Journal of Traffic and Transportation Engineering 12 (2024) 264-275
doi: 10.17265/2328-2142/2024.06.002

Training for Vessel Collision Prevention: Circumstances and Causes of Near-Miss Incidents

Yoshiaki Kunieda[1], Akihiro Nunome[1], Kotaro Ito[2] and Naruphun Chotechaung[3]

1. National Institute of Technology, Toyama College, Toyama 9398630, Japan

2. Japan Agency of Maritime Education and Training for Seafarers, Yokohama 2310003, Japan

3. Faculty of International Maritime Studies, Kasetsart University, Chon Buri 20230, Thailand

Abstract: Among the near-miss incidents related to the operation of training ship of the JMETS (Japan Agency of Maritime Education and Training for Seafarers), three characteristic cases were analyzed, extracting their circumstances and near-miss factors. Based on the results of these analyses, measures to prevent vessel collisions were studied, from which we proposed collision prevention training. The training entails (1) lookout training, (2) navigation planning training, (3) resource management training, and (4) false assumption prevention training. In future research, we aim to verify the effectiveness of the proposed training, improve the training's effectiveness, and contribute to the development of effective anti-collision support devices.

Key words: Collision prevention, near-miss incidents, collision prevention measures, false assumption.

1. Introduction

Trade and logistics have continued to develop in integration with the global economy. In island countries, such as Japan, and many other countries worldwide, logistics is primarily performed via marine transportation using vessels that transport large volumes of cargo at low cost. On the other hand, a number of maritime accidents, such as collisions and groundings, continue to occur. Many maritime accidents are caused by human factors, indicating the importance of education and training of seamen [1]. According to Japan Coast Guard statistics, approximately 2,000 maritime accidents occur annually in Japan. In 2022, the number of vessel accidents recognized by the Japan Coast Guard was 1,882 per year. Of these, 409 vessels, i.e., 22%, were involved in collisions. Marine accidents caused by human errors, including insufficient lookout and improper ship handling, accounted for approximately 80% of the total [2].

Training ships operated by the JMETS (Japan Agency of Maritime Education and Training for Seafarers) are encouraged to report near-misses to prevent accidents, which are classified into the following 20 categories: (1) crashes and falls; (2) falls; (3) collisions; (4) flying and falling; (5) collapses and overturns; (6) traps and entanglements; (7) cuts and scrapes; (8) contact with hot and cold objects; (9) electric leakage, electric shock, short circuit, and fire; (10) contact with harmful objects; (11) traffic accidents; (12) reaction and forced actions; (13) leaks and flooding; (14) bursting; (15) ship operation; (16) engine and equipment; (17) mistaken operation; (18) communication; (19) management and confirmation; and (20) others.

Furthermore, cases of near-misses related to ship operations and various onboard works have been reported [3]. We have examined measures to prevent collisions and maritime accidents through a detailed survey and analysis of near-miss incidents related to ship operations. The following measures can be adopted to prevent accidents: improving and strengthening education and training of seafarers, developing and promoting equipment and facilities to prevent collisions,

Corresponding author: Yoshiaki Kunieda, Ph.D., professor, research fields: maritime education and training.

and establishing and implementing management and systems to prevent accidents. Through case studies, this study identified the circumstances of ship operations that lead to near-miss incidents, and focused on education and training among accident prevention measures.

2. Purpose of the Study

In this study, among the collected near-misses related to ship operations, collision-related cases were comprehensively investigated to clarify the circumstances and causes of these cases and to consider appropriate countermeasures. This study aims to examine effective measures to prevent collisions, particularly with regard to education and training. Accident prevention measures may include improvements to mental, knowledge, and technical factors; improvements related to the design and quality of facilities and equipment; improvements related to the acquisition and exchange of information; improvements related to the environment and communication; and improvements related to management, education, and training [4]. In particular, we will focus on education and training from the viewpoint of human error prevention, and propose effective measures to prevent accidents.

3. Near-Miss Incidents

Representative cases and the related causes that may develop into collisions were extracted from near-miss incidents and examined.

3.1 Overtaken Case

In the overtaken case, a vessel was heading north on the Bungo Suido Channel and was in danger of colliding with an overtaking vessel when it turned left to head toward Beppu (Fig. 1).

While sailing to the Port of Beppu, immediately after the on-duty officer turned in at 08:00, a vessel moving at a higher speed was clearly approaching from behind in a position to overtake the vessel on the starboard side (point A, Fig. 1). The on-duty officer assumed that the other vessel would overtake on the starboard side and did not pay sufficient attention thereafter. After sailing through the Bungo Suido Channel, he/she checked the port side to turn left toward the Port of Beppu, only to find that the vessel he/she had expected to overtake on the starboard side was overtaking on his port side; in response, the left turn was stopped. Therefore, after passing the alteration point, the vessel turned approximately 300° to the right, turning its course toward the Port of Beppu (point B, Fig. 1).

