MA2016-5

MARINE ACCIDENT
INVESTIGATION REPORT

May 19, 2016

JTSB Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

MARINE ACCIDENT INVESTIGATION REPORT

Vessel type and name:	Cargo ship BEAGLE III
IMO Number:	9478353
Gross tonnage:	12,630 tons

Vessel type and name:	Container ship PEGASUS PRIME
IMO Number:	9283162
Gross tonnage:	7,406 tons

Accident type:	Collision
Date and time:	Around 03:10, March 18, 2014 (local time, UTC +9 hours)
Location:	South-east offshore Tsurugizaki, Miura City, Kanagawa Prefecture, Around 143° true, 3.5M from Tsurugisaki Lighthouse (approximately 35°05.7'N 139°43.2'E)

April 14, 2016

Adopted by the Japan Transport Safety Board

Chairman	Kazuhiro Nakahashi
Member	Kuniaki Shoji
Member	Satoshi Kosuda
Member	Toshiyuki Ishikawa
Member	Mina Nemoto

SYNOPSIS

<Summary of the Accident>

The cargo ship BEAGLE III with a master, second officer, and 18 crews proceeding in the south-southwest direction toward Kobe-ku Hanshin Port and the container ship PEGASUS PRIME with a master, second officer, and 12 crews proceeding in the northeast direction toward Tokyo-ku Keihin Port collided with each other at the baymouth of Tokyo Bay, south-east offshore Tsurugizaki, Miura City, Kanagawa Prefecture, Japan at around 03:10, March 18, 2014.

Seven crews of BEAGLE III died, two are missing, and the ship sank due to a damage hole in side shell plating of the central port-side.

A crew of PEGASUS PRIME was injured and the ship bow buckled.

<Probable Causes>

It is probable that the accident occurred because, when Ship A was navigating in south-southwest direction and Ship B was navigating in northeast direction at night and the both ships came closer to each other, Ship A turned to starboard, Ship B turned to port and kept proceeding straight, and the both ships collided with each other.

It is somewhat likely that Ship A turned to starboard because 2/O A of Ship A did not notice Ship B in the starboard ahead.

It is probable that Ship B kept proceeding straight because, after Ship B turned to port for passing by Ship A on the starboard side, 2/O B of Ship B did not conduct look-out properly and hence could not notice that Ship A in the starboard ahead turned to starboard.

1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

The cargo ship BEAGLE III with a master, second officer, and 18 crews proceeding in the south-southwest direction toward Kobe-ku Hanshin Port and the container ship PEGASUS PRIME with a master, second officer, and 12 crews proceeding in the northeast direction toward Tokyo-ku Keihin Port collided with each other at the baymouth of Tokyo Bay, south-east offshore Tsurugizaki, Miura City, Kanagawa Prefecture, Japan at around 03:10, March 18, 2014.

Seven crews of BEAGLE III died, two are missing, and the ship sank due to a damage hole in side shell plating of the central port-side.

A crew of PEGASUS PRIME was injured and the ship bow buckled.

1.2 Outline of the Accident Investigation

1.2.1 Setup of the Investigation

The Japan Transport Safety Board appointed an investigator-in-charge and four other vessel accident investigators on March 18, 2014.

1.2.2 Collection of Evidence

Interview on March 18, 21, 28 and July 3, 2014.

On-site investigation and interview on March 19, 20, and April 3, 2014.

Collection of questionnaire on April 7, 9, 14, 15, 30, May 14, 16, and September 26, 2014; March 23, April 2, 14, 17, 21, 22, 27, 30, May 14, 25, July 27, 28, and 30, 2015.

1.2.3 Tests and Research by Other Institutes

For the investigation of the accident, tests and research on the flood situation until the foundering and the change of the hull posture of BEAGLE III were conducted by National Maritime Research Institute.

1.2.4 Comments from Parties Relevant to the Cause

Comments on the draft report were invited from parties relevant to the cause of the accident.

1.2.5 Comments from the Flag State

Comments on the draft report were invited from flag States of BEAGLE III and

PEGASUS PRIME.

Comments on the draft report were invited from the substantially interested state of BEAGLE III.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

2.1.1 Navigation process by automatic identification system

According to 'information record collected from an automatic identification system (AIS) *1 by a private company' (hereinafter referred to as AIS record), the navigation process of BEAGLE III (hereinafter referred to as Ship A) and that of PEGASUS PRIME (hereinafter referred to as Ship B) can be summarized in Tables 2.1-1 and 2.1-2, respectively.

The position of Ship A and that of Ship B are the positions of GPS antennas mounted over the bridges and the course over the ground and the heading are the true bearing (the same is applied to what follows).

Table 2.1-1 AIS record of Ship A (extract)

Time (H:M:S)	Position		Course O.G. (°)	Heading (°)	Speed O.G. (kn)
	Latitude(N) (°-′)	Longitude (°-′)			
02:34:59	35-12.72720	139-46.31802	178.7	179	12.8
02:39:59	35-11.66010	139-46.20420	188.1	188	12.9
02:44:49	35-10.63110	139-46.02600	192.5	195	13.0
02:50:00	35-09.57120	139-45.55038	201.7	200	13.2
02:55:01	35-08.53458	139-45.06852	201.1	201	13.2
03:00:00	35-07.53162	139-44.52672	203.6	205	13.1
03:01:09	35-07.29948	139-44.40360	203.9	205	13.2
03:02:01	35-07.12842	139-44.31282	203.1	205	13.2
03:04:01	35-06.72228	139-44.10300	203.3	205	13.1
03:05:01	35-06.52392	139-43.99722	203.6	205	13.2
03:06:01	35-06.32388	139-43.88862	203.3	204	13.1

*1 Automatic Identification System (AIS) is equipment with which a ship automatically sends/receives information of identification code, type, ship name, ship position, course, speed, destination, and navigation state of the ship for information exchange with another ship or navigation aid facilities of a land station.

03:06:31	35-06.22320	139-43.83558	203.5	204	13.1
03:06:40	35-06.19650	139-43.82172	203.2	204	13.1
03:06:59	35-06.12942	139-43.78680	203.5	204	13.2
03:07:20	35-06.05808	139-43.75098	202.6	207	13.2
03:07:40	35-05.99490	139-43.71630	207.5	214	13.2
03:08:10	35-05.89992	139-43.64508	219.0	223	12.9
03:08:31	35-05.84238	139-43.58700	220.5	228	12.7
03:09:00	35-05.77530	139-43.49652	232.7	239	12.7
03:09:15	35-05.78682	139-43.11990	236.9	245	12.6
03:09:31	35-05.71362	139-43.38210	243.0	254	12.5
03:10:13	35-05.68638	139-43.21932	276.1	300	11.0
03:10:17	35-05.68860	139-43.20858	282.6	305	10.8
03:10:26	35-05.69928	139-43.18182	305.8	321	8.7
03:10:32	35-05.70738	139-43.17168	316.7	328	8.3
03:10:40	35-05.72178	139-43.15518	327.4	334	7.9
03:10:43	35-05.72700	139-43.15080	327.5	335	7.8
03:10:58	35-05.75310	139-43.13310	337.4	335	7.4
03:11:05	35-05.76912	139-43.12650	343.3	331	7.3
03:12:00	35-05.85918	139-43.06530	303.6	274	5.8
03:12:31	35-05.87382	139-43.01550	284.5	250	4.8
03:12:58	35-05.87358	139-42.97728	256.5	217	3.4
03:13:08	35-05.87052	139-42.96648	233.2	189	5.9
No record received afterward					

Table 2.1-2 AIS record of Ship B (extract)

Time (H:M:S)	Position		Course O.G. (°)	Heading (°)	Speed O.G. (kn)
	Latitude(N) (°—′)	Longitude (°—′)			
02:50:01	35-02.66802	139-39.04698	048.0	048	13.2
02:55:01	35-03.40902	139-40.05498	048.0	048	13.2
03:00:00	35-04.15302	139-41.05200	043.0	046	13.2
03:00:21	35-04.21098	139-41.11500	043.0	050	13.2
03:00:32	35-04.23702	139-41.14698	044.0	052	13.2
03:00:40	35-04.25700	139-41.17398	045.0	054	13.2

03:01:10	35-04.32702	139-41.27700	051.0	055	13.2
03:02:00	35-04.44102	139-41.45898	052.0	053	13.2
03:03:00	35-04.57902	139-41.66400	050.0	055	13.2
03:03:40	35-04.67100	139-41.81100	053.0	057	13.2
03:04:01	35-04.71402	139-41.88402	054.0	057	13.3
03:05:01	35-04.84602	139-42.10698	053.0	055	13.2
03:06:01	35-04.97598	139-42.31998	053.0	055	13.2
03:06:30	35-05.04102	139-42.42498	053.0	054	13.2
03:06:40	35-05.06700	139-42.46800	054.0	051	13.2
03:07:01	35-05.11302	139-42.53802	050.0	044	13.1
03:07:10	35-05.13900	139-42.56898	047.0	041	13.0
03:07:20	35-05.16300	139-42.59502	043.0	041	12.9
03:07:30	35-05.19102	139-42.62298	041.0	041	13.0
03:07:40	35-05.21898	139-42.65100	039.0	042	13.0
03:08:01	35-05.27502	139-42.70800	040.0	045	13.0
03:08:10	35-05.30202	139-42.73800	041.0	046	13.1
03:08:20	35-05.32698	139-42.76500	042.0	046	13.1
03:08:31	35-05.35602	139-42.79902	043.0	047	13.1
03:09:01	35-05.43402	139-42.89400	045.0	046	13.2
03:09:31	35-05.51202	139-42.98898	044.0	046	13.2
03:09:41	35-05.53500	139-43.01700	045.0	042	13.2
03:10:01	35-05.59302	139-43.08498	041.0	032	13.0
03:10:04	35-05.59902	139-43.09002	041.0	031	13.0
03:10:07	35-05.61000	139-43.10100	039.0	030	12.9
03:10:13	35-05.62800	139-43.11498	036.0	030	12.8
03:10:18	35-05.63700	139-43.12200	035.0	030	12.8
03:10:20	35-05.65302	139-43.13100	031.0	021	12.6
03:10:27	35-05.65800	139-43.13802	034.0	004	9.5
03:10:33	35-05.66400	139-43.14102	031.0	357	7.0
03:10:43	35-05.67600	139-43.14300	015.0	350	5.1
03:11:03	35-05.70000	139-43.13700	352.0	339	4.4
03:11:13	35-05.71200	139-43.13202	344.0	336	4.4
03:11:17	35-05.71800	139-43.12902	340.0	335	4.4
03:12:01	35-05.76702	139-43.09902	333.0	333	4.4

