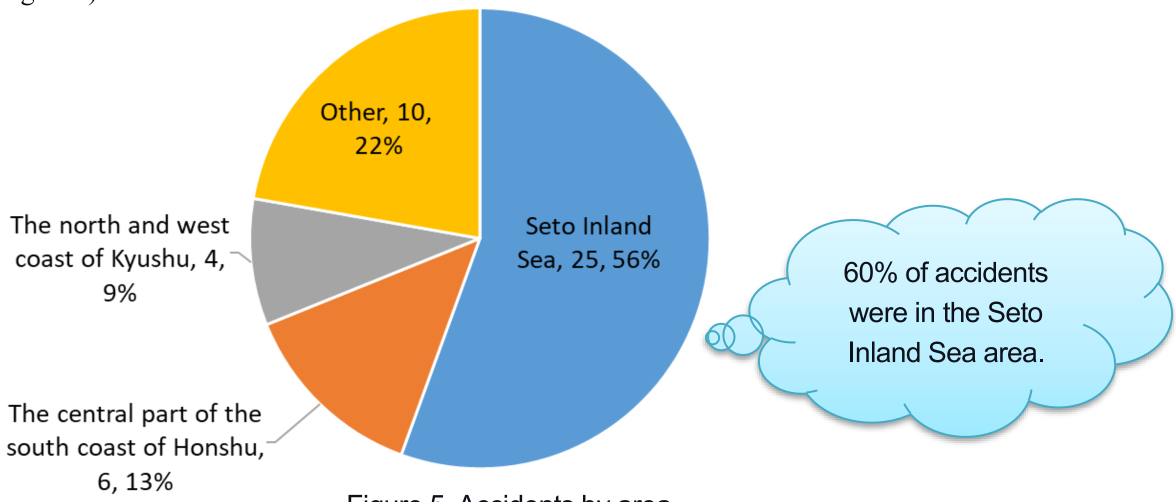


Figure 5. Accidents by area

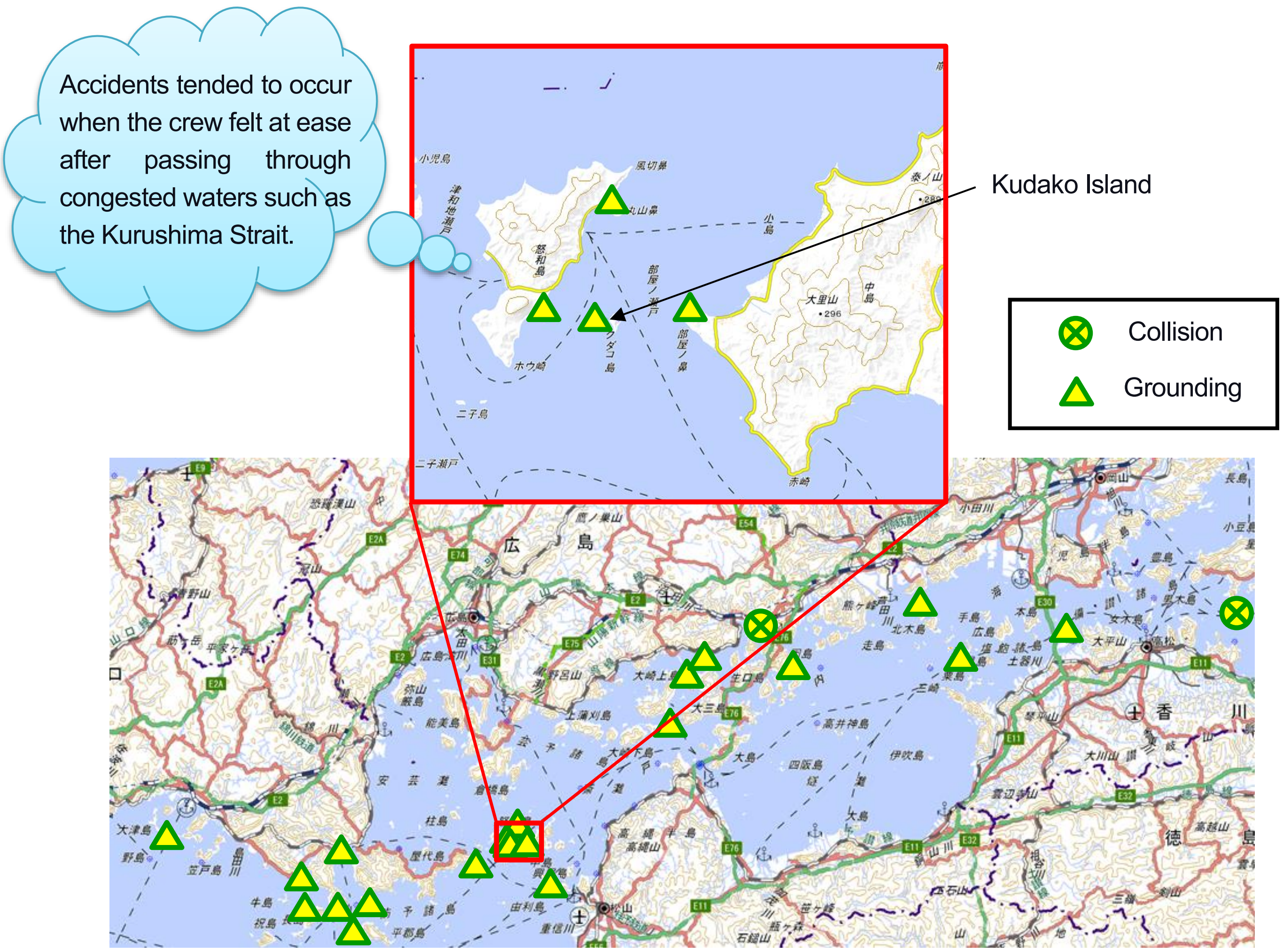


Figure 6. Accidents recorded in the J-MARISIS

By time range

By time range of the day, the highest number of accidents is 7 (16%) between 2 and 3 a.m., followed by 6 (13%) between 9 and 10 p.m., and 39 (87%, approximately 90%) between 9 p.m. and 5 a.m. (See Figure 7)

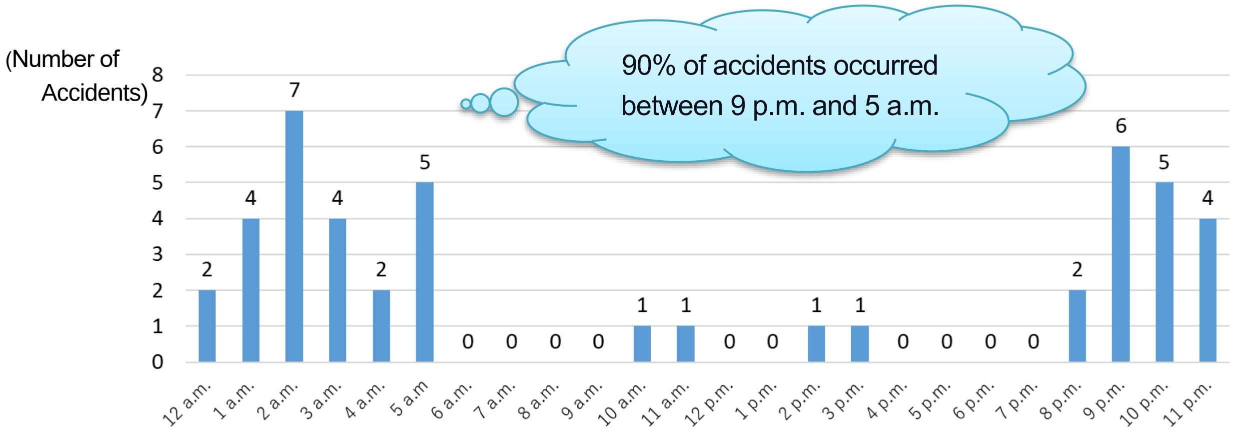


Figure 7. Accidents by time range of the day

By the number of crew members and bridge watchkeepers

By the number of crew members, the highest occurrence was at 14 vessels (31%) with four crew members, followed by 11 vessels (24%) with five crew members, and 43 vessels (96%) with three to six crew members. (See Figure 8)

By the number of bridge watchkeepers, 43 vessels (96%) were with one watchkeeper, followed by two vessels (4%) with two watchkeepers.