An analysis of the aforementioned case is as follows.

(1) The on-duty officer did not conduct a continuous and sufficient lookout. The on-duty officer visually confirmed that the overtaking vessel was initially poised to overtake on the starboard side of the vessel; owing to this "false assumption", he did not keep a continuous lookout thereafter and attempted to turn left even though the overtaking vessel was approaching from the port side. Thus, the lookout does not end with the finding of the target; rather, a continuous look-out is important [5, 6].

(2) The on-duty officer did not make full use of navigational instruments such as RADAR/ARPA (Radio Detection and Ranging /Automatic Radar Plotting Aids) and ECDIS (Electronic Chart Display and Information System) and was insufficient for the lookout. If he/she had checked signals of navigational instruments such

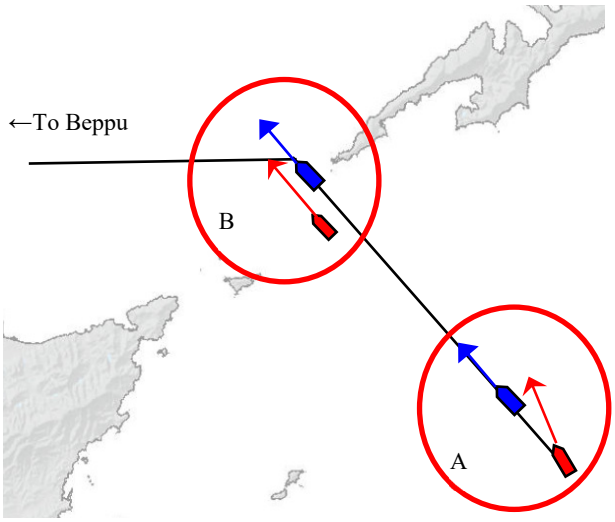

Fig. 1 Near-miss incident (overtaken case).

as RADAR/ARPA or ECDIS, he/she would have been able to detect that the overtaking vessel had changed from a starboard overtaking to a port overtaking. Proper use of navigational instruments is required for lookout [7].

(3) The course setting on the passage plan was set to the right in the case of a turn toward the Port of Beppu, which caused the overtaking vessel to execute a port overtaking. Even if the passage plan called for the vessel to be navigated in the center, the on-duty officer should have navigated to the left, so that it would be clear that the vessel would turn left and head for Beppu. Thus, the planning of optimal routes to prevent collisions is an important factor [8].

(4) The on-duty officer should have contacted the overtaking vessel in advance through international VHF (Very High Frequency Radio) or other means, informing it of the vessel's intention to head for the Port of Beppu and asked the vessel to overtake on its starboard side. Proactive use of communications is effective in preventing collisions [9].

(5) The on-duty officer should have considered that port overtaking is more reasonable than starboard overtaking when the overtaking vessel is heading toward Kanmon after passing through the Bungo Suido Channel.

(6) If the overtaking vessel is to proceed northeastward in the Iyo-nada Sea after passing through the Bungo Suido Channel, a starboard overtaking is appropriate; however, if the on-duty officer confirms that the vessel is in a starboard overtaking position, he/she should correct course to the left to make room on the starboard side for overtaking.

Based on the aforementioned analysis, the causes of the near-misses in the aforementioned case can be summarized in three points: (1) failure to perform a continuous lookout on watch, (2) an inappropriate passage plan, and (3) failure to take action based on appropriate prediction.

3.2 Fishing Boat Avoidance Case

While heading south off Sanriku in the early morning, the conditions were rough for small boats, with whitecaps in wind force 5. Possibly, this is why there were not many fishing boats in the area. As the sun rose and became brighter, whitecaps became more noticeable, and fishing boats were occasionally hidden among the waves. Under these circumstances, several fishing boats sailed from the land on the starboard side, and a crossing relation ensued. In this case, the own vessel is the give-way vessel, and the fishing boat is the stand-on vessel. While observing the azimuth change,

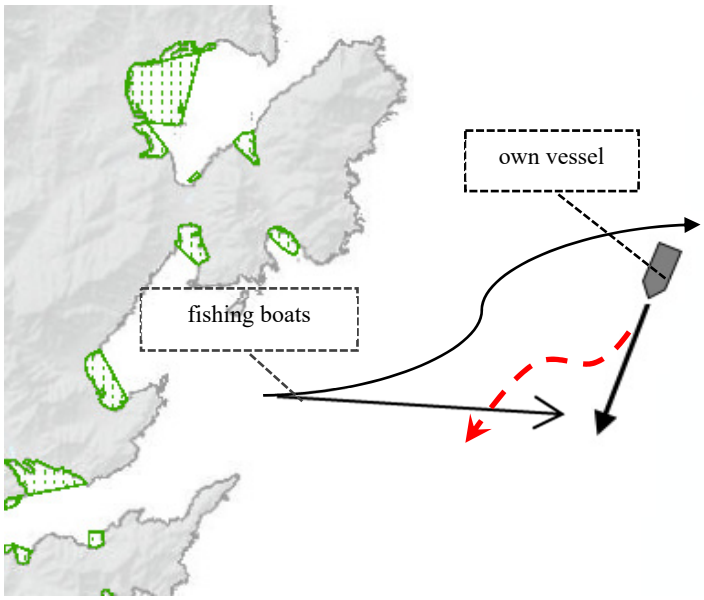

Fig. 2 Near-miss incident (fishing boats crossing).