03:12:31	35-05.79798	139-43.08000	334.0	334	4.2
03:13:01	35-05.82900	139-43.06302	335.0	335	4.1

2.1.2 Events leading to the accident according to the crews

According to the statements of the chief officer of Ship A (hereinafter referred to as C/O A), the able seaman of the watch of Ship A (hereinafter referred to as A/B A_1), the second officer of Ship B (hereinafter referred to as 2/O B), and the able seaman of the watch of Ship B (hereinafter referred to as A/B B), the accident occurred as follows.

(1) Ship A

On Ship A there were a master (Chinese, hereinafter referred to as Master A), second officer (Chinese, hereinafter referred to as 2/O A), and 18 other crews (all Chinese). Ship A left Yokohama-ku, Keihin Port for Kobe-ku, Hanshin Port at around 00:42, March 18, 2014.

After Ship A navigated out of the south exit of the Uraga Suido traffic route, Master A left the bridge at around 02:45 and 2/O A and A/B A_1 took charge of the watch on the bridge. Ship A navigated by automatic steering at about 13kn (speed over the ground; the same applied to what follows) southeast offshore Turugizaki, Miura City, Kanagawa Prefecture, Japan, heading south-southwest.

Under the direction from 2/O A to make starboard 10°, A/B A_1 made starboard 10° manually and noticed a starboard sidelight of Ship B.

On Ship A, under the direction from 2/O A who looked in a hurry, A/B A_1 took helm hard to starboard, but the middle of port side of Ship A and the bow of Ship B collided with each other.

(2) Ship B

On Ship B there were a master (South Korean, hereinafter referred to as Master B), 2/O B (Burmese), and 12 other crews (5 South Korean and 7 Burmese crews). Ship B left Busan, South Korea for Tokyo-ku, Keihin Port at around 09:05 (local time), March 16, 2014.

With the direction to notify Master B when Ship B reached the entrance of Nakanose traffic route, 2/O B, together with A/B B, took charge of watch on the bridge. Ship B navigated southeast offshore Turugizaki by automatic steering at about 13kn at around 03:00, March 18, heading northeast.

2/O B first recognized Ship A at around 4M port ahead by radar and a starboard sidelight of Ship A by binoculars. Since it seemed that both ships were in crossing situation, 2/O B that Ship A would alter the course to avoid Ship B.

Since Ship A, coming to the position about 2M from the port bow, did not try to avoid Ship B, 2/O B decided to turn to port and pass by Ship A on the starboard side and rotated the navigation setting dial of the autopilot by about 15° to left.

2/O B noticed that Ship A at around 0.5M starboard ahead was turning to starboard and decided that collision could not be prevented even if Ship B turned to starboard at that timing. For reducing a damage due to collision, 2/O B directed A/B B to make port 20 and shortly flashed a daylight signaling light twice to Ship A.

On Ship B, 2/O B found four or five flashes from Ship A and that Ship A was trying to point out that Ship B's turning to port was inappropriate. So 2/O B directed A/B B to take helm hard to starboard and to proceed full astern, although Ship B and Ship A collided with each other.

The accident occurred at around 03:10, March 18, 2014 at around 143°3.5M from Tsurugisaki Lighthouse.
(See Attached Fig. 1 Navigation course.)

2.1.3 Events from collision to escape and rescue

(1) Ship A

There were the following events according to the statement of the third officer, first engineer, third engineer, two able seamen, two ordinary seamen, two oilers of Ship A (hereinafter referred to as 3/O A, 1/E A, 3/E A, A/B A_2, A/B A_3, O/S A_1, O/S A_2, Oiler A_1, Oiler A_2), C/O A, and A/B A_1 and the reply to the questionnaire by Japan Coast Guard. (See Fig. 2.1-1.)

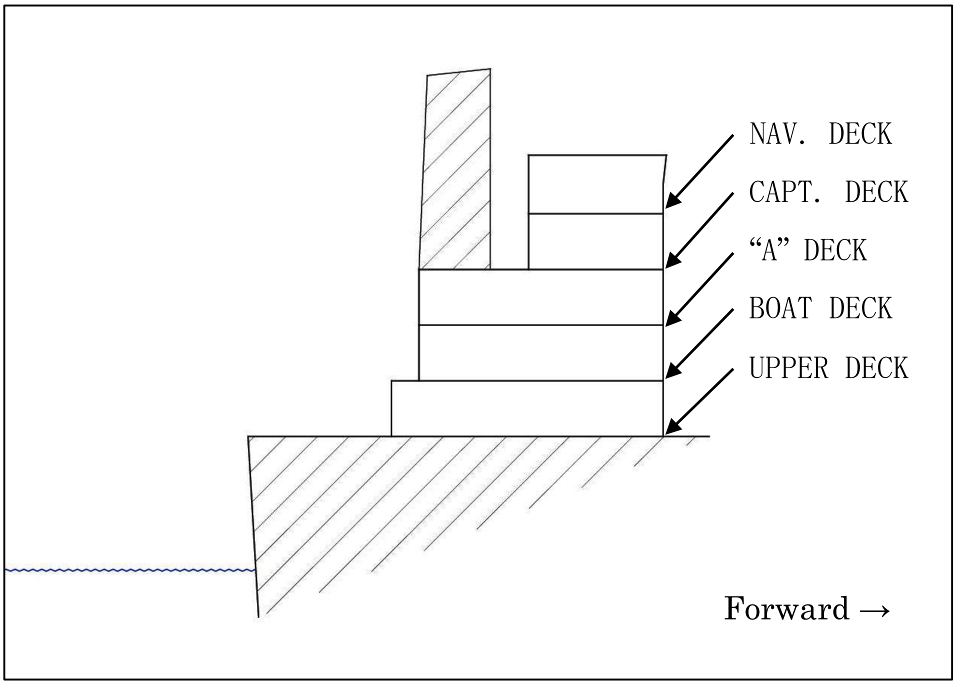


Fig. 2.1-1 Accommodation space of Ship A

(i) Nav. deck

Under the direction of Master A showing up to the bridge, A/B A_1 took helm hard to port and then took helm hard to starboard. As the bow suddenly lowered, the trim by bow became large and Master A and 2/O A fell down.

Since seawater came in from the opened entrance doors on starboard and port sides and the bridge was about to sink in the water, A/B A_1 escaped from the door. While holding on a wood piece, A/B A_1 was rescued by a 'rescue boat/lifeboat' (hereinafter referred to as rescue boat) of Ship B.

(ii) "A" deck

1/E A woke up by the collision and went out to a passage, where 1/E A met a chief engineer (hereinafter referred to as C/E A) who was going to the engine room. After returning to the cabin, 1/E A realized that the ship began tilting, and went out of the accommodation space through the passage on the port site toward the stern.

When receiving a phone call from the bridge to check the hull condition and preparing for the check, C/O A found that the ship began tilting and seawater came from the windows. So C/O A went out to the passage.

3/O A woke up by the collision and realized that the ship began tilting. 3/O A went out to the passage and found 3/E A who was trying to get out of the cabin and pulled him up to the passage. Together with C/O A and 3/E A, 3/O A went out of the accommodation space through the passage on the port site toward the stern.

C/O A and others found a nautical trainee (hereinafter referred to as Trainee A_1) who could not come out of the passage exit on the starboard side due to the tilting of the ship and tried to rescue him with a rope, but they saw Trainee A_1 drawn in the seawater flowing suddenly to the passage.

After the foundering of Ship A, 1/E A, 3/E A, C/O A, and 3/O A boarded a inflatable liferaft of Ship A. While they were drifting, they were rescued by a patrol boat at around 05:13.

(See Fig. 2.1-2.)

↑Forward

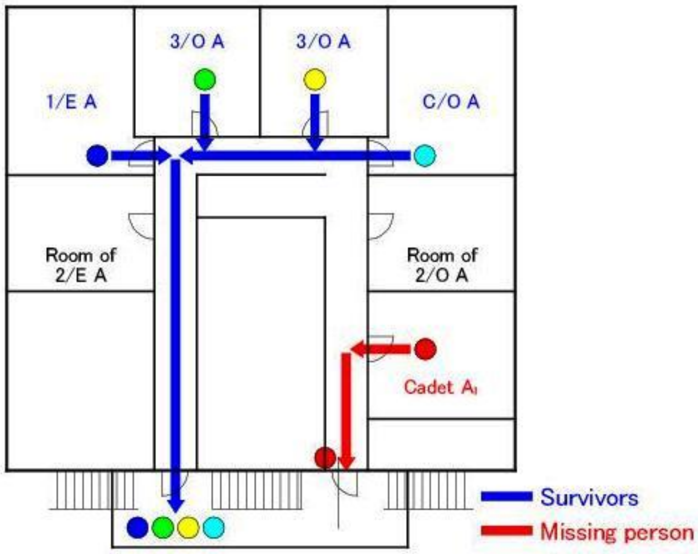


Fig. 2.1-2　Escape situation on A deck

(iii)　Boat deck

A/B A_2, A/B A_3, and O/S A_1 woke up by the collision and went out to a passage. Although they tried to go through the passage on the starboard side to the stern but could not open an exit door due to the tilting of the ship. A/B A_2 gave up going out through the door, entered the cabin of A/B A_1, and went out of the accommodation space through the window of the cabin. A/B A_3 and O/S A_1 went out of the accommodation space through the door that 1/E A opened from outside.