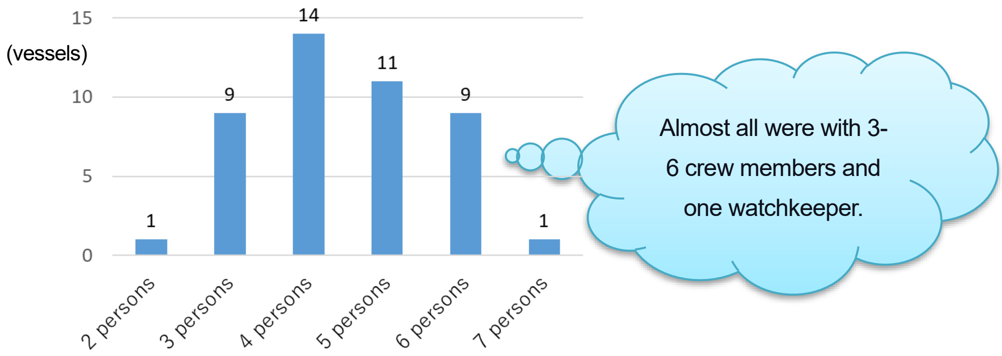
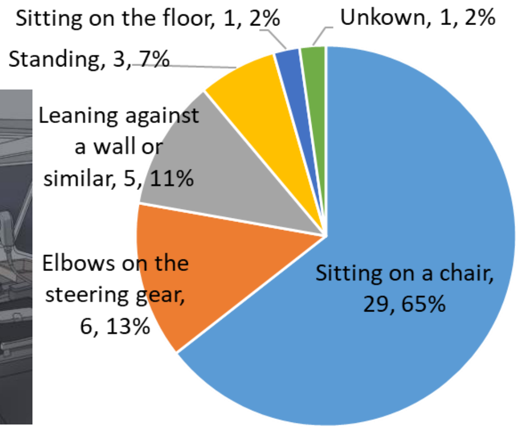


Figure 8. Vessels by number of crew members

By watchkeeper posture and autopilot use

By bridge watchkeeper posture, 29 vessels (65%), or approximately 70%, were with the watchkeepers on their chair, followed by six vessels (13%) with their elbows on the steering gear, and five vessels (11%) leaning against a wall or similar. (See Figure 9)

As for the autopilot, 43 vessels (96%) deployed it.



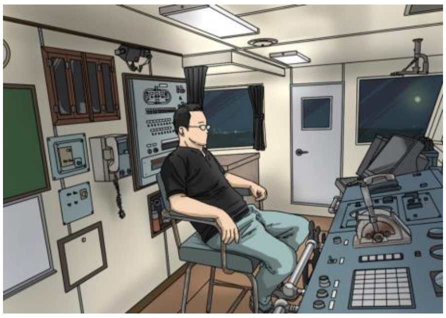


Figure 9. Vessels by bridge watchkeeper posture

By use of the Bridge Navigational Watch Alarm System

40 of the 45 vessels were equipped with the Bridge Navigational Watch Alarm System (BNWAS) as of the accident. These 40 vessels, 34 (85%) had their BNWAS activated, and 6 (15%) did not, such as having turned them off. (See Figure 10)

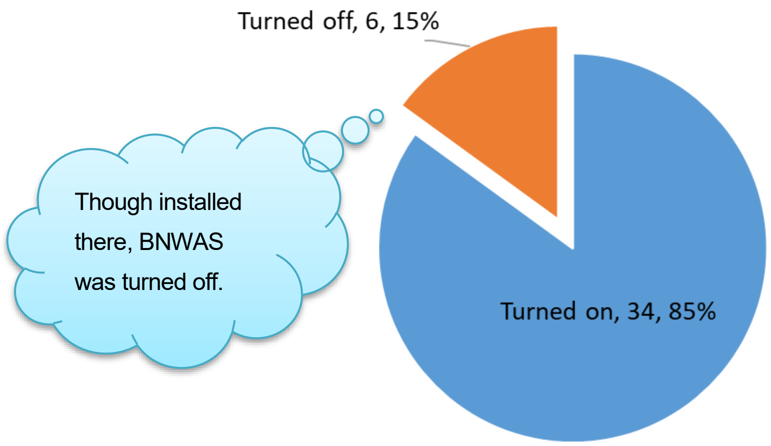


Figure 10. Vessels by BNWAS activation

BNWAS installation became mandatory in 2011 for vessels, including non-international coastal trading vessels of less than 500 gross tonnages.