several fishing boats turned left and were positioned to pass the stern of the own vessel. One of the fishing boats maintained the same course and speed, but the on-duty officer observed a change in the bearing of the fishing boat, assuming that similar to other fishing boats, it would also avoid the own vessel.

However, the fishing boat did not change her course and continued approaching; thus, the on-duty officer turned right to avoid the direction of the stern of the fishing boat. At the same time, a short blast of the whistle was made to indicate a right turn, which was made at a wide angle so that it could be clearly seen from the fishing boat. The fishing boat continued on its present course, and the own vessel passed by the stern of the fishing boat (Fig. 2).

In the aforementioned situation, all other fishing boats except one turned left and passed through the stern of the own vessel; however, one fishing boat continued straight ahead, causing a collision risk. The fishing boat was also likely to turn left and steer toward the stern of the own vessel; therefore, the on-duty officer had to watch out for this fishing boat and turn right to avoid it. In addition, to make it clear to the fishing boat that the own vessel was maneuvering to avoid a collision, an audio signal indicating a right turn was also made, while altering the wide angle of the course.

An analysis of the notable points of the aforementioned case is as follows.

(1) It is necessary not to make assumptions about a situation, assuming that the wind is strong and, thus, small fishing boats are not going to go out to fish.

(2) In whitecap conditions, fishing boats hide among the waves and the on-duty officer must be careful not to miss them.

(3) If the RADAR is not properly adjusted, the image of the fishing boats may be hidden by or removed with the sea clutter.

(4) Care should be taken not to make a false assumption that a fishing boat proceeding straight ahead will turn left and alter its course in the direction of the own vessel's stern similar to other fishing boats.

(5) Even if the own vessel avoids the fishing boat, it may still turn left; thus, it is necessary to keep a continuous lookout for the fishing boat.

(6) When the own vessel turns to the right to avoid a collision, it is necessary to alter the course at a wide angle so that the fishing boat can easily determine the own vessel's intention to avoid the collision.

(7) A signal (whistle signal) should be sounded to indicate that the own vessel is maneuvering to avoid the fishing boat. Depending on the situation, signals may also need to be made to attract attention by audio signal.

Based on the aforementioned analysis, the causes of the aforementioned near-misses are listed below.

(1) Insufficient lookouts that delay the detection of small vessels (fishing boats, etc.) hidden in whitecaps during stormy weather,

(2) Improper use of RADAR that delays detection of small vessels (fishing boats, etc.) owing to improper removal of sea clutter on the RADAR screen during stormy weather,

(3) The false assumption that all fishing boats behave the same when encountering multiple fishing boats,

(4) Failure to continuously monitor the behavior of fishing boats,

(5) Delay in ship handling to avoid the fishing boat that behaves differently from other fishing boats.

These causes of the aforementioned near-misses could be addressed via proper lookout, elimination of false assumptions about fishing boats, and ship handling to avoid fishing boats.

3.3 Vessel on Opposite Course and Restriction by Buoy

While sailing off Tosa, a vessel on the opposite course (A) was sighted at approximately 10° to the starboard side and it was difficult to determine whether to pass as a head-on situation or to pass on starboard-to-starboard. Therefore, the on-duty officer made a call using an international VHF radio-telephone to turn right and pass on port-to-port. When the vessels were approaching each other at a distance of approximately 5 nautical miles, they changed course to the right so that

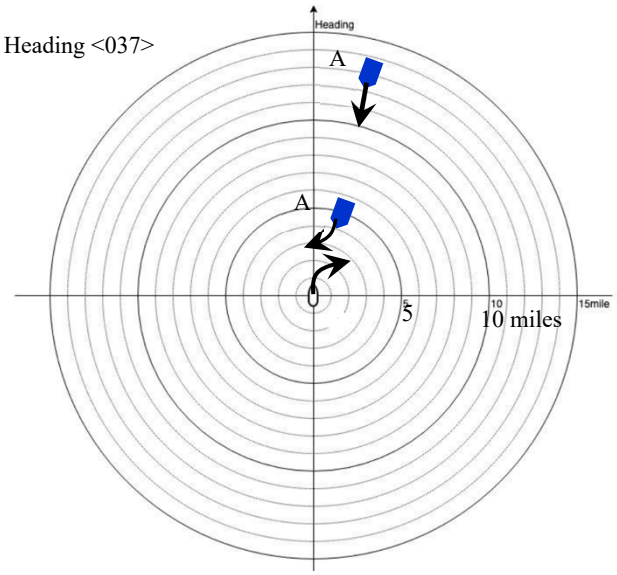

Fig. 3 Near-miss incident (sailing off Tosa-1).