After the foundering of Ship A, A/B A_3 boarded the inflatable liferaft where 1/E A and others already boarded. A/B A_3, 1/E A, and others on the liferaft were rescued by the patrol boat.

At around 04:10-20, A/B A_2, drifting on a wood piece, was rescued by a passenger ship (hereinafter referred to as Ship C) navigating at the back of Ship A. O/S A_1 swam to Ship C and was rescued.

(See Fig. 2.1-3.)

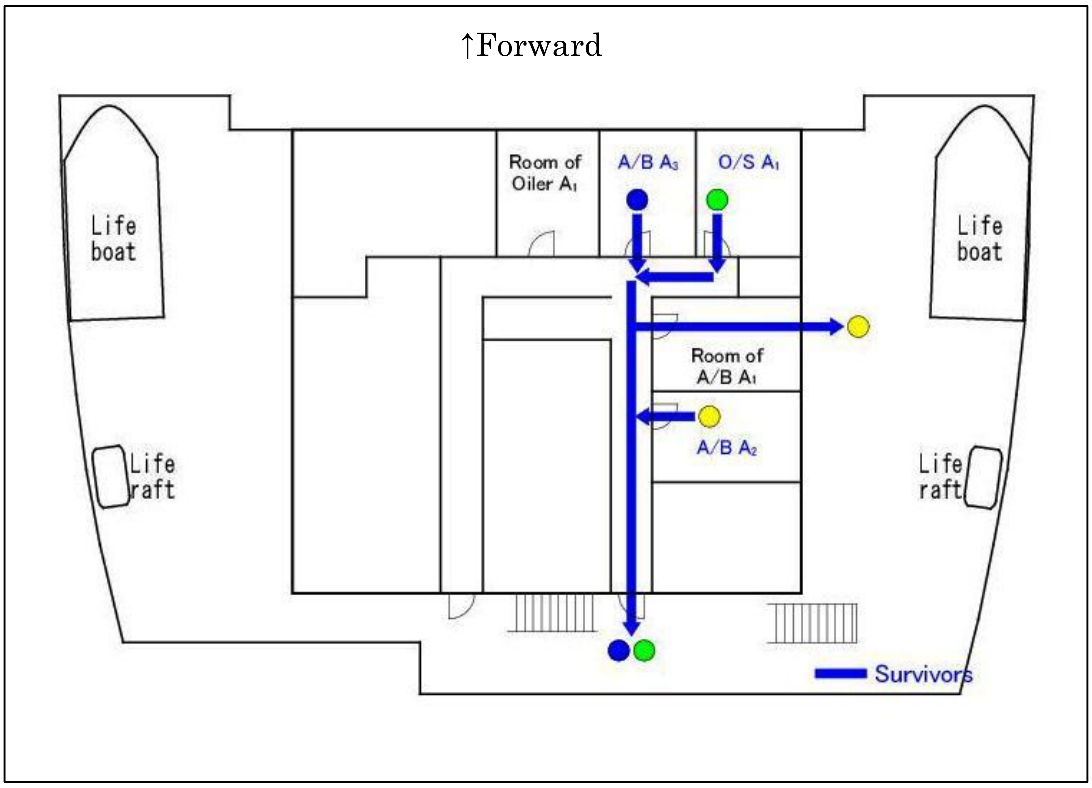


Fig. 2.1-3　Escape situation on boat deck

(iv)　Upper deck and engine room

O/S A_2 woke up by the collision, went out of the cabin, and met No. 1 oiler and head chef (hereinafter referred to as No. 1 Oiler A and Head Chef A respectively). O/S A_2 then went back to the cabin to get a lifejacket, went out to the passage again, and met Oiler A_2 and a nautical trainee (hereinafter referred to as Trainee A_2). They together went to the starboard side and tried to open a window of the kitchen to get out. Since they could not open the window, they went to the crew's mess room on the port side.

Oiler A_1 was taking charge of the watch with a second engineer (hereinafter referred to as 2/E A) in the engine control room. After feeling the collision, Oiler A_1 was directed on the phone by C/E A to start one of the spare electric generators. However since the ship tilted, Oiler A_1 and 2/E A went out of the engine room and joined O/S A_2 and others in the crew's mess room.

Oiler A_1 went out of the window of the crew's mess room. While drifting on a floating object, Oiler A_1 was rescued by the patrol boat at around 05:08.

O/S A_2, together with Oiler A_2, went out of the window of the crew's mess room, swam toward the stern, moved up to the stern deck, and joined other crews. Since Ship A foundered, they moved to the wood piece, on which A/B A_2 already boarded, and were rescued by Ship C.

2/E A and Trainee A_2 could not swim and remained in the crew's mess room. (See Fig. 2.1-4.)

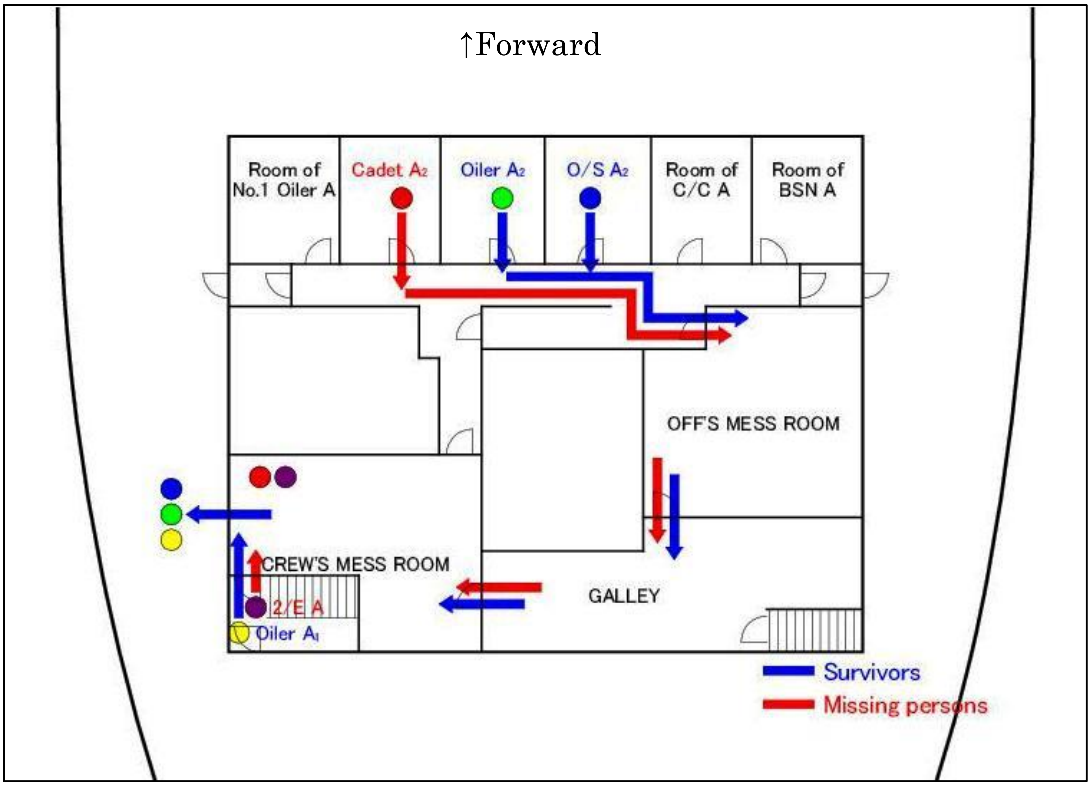


Fig. 2.1-4 Escape situation on upper deck

(2) Ship B

According to the statement of the Master B, 2/O B, A/B B, and a Third Engineer (hereinafter referred to as 3/E B) the situation after the collision could be described as follows.

Master B felt the collision and immediately went up to the bridge. Master B directed a chief officer (hereinafter referred to as C/O B), who was coming next, to call Tokyo Bay Vessel Traffic Service Center about the accident occurrence. After calling the ship owner DONG YOUNG SHIPPING CO., LTD. (hereinafter referred to as Company B_1), Master B formed a rescue boat station*2.

2/O B, third officer, and 2/E on a launched rescue boat tried to save the crews of Ship A and rescued A/B A_1. Then the rescue boat's propeller got tangled in a rope and could not navigate. So they reported Master B about the situation.

Receiving the report that the rescue boat could not navigate, Master B made a direction to launch a lifeboat and save the crews of Ship A.

*2 "Rescue boat station" is personnel deployment necessary to rescue those falling from their own ship or those wrecked.

C/O B, 3/E B, and A/B B boarded the lifeboat and tried to lower it to the sea. But the lifeboat fell to the sea and C/O B got injured.

A/B A_1 and three crews of Ship B on the rescue boat were rescued by the patrol boat at around 04:53.

Ship B navigated by itself and entered into Yokohama-ku, Keihin Port at around 13:30, March 19.