(Details on the mandatory installation of BNWAS: article from the JTSB Newsletter, released in July 2011).
https://www.mlit.go.jp/jtsb/bunseki-kankoubutu/jtsbnewsletter/jtsbnewsletter_No11/No11_pdf/jtsbnl-11_02.pdf

At 33 out of the 34 vessels that had activated their BNWAS, the alarm did not work.

As for possible reasons for the alarm not working, at the 16 vessels (48%), or almost half of the total, the sensors could have misinterpreted the operator's body movements as regular movement, even though dozing (e.g. the case study on page 6). On the other hand, the operator dozed at 9 vessels (27%), and the accident occurred in less than the set time (the alarm inactivation time) (e.g. the case on page 7). (See figure 11)

Of those that may not have passed the set time (the alarm inactivation time), 4 vessels had the time (the alarm inactivation time) set to be more than 10 minutes.

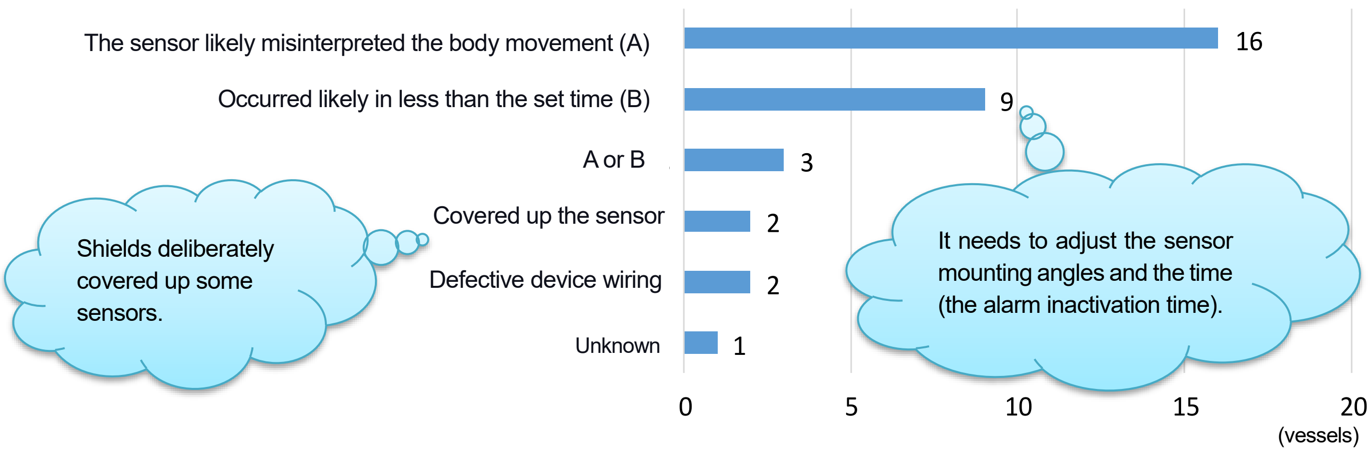
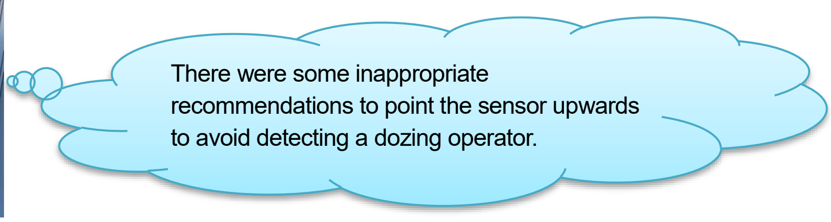


Figure 11. Reasons why the alarm did not work



3. Case studies of accidents caused by dozing

1. A case where BNWAS detected the operator's body movements though dozing, so the alarm did not work

Summary: A cargo ship (Vessel A, 9,589 tons, 18 crew members) was drifting at anchor, and a cargo ship (Vessel B, 498 tons, 5 crew members) was heading east-northeast when Vessel B collided with Vessel A. Vessel A suffered a gash in the port aft hull, while Vessel B suffered a crushing injury to her bow. Both sustained no casualties.