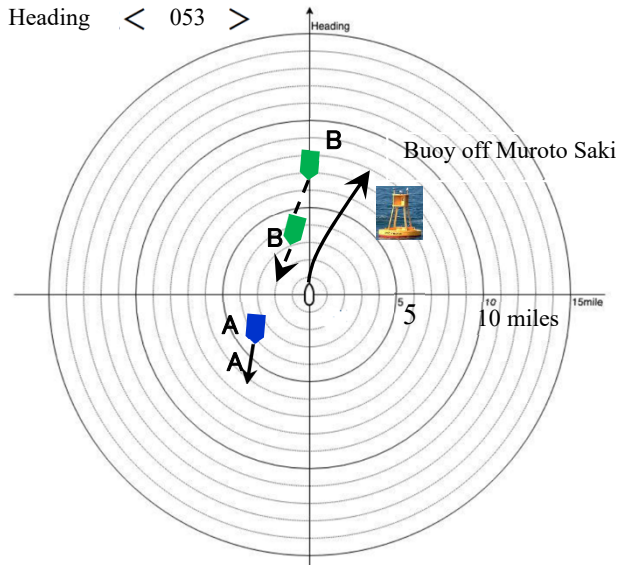

Fig. 4 Near-miss incident (sailing off Tosa-2).

they were passing each other port-to-port; at their closest approach, they were at a distance of 0.7 nautical miles (Fig. 3).

Vessel (B) was approaching from behind (A). Vessel (B) was approaching head-on and the vessels avoided each other by turning to the right. However, because the buoy off Muroto Saki was on the starboard side, it was not possible to make a wide-angle turn; thus, a small angle turn to the right was required. The closest approach distance of the vessel on the opposite course (B) was 0.7 nautical miles, but it was forced to pass very close to the buoy and had a near-miss (Fig. 4).

(1) Vessel (A) turned right and avoided the other vessel, and the closest approach distance was 0.7 nautical miles, which is considered a short distance in the open sea. However, because the on-duty officer confirmed each other's intentions using an international VHF radio telephone in advance, we do not consider this to be a problem. However, the danger of collision occurs when the on-duty officer falsely assumes that vessel (A) is passing starboard-to-starboard without continuously observing the vessel. Therefore, it is important to make early contact and mutually confirm to make turning to the right for collision avoidance.

(2) The on-duty officer did not make contact with the vessel on opposite course (B); moreover, because the buoy off Muroto Saki was located on the starboard side of the vessel, the closest approach distance to vessel (B) was 0.7 nautical miles. We consider that the other vessel was passing at a short distance from the vessel. In our opinion, the on-duty officer should have contacted vessel (B) and asked it to cooperate by turning to the right. North of the buoy off Muroto Saki (port side of the vessel), there are many westbound vessels. It is expected that many vessels will be encountered on opposite course. We believe that from the planning stage, the voyage should have been planned to pass to the south of the buoy off Muroto Saki.

4. Data Analysis in Case Studies

4.1 Importance of Continuous Lookout

Rule 5 of the International Regulations for Preventing Collisions at Sea states that "Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision."

The most important cause of the near-miss in the "overtaken" case (3.1) is the lack of a continuous lookout. We believe that there is a warning in this "overtaking" situation, which is unlike "head-on" and

"crossing" situations. In other words, Rule 13 on Overtaking, stipulated by the International Regulations for Preventing Collisions at Sea, states that "Notwithstanding any other stipulation of this Rule, any vessel overtaking any other shall keep out of the way of the vessel being overtaken." This regulation may have prevented the vessel's on-duty officer from providing a proper lookout. However, despite the importance of a continuous lookout having been indicated, the vessel's on-duty officer failed to keep a continuous lookout.

In the "fishing boat avoidance" case (3.2), the importance of a continuous lookout for one fishing boat that, unlike others, does not alter its course arises. It is necessary to keep a continuous lookout to observe whether the fishing boat will turn left and alter course to the stern of the own vessel like the other fishing boats, or whether it will continue to keep on its course. As a give-way vessel, the own vessel must make a decision at an early stage. If the own vessel avoids the fishing boat early, it will have enough time to respond even if the fishing boat turns left and goes toward the stern of the own vessel as the other fishing boats do.