2.1.4 Situation of Ships A and B according to Ship C

According to the statement of an officer of the watch of Ship C (hereinafter referred to as Officer C) which was navigating at the back of Ship A when the accident occurred, the situation of Ships A and B were as follows.

(1) Since the AIS information of Ship A, which overtook Ship C on the port side, indicated that the destination was offshore Kobe-ku, Hanshin Port, Officer C that Ship A would eventually turn to starboard and head for west. However, as Ship C navigated in the south-southwest direction, Officer C saw the collision between Ship A and Ship B.

(2) Officer C did not hear a communication by international VHF radio telephone (hereinafter referred to as VHF) between Ship A and Ship B or a sound of whistle blasted by either of the ships.

(3) Receiving a report from Officer C, the master of Ship C went to the bridge and reported Japan Coast Guard about the occurrence of the accident. Receiving a rescue request from the Japan Coast Guard, the master decided to start rescue and directed the crews to collect life buoys to the forecastle deck.

(4) Officer C saw that the bow of Ship A began foundering about 1-2 minutes after the collision. About 3-4 minutes after that, the front side of the deck house of Ship A foundered and only the rear side of the deck house and the stern remained above the sea. Officer C saw that Ship A continued foundering gradually and the entire hull sank in the sea about 50 minutes after the collision.

(5) Ship C rescued A/B A_2, O/S A_2, and Oiler A_2 who were drifting on the wood board, and O/S A_1 who swam to Ship C.

(6) After the patrol boat arrived at the site, Ship C restarted navigation. It entered into Okada Port, Oshima-cho, Tokyo, and transferred the saved four crews of Ship A to an ambulance.

2.2 Injuries to Persons

(1) Ship A

The followings are the situation of injuries to persons according to the reply to the questionnaire by Japan Coast Guard.

(i) C/E A (male, 46 years old) was found drifting southeast Tsurugizaki by the patrol boat at around 07:35, March 18, 2014, recovered, and found in an autopsy to have died of drowning.

(ii) Head Chef A(male, 23 years old) was found inside Ship A by a remotely operated vehicle (hereinafter referred to as ROV) at around 11:00, March 28, recovered, and found in an autopsy to have died of drowning.

(iii) Boatswain (hereinafter referred to as BSN A, male, 28 years old) was found inside Ship A by ROV at around 12:00, April 1, recovered, and found in an autopsy to have died of drowning.

(iv) 2/E A (male, 38 years old) was found on the seafloor near Ship A at around 13:15, April 2, and recovered. The cause of death could not be found.

(v) 2/O A (male, 28 years old) was found on the bridge of Ship A by a diver at around 13:00 on April 15, recovered, and found in an autopsy to have died of drowning.

(vi) Trainee A_1 (male, 25 years old) was found inside Ship A by a diver at around 13:10 on April 18, recovered, and found in an autopsy to have died of drowning.

(vii) No. 1 Oiler A (male, 44 years old) was found inside Ship A by a diver at around 15:15 on May 7, recovered, and found in an autopsy to have died of drowning.

(viii) Master A (male, 53 years old) and Trainee A_2 (male, 22 years old) are missing.

(2) Ship B

According to the reply to the questionnaire by Company B_1, C/O B (male, 49 years old) had a vertebra broken and needed medical treatment of about three months.

2.3 Damage to Vessel

(1) Ship A

According to the reply to the questionnaire by the operator of Ship A, WISDOM MARINE LINES S.A. (hereinafter referred to as Company A_1), Ship A, after the foundering, had a tear and crack on the side shell plating of the central port side hull and a buckling on the bow. (See Fig. 2.3.)

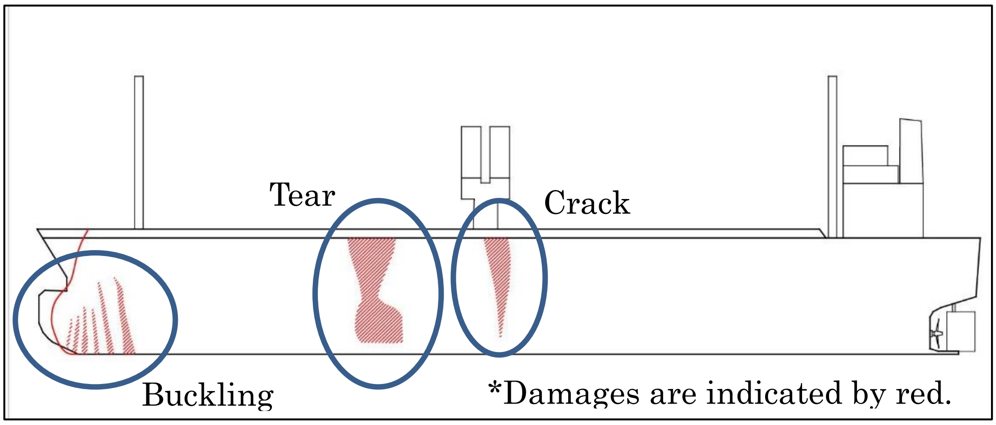


Fig. 2.3 Schematic illustration of damages on Ship A (port side)

(2) Ship B

Ship B had a buckling on the bow and the bow thruster was destroyed. (See Photo 2.3.)


Photo 2.3 Bow of Ship B

2.4 Crew Information

(1) Gender, Age, and Certificate of Competence

(i) Master A, male, 53 years old

Endorsement attesting the recognition of certificate under STCW regulation, Master (issued by Republic of Panama)

Date of issue: May 24, 2012

(Valid until December 1, 2016)

(ii) 2/O A, male, 28 years old

Endorsement attesting the recognition of certificate under STCW regulation, Second Officer (Issued by Republic of Panama)

Date of issue: January 10, 2014

(Valid until April 10, 2014)

(iii) Master B, male, 53 years old

First grade maritime officer (issued by Republic of Korea)

Date of issue: March 25, 2013

(Valid until March 24, 2018)

(iv) 2/O B, Male, 28 years old

Endorsement attesting the recognition of certificate under STCW regulation, Second Officer (Issued by Republic of Korea)

Date of issue: February 10, 2014

(Valid until December 31, 2016)

(2) Major seagoing experiences

(i) Master A

According to the reply to the questionnaire by Company A_1, Master A has had an experience of boarding Ship A since December 13, 2013.

(ii) 2/O A

According to the reply to the questionnaire by Company A_1, 2/O A has had an experience of boarding Ship A since January 11, 2014.

(iii) Master B

According to the statement of Master B and the crew list, Master B joined Company B_1 as chief officer in 2005, became master in 2010, has had an experience of boarding Ship B since February 23, 2014.

(iv) 2/O B

According to the crew list and the reply to the questionnaire by Company B_1, 2/O B entered as officer in 2008 an affiliate company, which lent/borrowed crews to/from Company B_1, became second officer in 2011, and has had an experience of boarding Ship B since February 15, 2014.

2.5 Vessel Information

2.5.1 Principal Particulars of Vessel

(1) Ship A

IMO number:	9478353
Port of registry:	Panama, Republic of Panama
Owner:	BEAGLE MARINE S.A. (Taiwan)
Operator:	Company A_1 (Taiwan)
Management company:	WELL SHIPMANAGEMENT AND MARITIME CONSULTANT Co., Ltd. (Taiwan) (hereinafter referred to as Company A_2)
Class:	BUREAU VERITAS (French Republic)
Gross tonnage:	12,630 tons
L x B x D:	129.90 m x 23.00 m x 16.00 m
Hull material:	Steel
Engine:	One diesel engine
Output:	5,180 kW
Propulsion:	4-brade fixed pitch propeller
Date of launch:	December 25, 2008

(2) Ship B

IMO number:	9283162
Port of registry:	Jeju, South Korea
Owner:	Company B_1 (South Korea)
Operator:	Company B_1
Management company:	NAM SUNG SHIPPING CO., LTD. (Republic of Korea) (hereinafter referred to as Company B_2)
Class:	KOREAN REGISTER OF SHIPPING (Republic of Korea)
Gross tonnage:	7,406 tons
L x B x D:	127.47 m x 20.00 m x 10.70 m
Hull material:	Steel
Engine:	One diesel engine
Output:	5,920 kW
Propulsion:	4-brade fixed pitch propeller
Date of launch:	November 23, 2003

(See Photo 2.5-1.)

Photo 2.5-1 Appearance of Ship B when on-site investigation was conducted

2.5.2 Loading Condition

(1) Ship A

According to the statement of C/O A and the reply to the questionnaire by Company A_1, Ship A had about 12,015 t cargos of steel coils, steel pipes, heavy machines, and others on board when it left Yokohama-ku, Keihin Port. The draught forward was about 7.6m and the draught aft was about 8.3m.

(2) Ship B

According to the reply to the questionnaire by Company B_1, Ship B had 450 containers (gross weight: about 4,641.9 t) on board when it left Busan. The draught forward was about 6.2m and the draught aft was about 7.3m.

2.5.3 Destination according to AIS record

According to the AIS record, Ship A headed for offshore Kobe-ku, Hanshin Port and Ship B headed for Tokyo-ku, Keihin Port when the accident occurred.

2.5.4 Hull and engine

(1) Ship A

According to the general arrangement, Ship A was a docking-bridge type bulk carrier with two cargo spaces. It had two cranes in the hull center and one derrick [*3] on each of the bow and the bridge front.

[*3] "Derrick" is cargo handling equipment mounted on a ship. Booms, which can move up and down, right and left, are attached on a derrick post and multiple ropes on pulleys are used to operate the booms and the cargo hooks at the tip of the booms.

(2) Ship B

Ship B was a docking-bridge type container ship. When the on-site investigation was conducted, there were containers on the deck but the view from the bridge was clear. (See Fig. 2.5-1, Photo 2.5-2.)