The course of the accident

March, 10 a.m. range

Vessel A

Officer A noticed by radar that Vessel B moving east-northeastwards, was approaching Vessel A.

Officer A questioned that Vessel B was approaching approximately 1.5 miles without changing course, so he sounded ship's whistle and called Vessel B on the VHF.

Master A sounded ship's whistle continuously and called Vessel B on the VHF, but there was no response from Vessel B.

Vessel B

Master B alone was on bridge watchkeeping duty under autopilot, heading east-northeastwards, he was on visual watch as there were just a few vessels around, and visibility was good.

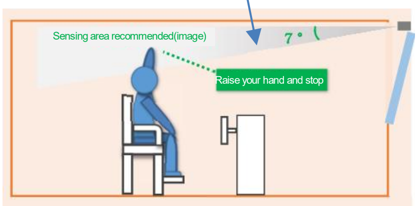
Master B was sitting on his chair and continuing to navigate when he dozed.

Master B heard the whistle and looked up to see Vessel A at close quarters on the starboard bow, and sensing the danger of a collision, he operated to move backwards at full speed.

The bow of Vessel B collided with the port aft hull of Vessel A.

- At the time of the accident, in addition to his duties as a master, Master B was also engaged in operational management and other responsibilities for Company B (owner and operator of Vessel B). Although he took intermittent leave, Company B could not find a replacement for the master's position, and **fatigue had built up in him after being on board for an extended period**.
- BNWAS is designed to raise the alarm if the person on duty shows **no movement for a specific time** and to have the person stop the alarm with his hand.
- The alarm did not work because **the sensors pointed downwards from the manufacturer's recommended position** and **detected the body and foot movements of Master B, who dozed**.

Position and angle at which the person cannot stop the alarm without raising a hand



Sensing area recommended by the manufacturer.

Probable causes: It is probable that Master B dozed because **he was fatigued from being on board for an extended period, there were few vessels around, he was on duty in his chair with autopilot,** and his alertness level was likely low, **having believed the alarm would work if he dozed.**

It is likely that **BNWAS did not likely raise the alarm because the sensor pointed lower than the manufacturer's recommended position and detected the body and leg movements of Master B, who dozed.**

Safety Actions (measures to prevent accidents)

- Operators should **have crew members take leaves at appropriate intervals** to let them perform their bridge watchkeeping duty properly and in good condition and **instruct them to get out of their chairs and into the open air to dispel any drowsiness** if they feel drowsy while on duty**.**
- Shipowners, masters and bridge watchkeepers of vessels equipped with a BNWAS **should not overconfidently depend on the system, endeavour to prevent sleep operation, thoroughly check the system working at departure and under sail, adjust the sensor conditions such as its mounting angle, and set the time (the alarm inactivation time) to be short as possible**.

The investigation report on this case is published on the JTSB website. (Published on March 28, 2019)
https://www.mlit.go.jp/jtsb/ship/rep-acci/2019/MA2019-3-2_2018tk0019.pdf

2. A case where the alarm did not work because of dozing in less than the set time (the alarm inactivation time)

Summary: The tanker (299 tons, 4 crew members) heading east-southeast in the night got aground on a reef. The vessel sustained cracks and dented damage to the hull planking, with no casualties.

The course of the accident

March, 10 p.m. range

The vessel was sailing towards the east-southeast by autopilot with the master alone on bridge watchkeeping.

The master was on watch with both elbows on the steering gear and felt sleepy, but thought he would not doze as he would have the vessel veer shortly, so he continued in the same position and, at some point, dozed.

The vessel went past the planned veering point and grounded on a nearby reef.

On the day of the accident, the master woke up at around 4:30 am and was then on duty for loading, unloading and bridge duty, and after those duties, he did the paperwork and other tasks, **which led to a lack of sleep and fatigue**. And having seen off a vessel on the opposite lane at the left, he **became relaxed as he saw no other vessels around** and dozed.