In the "vessel on opposite course and restriction by buoy" case (3.3), it was difficult to determine whether the vessel was passing on starboard-to-starboard or a head-on situation. We believe that the continuous lookout of the vessel on opposite course (A) made the on-duty officer recognize the need to contact the vessel by international VHF radiotelephone. In contrast, as a result of the continuous lookout for the vessel on the opposite course (B), it is believed that they did not contact the vessel because it was clearly a head-on vessel.

4.2 Utilization of Navigational Instruments

Rule 5 of the International Regulations for Preventing Collisions at Seat, the lookout clause, states that "a proper lookout shall be kept at all times by sight and hearing as well as by all available means appropriate in prevailing circumstances and conditions," and that all other effective means other than sight shall also be utilized.

In the "overtaken" case (3.1), lookout by sight is a matter of course, but even a slight review of the RADAR/ARPA or ECDIS images would have revealed that the overtaking vessel in question was not overtaking on the starboard side, but on the port side. RADAR/ARPA is effective as a navigational instrument for detecting other vessels and obstacles, and by adjusting RADAR appropriately, other vessels can be detected at an early stage.

In the "fishing boat avoidance" case (3.2), it was difficult to detect small vessels, such as fishing boats, due to the whitecaps at a wind force of 5. In this situation, it is important to properly perform sea clutter in RADAR removal. It is especially important to properly adjust the sea clutter rejection function. Care should be taken not to remove small object markers such as fishing boats together with the sea clutter. It is also important to effectively utilize AIS (Automatic Identification System) data in RADAR and ECDIS, because if small vessels, such as fishing boats, are equipped with AIS, early detection will be possible without being affected by sea conditions.

In situations such as those described in the "vessel on opposite course and restriction by buoy" case (3.3), it is important to plan a voyage based on forecasts of vessel traffic flow from charts and current bulletins in advance. In addition, during navigation, the traffic flow of vessels should be monitored from the wide-area range of RADAR and ECDIS for reference when changing the plan and setting the course. Furthermore, in cases such as that in the "fishing boat avoidance" case, it is necessary to quickly and reliably ascertain the movements of the fishing boat concerned. Relying on navigation instruments such as RADAR and ECDIS may cause delays in response. The own vessel has avoided the fishing boat by turning right to avoid it, but the fishing boat may turn left as well. Thus, as other fishing boats engaged in right turn avoidance, and the

navigation instruments may be delayed in ascertaining the fishing boat's movement, it is necessary to keep a visual lookout.

4.3 Voyage Planning Considerations

In preparing a preplanned voyage plan, it is necessary to take into account collision prevention measures.

In the "overtaken" case (3.1), the passage plan should be designed to allow for navigation at the center of the channel, as close to the port side as possible, because after passing through the Bungo Suido Channel, the vessel will turn left and head for Beppu. If the overtaking vessel turns right after passing the Bungo Suido Channel and heads toward Iyonada, it is considered to be overtaking on the starboard side. Furthermore, if the vessel turns left after passing through the Bungo Suido Channel and heads toward Kanmon via Himejima-offing, it is more natural to overtake on the port side. Therefore, the own vessel should navigate on the port side as much as possible to encourage starboard overtaking by navigating on the port side, considering the relationship of passing safety with the vessel on the opposite course. Moreover, it is important to navigate with the necessary modifications based on the existing conditions in addition to navigating as per the preplanned passage plan. Modifying the passage plan by confirming the intention of the overtaking vessel via an international VHF radio telephone or other means is also important.

In the "fishing boat avoidance" case (3.2), it would be helpful to know in advance from the voyage plan that the own vessel will be sailing offshore where the fishing port is located in the early morning hours when the fishing boats are leaving the port, so that the own vessel can be prepared in advance. Even if the voyage plan cannot be easily adjusted, accidents can be prevented by understanding and simulating potential situations in advance.

In the "vessel on opposite course and restriction by buoys" case (3.3), a course line should be set at the initial passage planning stage such that the vessel navigates on the starboard (south) side of the buoy off Muroto Saki. The own vessel is sailing northeast off Muroto Saki; thus, it is obvious that there are vessels on the opposite course. In the event of a head-on situation, the own vessel is to turn right to avoid a collision and pass on port-to-port with the vessel on the opposite course. In this case, the plan should be to navigate on the right side of the buoy from the beginning so as not to be restricted by the buoy when turning right. Even if the original passage plan was to navigate to the left of the buoy, the on-duty officer should assess the situation in advance and change course to the right of the buoy at the earliest possible opportunity.

4.4 Communication

Vessels are equipped with international VHF radio telephones as a means of communicating with other vessels and communication stations on land.

In the "overtaken" case (3.1), by communicating with the overtaking vessel concerned, it is possible to inform the vessel of its intention to turn left and head for Beppu Bay after passing through Bungo Suido Channel. Communication may also confirm the overtaking side of the overtaking vessel and request starboard overtaking.