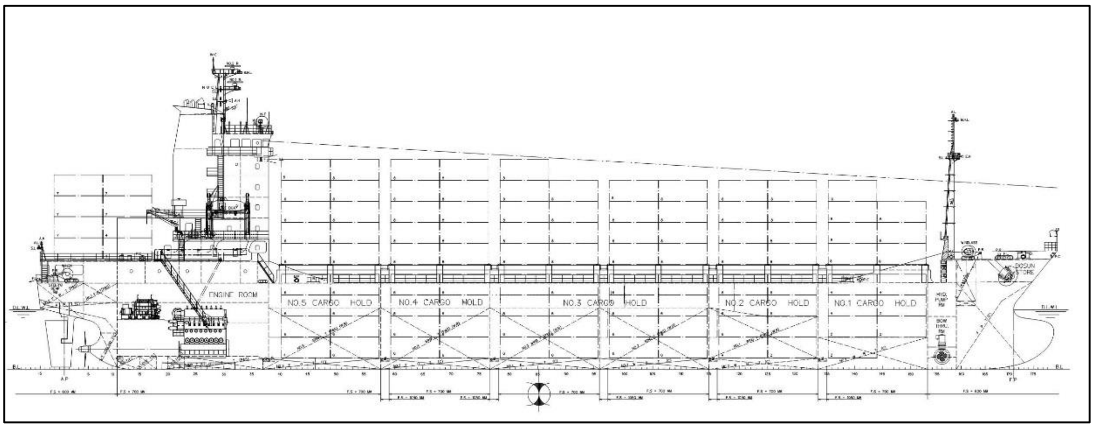


Fig. 2.5-1 General arrangement of Ship B

Photo 2.5-2 View from the bridge of Ship B when the on-site investigation was conducted

According to the statement of Master B and 2/O B, there was no failure or malfunction of the hull, engine, or machinery when the accident occurred.

2.5.5 Navigation equipment

(1) Ship A

According to the particulars table, there were a steering stand, two radars, GPS receiver, AIS, VHF, and others on the bridge.

(2) Ship B

On the bridge, there was a steering stand in the center, radar on each side of the stand, GPS receiver and AIS display above a chart table mounted on the starboard rear side, and VHF on the front wall. (See Fig. 2.5-2, Photo 2.5-3.)

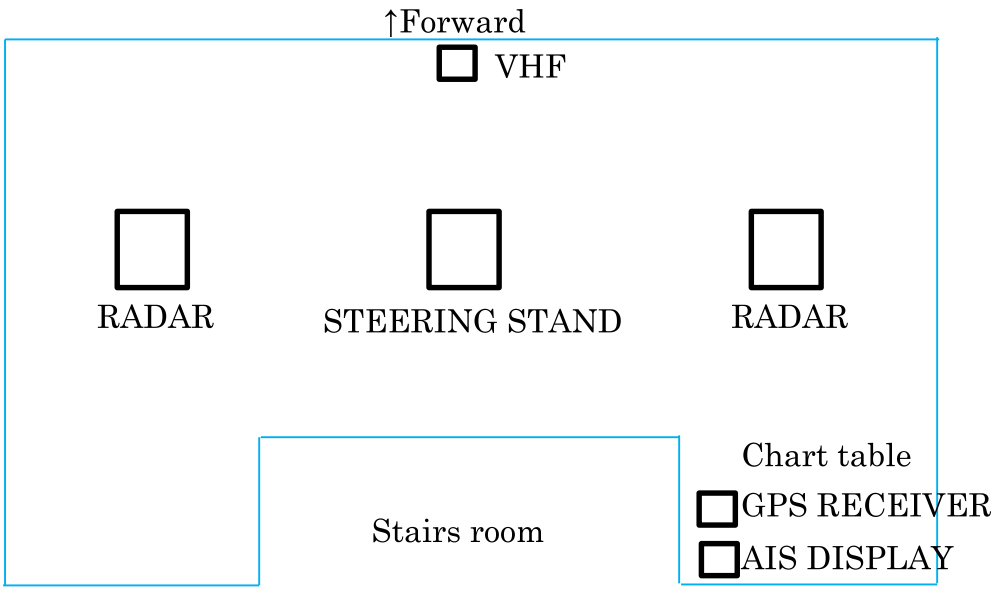


Fig. 2.5-2 Layout of navigation equipment of the bridge of Ship B

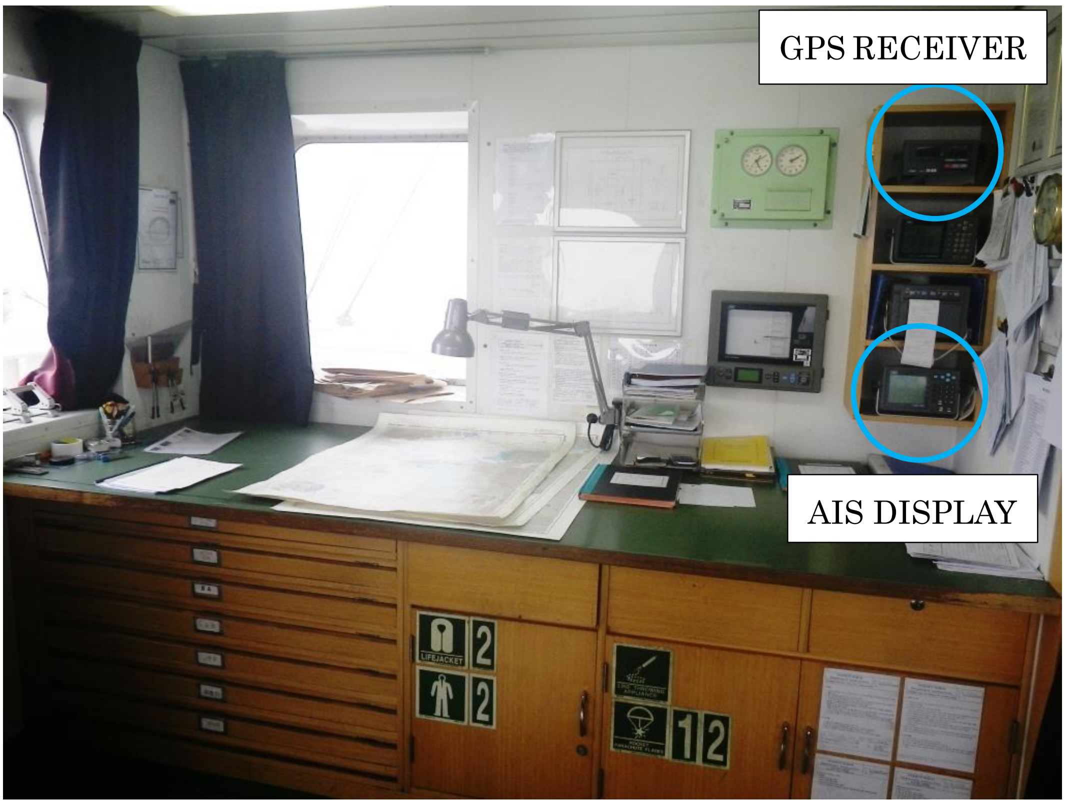


Photo 2.5-3 Chart table situation of Ship B

The AIS display of Ship B shows the position of a ship which transmits AIS information about the bearing and distance. If other ships are searched, various data of these ships are shown. The radar of Ship B did not have a function of overlaying AIS information.

2.5.6 Maneuverability of ships

(1) Ship A

The following is the maneuverability of Ship A according to the ship's particulars table and test record of official sea trail.

(i) Speed

Full load service speed	13.5 kn

(ii) minimum time of ship stop and reach (Ballast condition, Speed 15.6 kn)

Time of ship stop	3 min. 47 sec.
Track reach	950 m

(iii) Turning circle (Ballast condition)

	Port 35°	Starboard 35°
Speed	15.9 kn	15.5 kn
Advance[*4]	467 m	355 m
Tactical diameter[*5]	517 m	475 m

(2) Ship B

The following is the operability of Ship B according to the ships particulars table and test record of official sea trail.

(i) Speed

Navigational speed	16.75 kn

(ii) minimum time of ship stop and reach (Ballast condition, Speed 17.0 kn)

Time of ship stop	4 min. 30 sec.
Track reach	1,249 m

(iii) Turning circle (Ballast condition)

	Port 35°	Starboard 35°
Speed	16.8 kn	16.9 kn

[*4] "Advance" is the distance traveled in the direction of the original course by the midship point of a ship from the position at which the rudder order is given to the position at which the heading has changed 90° from the original course.

[*5] "Tactical diameter" is the distance travelled by the midship point of a ship from the position at which the rudder order is given to the position at which the heading has changed 180° from the original course. It is measured in a direction perpendicular to the original heading of the ship.

Advance	349.6 m	348.8 m
Tactical diameter	436.2 m	450.1 m
Time of 360° turn	4 min. 02 sec.	4 min. 09 sec.

2.5.7 Lifesaving appliances

(1) Ship A

The lifesaving appliances are the followings according to the ship's particulars table and the lifesaving appliances arrangement plan.

(i) Lifeboat and rescue boat

On the boat deck, there were a lifeboat with a capacity of 21 on the port side and a rescue boat with a capacity of 21 on the starboard side.

(ii) Liferaft

There were an inflatable liferaft with a capacity of 25 at the back of each of the lifeboat and the rescue boat, and an inflatable liferaft with a capacity of 6 on the forecastle deck.

(2) Ship B

The lifesaving appliances are the followings according to the ship's particulars table, general arrangement, and statement of Master B.

(i) Lifeboat and rescue boat

On the A deck, there were a lifeboat with a capacity of 18 on the starboard side and a rescue boat with a capacity of 18 on the port side.