The vessel was equipped with **BNWAS set to raise the alarm at no movement of the bridge watchkeeper for 7 minutes, though, at the accident, the alarm did not work because he dozed in less than 7 minutes**, and the accident occurred before the set time.

Having experienced the accident, they **changed to set the time (the alarm inactivation time) at the BNWAS to 3 minutes**.

Probable causes: It is probable that the vessel grounded at night because the master dozed, the vessel went past the planned veering point and continued to be navigated towards a nearby reef.

Safety Actions (measures to prevent accidents)

- If the bridge watchkeeper feel drowsy while on watch duty alone, **move your body and open the windows to expose yourself to the air** to prevent dozing.
- Shipowners, masters, and bridge watchkeepers need to check and monitor the BNWAS and **have the time (the alarm inactivation time) short as possible**.

The investigation report on this case is published on the JTSB website. (Published on November 26 2020)
https://www.mlit.go.jp/jtsb/ship/rep-acci/2020/keibi2020-10-32_2020hs0056.pdf

Colum

Inattention is a consequence, not a cause:

Chronic sleep deprivation situations don't prevent dozing!

Concerning the theme of "accidents caused by dozing", we appreciate having given contributions from Tomohide Kubo, Shun Matsumoto, Hiroki Ikeda and Yuki Nishimura of the Field Intervention Team, Research Center for Overwork-Related Disorders, National Institute of Occupational Safety and Health, Japan.

Some readers may believe that dozing is due to "not paying enough attention' or 'laziness". You may even hear managers or supervisors giving such guidance. However, this needs to be corrected. Dozing is a physiological phenomenon bound to occur, incredibly when sleep is chronically challenging to come by on the job. When we lack sleep, our brain spontaneously tries to preserve its function by dozing.

Figure 1 shows the results of the Psychomotor Vigilance Task (PVT test), a nationally and internationally renowned test for sleepiness. The test lasts 10 minutes each time. It is a simple reaction time test in which the subject is required to press a button as soon as possible to stop the digital counter on the display when it starts counting. However, as you never know when the digital counter will start counting, you are required to keep your eyes on the display at all times. This makes it very tedious and drowsy, but because it is a simple test, it is used nationally and internationally as a very high indicator of sensitivity to drowsiness. Figure 1 shows the elapsed time of the 10-minute test on the horizontal axis and the reaction time when the test subject can stop the button on the vertical axis. In this way, the subject can press the button and stop at a constant speed for 10 minutes when he is not tired, whereas when he is tired or sleep deprived, there is a more significant variation in pressing the button earlier or later for the same 10-minute test time.