In the "fishing boat avoidance" case (3.2), it is assumed that fishing boats are not equipped with international VHF radio telephones; thus, it would be effective to implement a right turn signal and warning signals through whistling. Moreover, making a considerable change in course so that the own vessel's avoidance action can be easily observed by the fishing boat is important.

In the "vessel on opposite course and restriction by buoy" case (3.3), the own vessel contacted vessel (A) via an international VHF radio telephone because it was difficult to determine whether it was a head-on vessel or a passing vessel. The vessel turned right, with the vessels passing each other port-to-port. However, regarding the vessel on the opposite course (B), it was

clearly a head-on vessel; therefore, it avoided a right turn without making contact with the vessel. However, owing to the presence of a buoy on the starboard side, the vessel was unable to navigate under Rule 16 of the International Regulations for Preventing Collisions at Sea (Action by the give-way vessel), which states, "Every vessel which is directed to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear." In this case, the vessel could have made prior contact with the vessel on the opposite course (B) in advance and these vessels could have turned left to each other and proceeded on a starboard-to-starboard. We believe that communication will ensure safety by keeping each other informed of the other's actions.

4.5 Eliminating False Assumptions

Inadequate or misinformed situational awareness and decision-making can lead to accidents. To prevent accidents caused by wrong "false assumptions", we believe it is necessary to anticipate various situations.

In the "overtaken" case (3.1), the on-duty officer confirmed that the other vessel approaching from behind was poised to overtake on the starboard side. However, after this confirmation, the officer did not keep a continuous lookout; therefore, the officer made a "false assumption" that the overtaking vessel would overtake on the starboard side. Moreover, the officer made another "false assumption" that the situation will continue without any change. The on-duty officer had to anticipate not only starboard overtaking but also port overtaking. It was also necessary to consider whether the overtaking vessel would turn right and head toward Iyonada or left and head toward Kanmon after passing through the Bungo Suido Channel. After considering various situations, it is necessary to collect information and emancipate situational awareness from "false assumptions" to correct "situational awareness". In this case, a continuous lookout will provide information about the change from starboard overtaking to port overtaking. Based on this information, revised situational awareness will be created regarding the impact of overtaking vessel on the own vessel left turn toward Beppu. The revised situational awareness would lead to decision-making, such as contacting the overtaking vessel via an international VHF radio telephone and requesting starboard overtaking.

In the "fishing boat avoidance" case (3.2), several fishing boats departed; moreover, with the exception of one fishing boat, the other fishing boats turned left and steered their course toward the own vessel's stern. In this situation, the own vessel's on-duty officer may make a "false assumption" that the other fishing boat will likewise turn left to avoid the vessel. If the vessel's avoidance is delayed due to this "false assumption", there will be no time to correct the situation if the concerned fishing boat suddenly turns left to avoid a collision and a collision will occur. In this case, the "false assumption" that the fishing boat will turn left and avoid the own vessel, as the other fishing boats do, is misinformed. The on-duty officer needs to assume all possible circumstances regarding the fishing boat's behavior. Furthermore, a continuous lookout should be kept so that the fishing boat's movement can be recognized at an early stage. In the "fishing boat avoidance", the officer may have made a "false assumption" that the fishing boats would stop fishing because of the rather strong wind force of 5. This may have delayed the discovery of the fishing boat by this false belief. Especially in whitecaps, fishing boats can be missed because they are hidden between the waves, or it is difficult to recognize them from the RADAR image due to reflections off the sea clutter. Therefore, proper lookouts should be conducted, keeping in mind that even if it is a little windy, fishing boats will be out fishing, especially in the early morning.

In the "vessel on opposite course and restriction by buoy" case (3.3), it was difficult to determine whether the vessel on the opposite course (A) would be a head-on vessel or whether it would pass through on starboard-to-starboard. If a decision is made based on the "false assumption" that the vessel is a "head-on" or "passing"

vessel, it may lead to an accident. In fact, the on-duty officer is not susceptible to false assumptions, but keep in touch via an international VHF radio telephone and safely pass each other port-to-port by turning to the right. In the subsequent avoidance of the vessel on the opposite course (B), the vessel may assume that there is a wide space on the starboard side owing to the lack of land and that there is no problem in turning right to avoid the vessel. However, there is a buoy on the starboard side, which limits the space for avoiding the vessel. The possibility of this "false assumption" can be eliminated by confirming the passage plan is confirmed in advance. In addition, a proper lookout would be able to identify the presence of buoys and would recognize that starboard avoidance is restricted.

5. Collision Prevention Measures

The following measures to prevent collisions were considered based on the common causes of each near-miss incident.

5.1 Lookout Training

According to the current status of maritime accidents published by the Japan Coast Guard in 2022, approximately 30% of collision maritime accidents are caused by insufficient lookout [2]. Therefore, we propose the following training measures, with emphasis on lookout, to ensure safe and proper lookout at all times.