(ii) Liferaft

There were an inflatable liferaft with a capacity of 20 at the back of each of the lifeboat and the rescue boat, and an inflatable liferaft with a capacity of 6 on the forecastle deck.

2.6 Weather and Sea Conditions

2.6.1 Weather data

Weather data obtained at Tateyama Special Regional Climate Observatory located about 18km southeast the accident place are the followings.

03:00 Weather - fine, Wind direction - ENE, Wind scale - 1, Visibility - 6.01 km

04:00 Weather - fine, Wind direction - S, Wind scale - 3, Visibility - 7.80 km

2.6.2 Current

According to the tide tables issued by Japan Coast Guard, the tide at the baymouth of

Tokyo Bay was in the northwest direction at about 1.2kn when the accident occurred.

2.6.3 Observation by crew

According to the statement of Officer C, the weather was fine with the wind scale 2 in the south-southwest direction and the visibility was fine.

2.7 Characteristics of the Area

2.7.1 Sailing directions

South and East Honshu coast sailing directions (published in March 2012) issued by Japan Coast Guard gives the following overview of Tokyo Bay and surrounding area and Sailing Direction 4th Edition (published in 2013) issued by UK Hydrographic Office gives a similar overview.

Tokyo wan is entered between Su-no-Saki and Tsurugi Saki, the enterance of which is Urada Suido; in the inside lie major ports such as Keihin Ko, Chiba Ko and Yokosuka Ko.

In Tokyo Wan, traffic is quite heavy with all types of vessels and large density of fishing vessels may be encountered in the vicinity of passages; so careful attention is required when navigation.

2.7.2 Scope of Maritime Traffic Safety Law

Maritime Traffic Safety Law and Maritime Traffic Safety Law stipulate the followings about the area covered by Maritime Traffic Safety Law.

(1) Maritime Traffic Safety Law

Chapter I. General Provisions

(Purpose of The Law and Applicable Sea Areas)

Article 1.

The purpose of this Law is to ensure the safety of ships' traffic by prescribing special modes of navigation and by effecting control for preventing danger to ships' traffic in the traffic congested areas.

2. This Law shall apply to the sea areas of Tokyo Wan, Ise Wan (Including the sea areas adjacent to the mouth of Ise Wan and those portions of Mikawa Wan which are adjacent to Ise Wan) and Seto Naikai, except such areas as are listed below, and the boundaries between these sea areas and other sea areas (excluding the areas listed below) shall be fixed by the Cabinet Order.

(i) Port areas under the Port Regulations Law (Law No. 174 of 1948);

(ii) Port and harbor areas prescribed in Article 2 Paragraph 3 of the Port and Harbor

Law (Law No. 218 of 1950) which are other than those under the Port Regulations Law;

(iii) Sea areas within fishing ports designated by the Minister of Agriculture, Forestry and Fisheries under Article 5 Paragraph 1 of the Fishing Port Law (Law No. 137 of 1950);

(iv) Sea areas along the coast, specified by the Cabinet Order as areas not normally navigated by vessels other than fishing vessels.

(2) Cabinet Order for the Enforcement of the Maritime Traffic Safety Law (Cabinet Order No.5 of 1973 as amended through Cabinet Order No.176 of 1984)

(Boundaries Between Sea Areas Where Maritime Traffic Safety Law is Applicable and Other Sea Areas.)

Article 1.

Boundaries between the sea areas where the Maritime Traffic Safety Law (hereafter referred to as "the Law") is applicable under Article 1 Paragraph 2 (these sea areas will hereafter be referred to as "the applicable sea areas") and other sea areas (excluding those mentioned in each item of the paragraph) shall be as shown in the following table:

Areas Where Applicable Sea Areas Are Located	Boundaries Between Applicable Sea Areas and Other Sea Areas
Tokyo Wan	A line drawn from Su-no-Saki Lighthouse (34° 58'19"N,139° 45'39"E) to Ken Saki Lighthouse (35° 08'17"N,139° 40'50"E)

2.7.3 Water depth of the foundering area of Ship A

According to the reply to the questionnaire by Company A_1, the water depth of the area where Ship A foundered, measured by ROV, was about 93m.

2.8 Safety Management of the Vessels

(1) Ship A

For the watch on the bridge, the safety management manual created by Company A_2 defined situation levels according to the surrounding situation and stipulated personnel arrangement and duty according to the situation level. (See Table 2.8-1 and Table 2.8-2.)

Table 2.8-1

Watch Condition	Ship's External Environment		
	Visibility	Waterway	Traffic
1	Unrestricted	Off-Shore	Light
2	Restricted	Coast	Moderate
3	Restricted	Separation	Heavy
4	Restricted	Pilotage	Heavy

Table 2.8-2

Bridge Team Duties by Watch Condition					
Watch Condition	Bridge Team Duty				
	Collision Avoidance	Communi-Cations	Navigation	Helm	Look Out
1	Watch Officer			AB	
2	Master	Officer		AB	
3	Master	One / Two Officer		AB	+AB
4	Pilot	Master / Officer		AB	+AB

(2) Ship B

The safety management manual created by Company B_2 stipulated the direction of a master as in the followings.

The master should command directly on the bridge when following situation;

1) When entering or leaving port
2) Following situation in coastal navigation
   i) When ship's position in doubt
   ii) When strong current effect ship's maneuvering performance
   iii) When obstructions such as fishing nets, float exist.
3) When passing narrow channel, canal or traffic separation scheme
4) When the condition of M/E or any navigational equipment is poor
5) When bounding mass-traffic or fishing group working area
6) When encountering rough weather or restrict visibility
7) When approaching major Wheel Over Points
8) Other expecting dangers to life or ship

2.9 International Standards of Bridge Watch

Item 3 and Item 3-1 of Section A-8-2 in Chapter 8 of mandatory standards in the Annex of STCW Convention[*6] designate the followings.

CAPTER VIII　STANDARDS REGARDING WATCHKEEPING

Section A-VIII/1　(omitted)

Section A-VIII/2　Watchkeeping arrangements and principles to be observed

PART 1 – PART 2　(omitted)

PART 3　WATCHKEEPING AT SEA

Principles applying to watchkeeping generally

8　(omitted)

9　The master of every ship is bound to ensure that watchkeeping arrangements are adequate for maintaining a safe navigational watch. Under the master's general direction, the officers of the navigational watch are responsible for navigating the ship safety during their periods of duty, when they will be particularly concerned with avoiding collision and stranding.

10 – 11　(omitted)

PART 3-1　PRINCIPLES TO BE OBSERVED IN KEEPING A NAVIGATIONAL WATCH

12　(omitted)

Look-out

13 -15　(omitted)

16　In determining that the composition of the navigational watch is adequate to ensure that a proper look-out can continuously be maintained, the master shall take into account all relevant factors, including those described in this section of the Code, as well as the following factors :

.1　visibility, state of weather and sea ;

.2　traffic density, and other activities occurring in the area in witch the vessel is navigating ;

.3　the attention necessary when navigating in or near traffic separation schemes or other routing measures

.4　the additional workload caused by the nature of the ship's functions, immediate operating requirements and anticipated manoeuvers :

.5　the fitness for duty of any crew members on call who are assigned as members of

[*6] "STCW Convention (The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers)" is an international convention on the standards of training, certification, and watchkeeping for crews established in 1978.

the watch ;

.6 knowledge of and confidence in the professional competence of the ship's officers and crew ;

.7 the experience of each officer of the navigational watch, and the familiarity of that officer with the ship's equipment, procedures, and manoeuvring capability ;

.8 activities taking place on board the ship at any particular time, including radio communication activities and the availability of assistance to be summoned immediately to the bridge when necessary ;

(the rest is omitted)

2. 10 Information of influence of oil spill on the environment and oil removal

2.10.1 Oil spill

According to the reply to the questionnaire by Company A_1, Ship A had, as fuel, about 39 t of heavy oil A and about 355 t of heavy oil C in addition to lubrication oil, and the fuel oil partially spilled from an air vent pipe of each tank after the foundering.

2.10.2 Influence on the environment

The influence of the oil spilled from Ship A after its foundering on the environment is the following.

(1) Chiba Prefecture

According to the reply to the questionnaire by Agriculture, Forestry and Fisheries Department, Chiba Prefecture, the floating oil began reaching the coast of Futtsu City, Kyonan Town, Minami-Boso City, and Tateyama City on March 19 and the fishery operators engaged in laver culture, fixed shore net fishing, edible brown algae collecting, fishery with fishing boats along the coast stopped the operation until April 30.

(2) Kanagawa Prefecture

According to the reply to the questionnaire by Environment and Agricultural Administration Office, Kanagawa Prefecture, the floating oil began reaching the coast of Miura City, Yokosuka City, Hayama Town, Zushi City, Kamakura City, and Fujisawa City on March 20, and the fishery operators engaged in edible brown algae and sea weed collecting stopped the operation until early June.

2.10.3 Information of oil removal

According to the reply to the questionnaire by Japan Coast Guard and Company A_1, the following countermeasures were taken to remove the oil spilled and spread from Ship A and prevent the oil spill.

(1) Oil removal

The floating oil in and around the area where the accident occurred was monitored by 83 airplanes (total number) of Japan Coast Guard in the period from March 18 to October 27 and oil removal works such as oil dispersing by water discharge or oil collecting were conducted by 280 patrol boats (total number) and oil removal company's ships arranged by Company A_1.

(2) Oil spill prevention

For the prevention of further oil spill from the fuel tanks of Ship A, a salvage company, under the request from Company A_1, closed the air vent pipe of each tank by April 12-24, removed oil from the tanks in the period from May 2 to June 1, and collected about 49.5 t of oil and about 187.0 t of water-mixed oil.