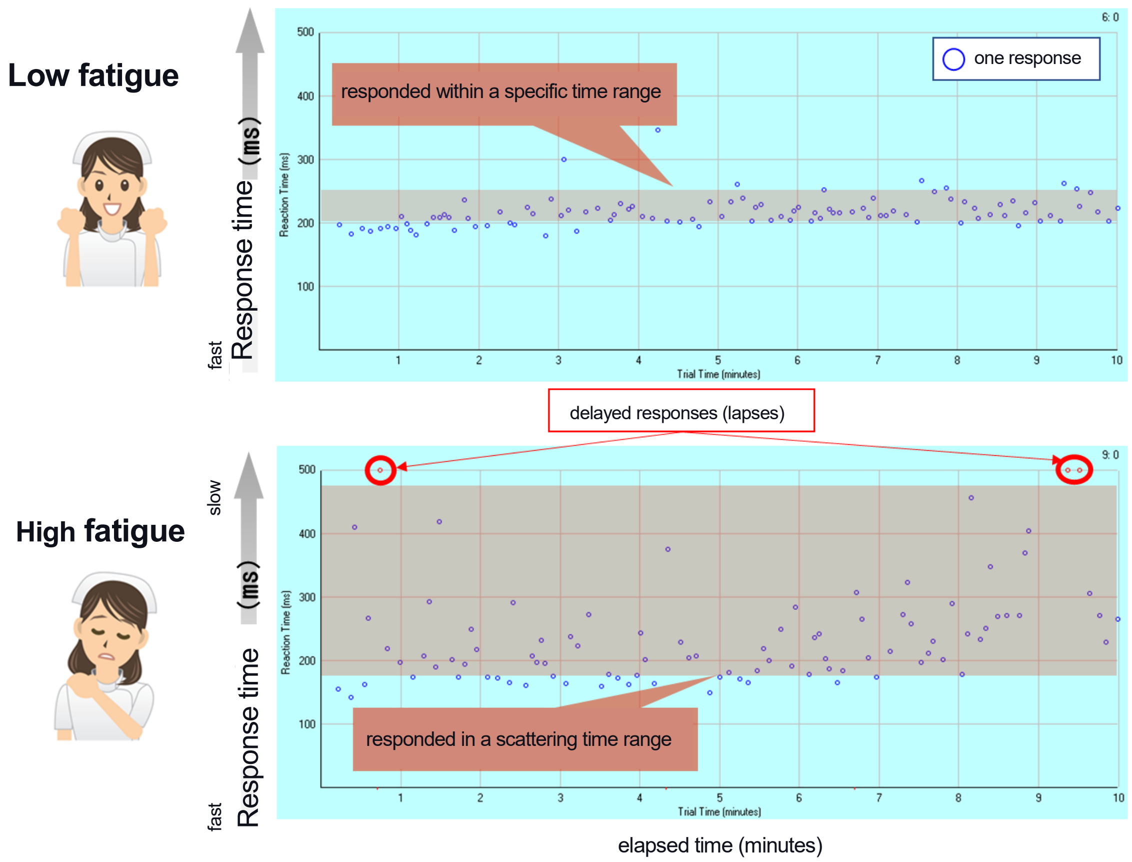
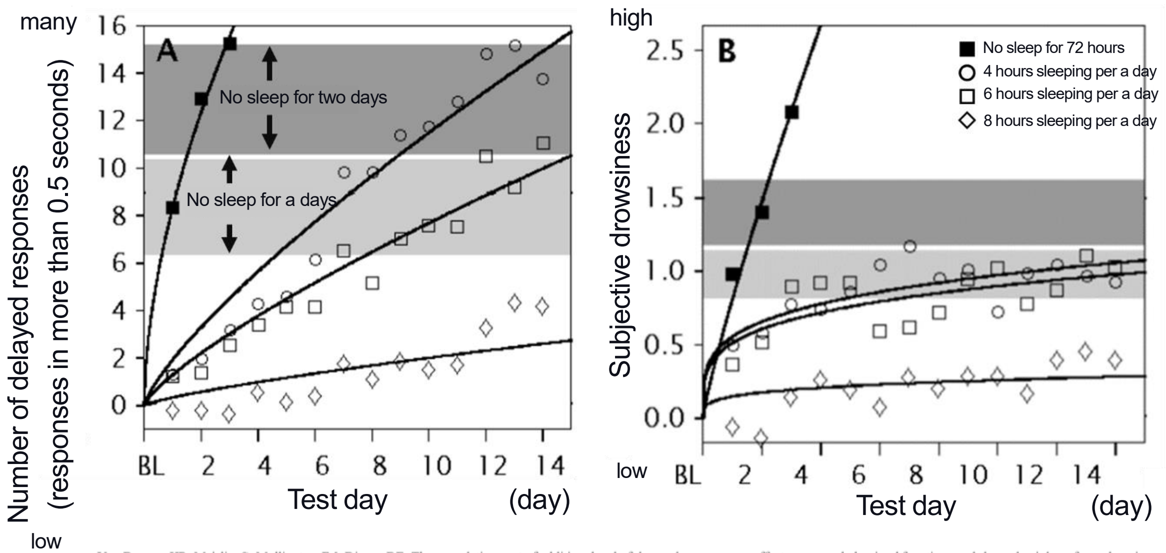


Figure 1 Results of the reaction time testing task (Psychomotor Vigilance Task)

As these results show, when we become tired, our brain functions are less able to maintain constant attention. In addition, button presses after more than 0.5 s are called delayed responses (lapses), indicators of momentary dozing; the delayed response circled in red in Figure 1 appeared three times in ten minutes. It shows that we cannot control the onset of dozing by our willpower alone, especially in sleep-deprived situations.