(1) Training with ship handling simulator: Conduct drills based on various scenarios, including past maritime accidents and near-miss cases. In particular, the scenarios should enable trainees to understand the importance of lookout and train to conduct continuous lookout by learning the lookout basics. We believe that the scenario could include a deliberate change of course or speed by the vessel to be avoided to emphasize continuous lookout training.

(2) Scenario development training: This is related to the lookout by developing the aforementioned simulator training scenarios. We believe that developing scenarios that allow trainees to master the importance of lookout is also a good approach to train oneself.

(3) Team-based training: The team will exchange opinions about past accidents and near-miss cases. The decision-making process can be improved by determining lookout points and developing a coordinated team lookout.

5.2 Voyage Planning Training

Voyage planning is essential for safe and efficient navigation. We propose providing training in safe navigation, especially in the planning of voyage plans from the perspective of collision prevention.

(1) Voyage planning training: A voyage plan is prepared by two or three persons by providing a predetermined sea area, port of departure and port of destination. By discussing and planning the voyage plan by team members, a safer and more efficient plan can be developed.

(2) Presentation of voyage plan: Present the planned voyage plan to other teams. By making a presentation, the contents and points planned can be understood in depth and information about voyage planning can be shared.

(3) Exchange of opinions on voyage plans: Exchange of opinions with other groups on the voyage plans developed and presented by each group will provide new insights and improve the plans.

5.3 Resource Management Training

BRM (bridge resource management) was added to the Manila amendments to the STCW (The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) Convention as a minimum requirement for certification of personnel on deck duty. The following training on BRM for marine accident prevention is proposed.

(1) Training That Assumes a Single Watch On-Duty Officer: Provide training in the effective use of navigational instruments such as RADAR/ARPA and ECDIS as hardware resources. Provide the training to

learn how to effectively use navigational instruments by utilizing simulators and actual equipment in case of accidents and near-misses. In cases when simulators are not available, a discussion on the use of navigational instruments by several group members, assuming a case study, will be sufficient. This training allows the navigational instruments to serve as an effective lookout aid for the on-duty officer and to assist in decision-making for ship handling to avoid collisions. In addition, training on communication with other vessels using international VHF radio telephones as a resource will be conducted by establishing accident and near-miss cases. Navigational instruments and navigational on-duty officers on other vessels can be considered as resources, so training for communication can be easily conducted by transceivers without actual international VHF radio telephone equipment.

(2) Team Training. When multiple people are on duty watch instead of a single duty watch, the level of activity may be higher and safer operations can be achieved. However, safety cannot be achieved simply more than one person being on duty. The following functions are necessary: (1) Ensure the members in the navigation bridge execute their assigned tasks; (2) Appropriately integrate the results of the assigned tasks through mutual information exchange among the members; and (3) Ensure the members cooperate with each other. We believe that role-plays and desk discussions are effective in developing these functions. It is essential that these trainings be conducted after carrying out the following: (1) Based on the analysis of the subject accident cases, identify the ship handling action, such as collision avoidance, that was conducted in the process leading up to the accident; (2) Clarify the technology and application method (technology management) that was necessary for ship operations based on the conditions affecting ship operation, such as navigational waters, vessel congestion, and visibility conditions at the time of the accident; (3) Identify how and why the team's activities (organizational management) can achieve safe operations.

5.4 False Assumption Prevention Training

The dangers of false assumptions have been pointed out in various fields [10]. There are many accidents caused by false assumption, such as the unfounded assumption that it is safe, or the assumption that the other vessel will avoid colliding with me. To avoid falling into false assumptions and, instead, make appropriate judgments, the following training is proposed.

5.4.1 Critical Thinking Training

Ways to develop critical thinking include (1) getting into the routine of asking questions, (2) observing things from different perspectives, (3) seeking evidence, (4) challenging assumptions, (5) recognizing logical fallacies, and (6) obtaining feedback on one's thinking, which should be practiced on a regular basis. In addition, by utilizing accident and near-miss cases, several trainees will discuss the causes and countermeasures, and put into practice (1) through (6) above. At this time, trainees gain new insights by referring to the opinions of others and also learning critical thinking from a wide range of perspectives.

5.4.2 Metacognitive Training

It is an exercise in self-reflection, thinking about one's own thought processes, asking questions about their own ideas and assumptions, and trying to understand how they were formed. Reflect on the thought process of one's own ship handling in accident and near-miss case situations, and consider new ship handling procedures based on the opinions of others.

5.4.3 Hypothetical Thinking Training

This is a training exercise to practice making and testing multiple hypotheses for any given situation or case. Referring to accident and near-miss cases, multiple situations are assumed and how to respond to them is considered. It may also involve a discussion of them by more than one person. It may also be effective to train under various environmental conditions, such as weather and sea conditions, restricted waters, and passage widths. Various environmental conditions will change the measures taken to prevent accidents.