2.11 Survey on Foundering of Ship A

A survey of water immersion situation and hull posture changes of Ship A in the foundering process was outsourced to National Maritime Research Institute, and the outline of the survey results is the followings.

(1) The stability was sufficient, according to the loading condition when Ship A left the port.

(2) The amount of water came from the tear was about 3,450 m^3, 6,170 m^3, and 8,970 m^3 respectively in 20 seconds, 40 seconds, and 60 seconds after the start of the water immersion.

(3) The tear was caused between the hull center and the bow on the port side. At first, water came into the ballast tank on the port, causing tilting of about 8° on the port side. As the amount of water coming into the cargo space increased, the tilting on the port side reduced and the trim by the head developed with the lapse of time.

(4) The amount of water inside the ship was about 1,200 t in 65-70 seconds after the start of the water immersion and the buoyancy became smaller than the ship weight. Then the ship began foundering 65 seconds after the start of the water immersion.

2.12 Similar accident and traffic situation in and around the accident area

2.12.1 Similar accident in and around the accident area

According to the ship accident hazard map[*7] of the Japan Transport Safety Board, four

[*7] "Ship accident hazard map" is an internet service provided by the Japan Transport Safety Board where ship accidents and navigation safety are presented on a world map.
URL:http://jtsb.mlit.go.jp/hazardmap/

collision accidents between ships heading for south entrance of the Uraga Suido traffic route and those leaving the traffic occurred in the accident area and the accident date, ship on the north, ship on the south, registry, and gross tonnage are given in Table 2.12.

Table 2.12 similar accidents

No.	Time of Accident	North-bound (Gross tonnage)	South-bound (Gross tonnage)
①	04:42, Sep. 02, 1997	Foreigners flag 11,964 tons	Japanese flag 499.95 tons
②	18:30, Oct. 07, 1998	Foreigners flag 7,073 tons	Japanese flag 499 tons
③	18:10, Jan. 25, 2000	Japanese flag 4,375 tons	Foreigners flag 9,810 tons
④	05:18, Apr. 13, 2006	Foreigners flag 6,182 tons	Japanese flag 498 tons

2.12.2 Traffic situation in and around the accident area

According to the AIS information, among the ships transmitting AIS information and navigating in the 0.5M north and south area around the accident area 24 hours before the accident (03:00, March 17, 2014 to 03:00, March 18, 2014), 150 north-bound ships headed for Uraga Suido traffic route and 152 south-bound ships left Uraga Suido traffic route. (See Figs. 2.12-1 and 2.12-2.)

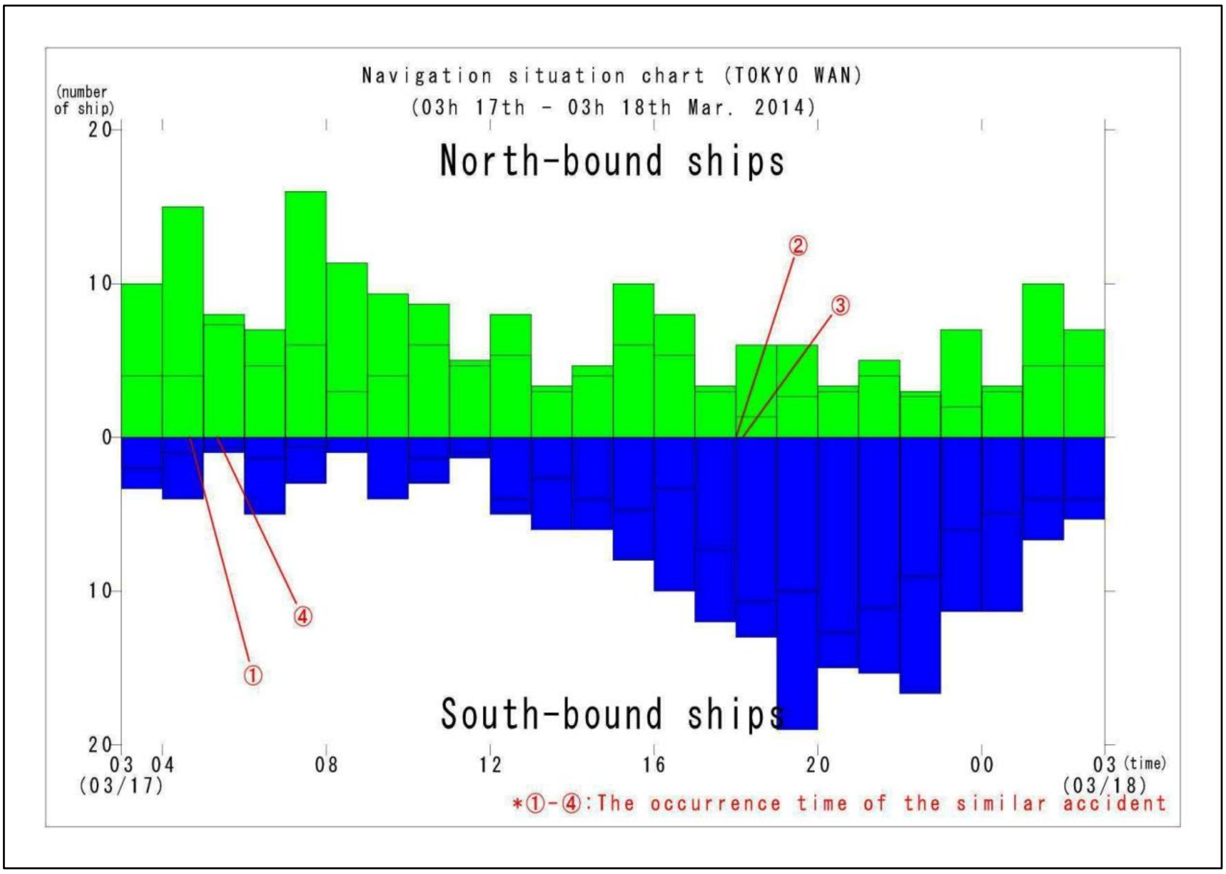


Fig. 2.12-1 Navigation situation chart in different time ranges

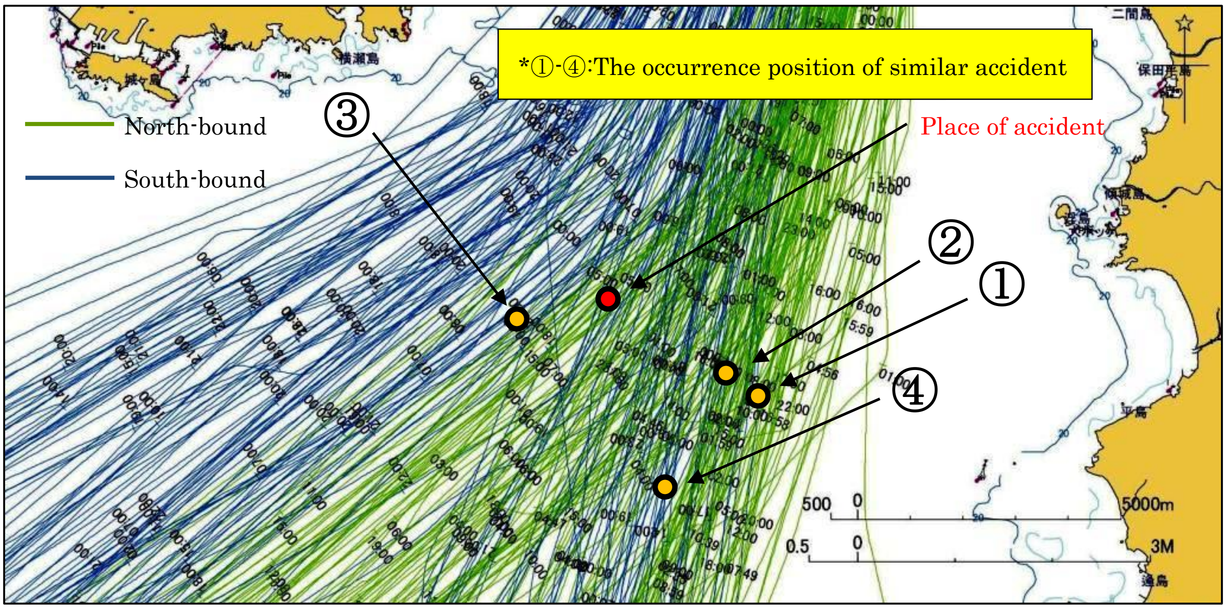


Fig. 2.12-2 Track chart of ships in the accident area (24 hours before the accident)

3 ANALYSIS

3.1 Situation of the Accident Occurrence

3.1.1 Analysis on relative bearing and distance between Ship A and Ship B

From 2.1.1, it is probable that the relative bearing and distance between Ship A and Ship B at each time of 03:06:01, 03:06:30, 03:07:20, 03:08:10, 03:08:31, 03:09:41, and 03:10:13 are as given in Table 3.1.

(See Attached Fig. 2 Situation of Ship A and Ship B approaching each other.)

Table 3.1 Relative bearing and distance between Ship A and Ship B

Time (H:M:S)	From A to B(°)		From B to A(°)		Distance (M)
	True	Relative	True	Relative	
03:06:01	224	S 19.7	044	P 11.3	1.86
03:06:30	224	S 20.4	044	P 9.6	1.66
03:07:20	227	S 19.7	047	S 5.7	1.31
03:08:10	231	S 8.3	051	S 5.3	0.96
03:08:31	233	S 5.1	053	S 6.1	0.81
03:09:41	239	P 23.3	059	S 16.7	0.32
03:10:13	236	P 64.2	056	S 25.8	0.10

*The bearing and distance at 03:06:30 and 03:09:41 were estimated from the AIS record of Ship A and the relative bearing is the bearing of the counterpart ship based on the heading of Ship A or Ship B. S and P indicate starboard and port, respectively.