Van Dongen HP, Maislin G, Mullington JM, Dinges DF. The cumulative cost of additional wakefulness: dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. Sleep. 2003 Mar 15;26(2):117-26. doi: 10.1093/sleep/26.2.117. Erratum in: Sleep. 2004 Jun 15;27(4):600. PMID: 12683469.

Figure 2. Chronic sleep deprivation and poor performance

Figure 2 shows the results of an experiment using this PVT test, which clearly illustrates the frightening of chronic sleep deprivation. In addition to staying up all night for three days (72 hours), there were four conditions of sleeping, four hours a day, six hours a day and eight hours a day for 14 days, with several dozen subjects participating in each experimental condition. The left chart shows the results of the PVT test, and the right graph shows the results of subjective drowsiness, with higher values on the vertical axis indicating poorer performance respectively.

First, the results of the PVT test on the left graph show that the average number of delayed responses when a person stayed up all night a day is about eight, the same as when a person slept 4 hours a week. And as well the average number is 11 when a person stayed up all night for two days, the same as when a person slept 4 hours for ten days. This result shows that if you didn't get enough sleep, you would eventually stay at the same level of attention as if you had stayed up all night. Even more frightening is the interpretation when compared to subjective sleepiness. The objective test, the PVT test, shows that the maximum performance level is equivalent to those who stayed up all night for two days, while subjective drowsiness does not reach the level of those who stayed up all night for two days, even after getting repeated short sleep periods. In other words, when people are chronically sleep deprived, even if they think they are not sleepy, their work performance is at the same poor level as if they had stayed up all night. The lesson learned from this is that you cannot ignore the effects of chronic sleep deprivation in industries where a single mistake can lead to fatal accidents or injuries.

Therefore, managers and supervisors should be aware that the prehistoric occupational health and safety management theory, "the carelessness of the worker causes accidents!" can never prevent accidents caused by dozing. Inattention is not a cause but a consequence. If employees are to do their duty on work shifts that do not allow them to get enough sleep, dozing will occur as a human physiological phenomenon, depending on the individual.

The most important message from us to the readers in this column is that the first and foremost step to prevent accidents caused by dozing is not to rely on the efforts and perseverance of individual workers, but to review the way they work, focusing on the arrangement of breaks and days off.

4. Summary (Conclusion)

There are the following characteristics found in marine accidents caused by dozing at cargo ships and tankers:

- **40% of accidents occurred in March and April,** and **90% occurred between 9 p.m. and 5 a.m**.
- **80% of accidents were of grounding**; **60% were of 200-500 tons**.
- **60% of accidents occurred around the Seto Inland Sea**, with many **grounding accidents near the narrow waterway**.
- **Almost all accidents were of vessels with 3 to 6 crew members with just one bridge watchkeeper**.
- **70% of the accidents were of the bridge watchkeeper sitting in a chair; almost all were using autopilot.**

Concerning the use of the Bridge Navigational Watch Alarm System (BNWAS):

- **20% of the vessels had the equipment but had it inactive**.
- Of those in which the alarm did not work, **in half of the cases, the sensor likely detected the operator's body movements,** even dozing: **In 30% of accidents, the operator likely dozed at the accidents in less than the set time (the alarm inactivation time).**

Based on the case studies of accidents investigated, the followings are crucial for accident prevention:

- Operators should **grant leave at appropriate intervals** so crew members can adequately carry out their bridge watchkeeping duties.
- Shipowners, masters and bridge watchkeepers of vessels equipped with BNWAS should **thoroughly check the system working at departure and under sail, adjust the sensor conditions such as its mounting angle, and set the time (the alarm inactivation time) to be short as possible**.
- If the bridge watchkeeper feel drowsy while on watch duty alone, **move your body and open the windows to expose yourself to the air** to prevent dozing.

A word from Director of the Analysis, Recommendation and Opinion Office

As the saying goes, "In spring, one sleeps a sleep that knows no dawn", and as the weather gets warmer in spring, we find that accidents caused by dozing also increase. In addition, some hay fever medications can also cause drowsiness, so those taking them should be careful.

Even if you have the Bridge Navigational Watch Alarm System (BNWAS), please have it work in the right manner, and be in your mind, "Don't throw pearls before swine."

We wish you all safe sailing.

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