Whether using a simulator training or case study training, training is effective when the environmental conditions are changed and optimal responses for each environmental condition are considered. This is thought to help develop the habit of considering multiple possibilities rather than sticking to a single interpretation.

5.4.4 EQ (Emotional Intelligence Quotient) Training

This training will help trainees understand their own emotions and be empathetic toward the emotions of others, thereby avoiding judgments based on false assumptions. We believe it is possible to understand the impact of emotional reactions on thinking. There are various types of EQ, and we propose the following training. As a training to improve self-awareness, the trainees will have an opportunity to deepen their self-awareness by sharing their thoughts on accidents and near-miss cases and accepting feedback from others. As a training to improve self-management skills, trainees will examine and discuss how emotions affected decision-making in accident and near-miss cases and how to make better decisions. As a relationship skill improvement training, teamwork and communication in accident and near-miss cases will be reviewed and discussed to improve teamwork and communication skills.

5.4.5 Debiasing Training

Understand the various cognitive biases that humans have and learn how these biases affect judgment. This allows us to move away from bias-based thinking. As a concrete example, the following training will be conducted: Examine and discuss accident and near-miss cases caused by biases and false assumptions to make correct decisions; and consider responses to accident and near-miss cases from various perspectives and exchange opinions so that diversity can be recognized as something valuable.

5.4.6 Training in Diversified Thinking

As in critical thinking training, practice thinking about a problem or topic from different angles. Training should enable trainees to understand the perspectives of others and to learn from people from different cultures and backgrounds. This allows trainees to understand the perspectives of others and learn from people from different cultures and backgrounds.

5.4.7 Promoting Creative Thinking

Cultivate flexible thinking beyond stereotypes by training trainees to think freely about ideas and to seek alternative solutions.

6. Conclusions

We analyzed near-miss cases related to the operation of training ships. From each case, we proposed the causes of the near-misses and measures to prevent collisions, particularly training to prevent collisions from the viewpoint of human error prevention. Analysis of the near-miss cases yielded the following six items:

(1) the importance of lookout, including continuous lookout,

(2) the importance of utilizing various resources such as navigational instruments,

(3) the importance of a voyage plan considered with collision prevention in mind,

(4) the importance of effective communication implementation,

(5) collision prevention measures, according to the situation at the scene,

(6) the importance of preventing false assumptions.

We examined effective training for these situations and made concrete proposals. In future research, we plan to verify and improve the effectiveness of these trainings as well as consider more effective training content and methods.

References

[1] Albayrak, T., and Ziarati, R. 2012. “Encouraging Research in Maritime Education & Training.” *Journal of Maritime Transport and Engineering* 1 (1): 4-9.

[2] Japan Coast Guard. 2023. *Japan Coast Guard Report 2022.* Accessed September 15, 2024. https://www6.kaiho.mlit.go.jp/info/keihatsu/20230609_state_measure01.pdf.

[3] Amano, K., et al. 2015. “Summary of Near-Miss Reports in FY 2013.” *The Journal of National Institute for Sea*

Training 41: 43-55.

[4] Yoshida, S. 2003. "A Study of Educational Training about a Dangerous Foresight and Risk Management for Constructive Managing Engineers." *The Society of Heating, Air-Conditioning Sanitary Engineers of Japan* 3: 2037-40.

[5] Nishimura, T., and Kobayashi, H. 2009. "A Study on lookout Characteristic in Collision Avoidance-II." *Journal of Japan Institute of Navigation* 120: 81-8.

[6] Nishizaki, C., Itoh, H., and Takemoto, T. 2015. "A Study on Error Modes in Officers' Watch Keeping Based on the Behavior Analysis." *Journal of Japan Institute of Navigation* 132: 105-13.

[7] Okada, K., Fujimoto, S., Fujiwara, S., and Fuchi, M. 2015. "Evaluating Navigational Information and the Abilities of OOW Who Handle Navigational Instruments." *Journal of Japan Institute of Navigation* 132: 1-8.

[8] Higaki, T., Hashimoto, H., and Yoshioka, S. 2022. "Route Optimization for Automatic Collision Avoidance Using Inverse Reinforcement Learning." *Proceedings of the Japan Society of Naval Architects and Ocean Engineers* 34: 189-92.

[9] Tasaki, Y., Kashima, H., Kunieda, Y., and Takemoto, T. 2016. "The Feature of Bridge-to-Bridge Communication Using VHF in Marine Traffic Density Area." *Journal of Japan Institute of Navigation* 133: 58-65.

[10] Ino, A., Fujimoto, S., and Konishi, T. 2018. "The Influence of 'Prejudice' on Watch-Keeping: 'Collision Cases between Fishing Vessels and Power-Driven Vessels except Fishing Vessels'." *Journal of Japan Institute of Navigation* 13: 12-9.