3.1.2 Analysis on the heading and turning angular velocity of Ship A and Ship B

From 2.1.1, it is probable that the turning round angular speed calculated from the heading at each time of Ship A and Ship B was as follows.

(1) Ship A

The turning angular velocity of Ship A arose on the starboard side at around 03:07:20 and increased at around 03:09:15 until around 03:10:26.

(2) Ship B

The turning angular velocity of Ship B arose on the port side at around 03:06:30, continued until around 03:07:10, arose slightly and converged on the starboard side until around 03:08:10, arose on the port side from around 03:09:41 to around 03:10:07, and increased on the port side again at around 03:10:20.

(See Attached Fig. 3 Heading and turning angular velocity of Ship A, Attached Fig.4 Heading and turning angular velocity of Ship B.)

3.1.3 Course of the events

From 2.1.1, 2.1.2, 3.1.1, and 3.1.2, the situation were as follows.

(1) Ship A

(i) It is probable that Ship A left Yokohama-ku, Keihin Port for Kobe-ku, Hanshin Port at around 00:42, March 18, 2014.

(ii) It is highly probable that Ship A navigated at the heading of 205° and at about 13kn during the period from 03:00:00 to 03:06:59.

(iii) It is highly probable that Ship A turned to starboard at the position about 1.31M from Ship B at around 03:07:20.

(iv) It is probable that Ship A began increasing the turning angular velocity to the starboard side since around 03:09:15 and collided with Ship B.

(2) Ship B

(i) It is probable that Ship B left Busan Port, Republic of Korea for Tokyo-ku, Keihin Port at around 09:05, March 16, 2014 (local time).

(ii) It is highly probable that Ship B navigated at the heading of 055° and at about 13kn during the period from 03:01:10 to 03:06:01, March 18, 2014.

(iii) It is highly probable that Ship B began turning to port at the position about 1.66M from Ship A at around 03:06:30 and proceeded straight at the heading of about 046° during the period from 03:08:10 to 03:09:31.

(iv) It is highly probable that Ship B turned to port at the position about 0.32M from Ship A at around 03:09:41.

(v) It is probable that Ship B stopped turning to port at the heading of 030° at around 03:10:07 and then collided with Ship A.

3.1.4 Date and time of the accident

From the followings, it is highly probable that the accident occurred at around03:10, March 18, 2014.

(1) From 2.1.1, Ship B's speed began decreasing at around 03:10:20.

(2) From 2.1.1, 2.1.2, 3.1.2, and 3.1.3, it is probable that Ship B stopped turning to port at around 03:10:07, which was due to the steerage of taking helm hard to starboard, but Ship B began turning to port at around 03:10:20.

(3) From 2.5.6 and 3.1.2, the turning angular velocity of Ship B was about 4.5°/s at

around 03:10:20, which exceeded about 1.5°/s the average turning angular velocity of making 360° turn at port 35°.

3.1.5 Place of the accident

From 3.1.4, it is highly probable that the bow position of Ship B at around 03:10 was around 35°05.7′ N and 139°43.2′ E (about 143° 3.5M from Tsurugisaki lighthouse).

3.1.6 Death and injuries to persons

From 2.1.3 and 2.2, the situation was a follows.

(1) Ship A

C/E A, Head Chef A, BSN A, 2/O A, Trainee A_1, and No. 1 Oiler A died of drowning.

2/E A died of unknown cause.

Master A and Trainee A_2 are missing.

(2) Ship B

It is probable that C/O B had the vertebra broken since the lifeboat with C/O B on fell down to the sea when it was being lowered.

3.1.7 Damage to ships

From 2.1.3, 2.1.4, and 2.3, it is probable that Ship A foundered due to a tear on the side shell plating of the central port and a buckling at the bow and a crack at the side shell plating of the central port were caused in the foundering, and that Ship B had a buckling at the bow and a damage at the bow thruster.

3.1.8 Situation of collision

From 2.1.1, 2.1.2, 3.1.3, and 3.1.7, it is probable that the central port of Ship A which was turning to starboard and the bow of Ship B collided with each other at almost right angle and the bow of Ship B got into the side shell plating of the central port of Ship A.

3.1.9 Analysis on foundering situation of Ship A

From 2.1.1, 2.1.3, 2.1.4, 2.7.3, 2.11, and 3.1.7, the situation was as follows.

(1) It is somewhat likely that the bow of Ship A and that of Ship B headed in the same direction and the bow of Ship B was detached from the central side shell plating on the central port of the hull of Ship A because the heading of Ship A was 331° at around 03:11:05 and that of Ship B was 339° at around 03:11:03.

(2) It is probable that water came in Ship A through the tear on the side shell plating

on the central port and Ship tilted toward the port and bow sides and that the bow of Ship A began foundering about 65 seconds after the start of the water immersion.

(3) It is probable that, after the front side of the deck house of Ship A foundered, the bow reached the seafloor about 93m deep and the its foundering stopped and that only the rear side of the deck house and the stern remained above the sea and then the stern gradually foundered. (See Fig. 3.1.)

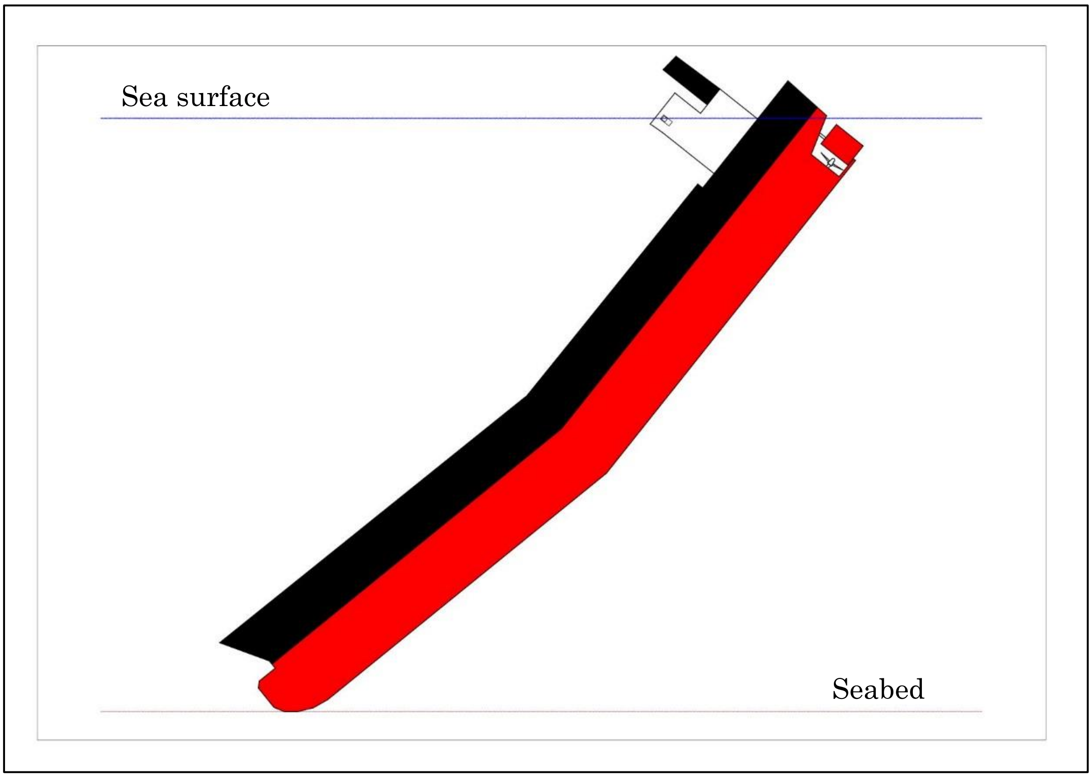


Fig. 3.1 Bow of Ship A reaching the seafloor

(4) It is probable that Ship A completely foundered under the sea at around 04:00.

3.2 Causal Factors of the Accident

3.2.1 Analysis on crews and ship situation

From 2.4 and 2.5.4, the situations were as follows.

(1) Crews

(i) 2/O A had a legal and valid endorsement attesting the recognition of certification. It is probable that 2/O A had about two-month experience on Ship A.

(ii) 2/O B had a legal and valid endorsement attesting the recognition of certification. It is probable that 2/O B had about one-month experience on Ship B.

(2) Ships

(i) The condition of the hull, engine, and machinery of Ship A could not be clarified since 2/O A died in the accident and Ship A foundered.

(ii) It is probable that Ship B had no failure or malfunction of the hull, engine, and machinery.

3.2.2 Analysis on weather and sea conditions

From 2.6.3, it is probable that the weather was fine with south-southwest wind of wind scale 2 and the visibility was good when the accident occurred.

3.2.3 Analysis on situation of look-out, maneuvering

From 2.1.1, 2.1.2, 3.1.1, 3.1.3, and 3.1.8, the situation was as follows.

(1) Ship A

(i) After Ship A navigated out of the south exit of the Uraga Suido traffic route, Master A left the bridge at around 02:45, 2/O A and A/B A_1 took charge of the watch on the bridge, and Ship A navigated by automatic steering southeast offshore Turugizaki, heading south-southwest.

(ii) It is probable that, on Ship A, under the direction from 2/O A to make starboard 10°, A/B A_1 made starboard 10° manually and then noticed the starboard sidelight of Ship B ahead.

(iii) It is somewhat likely that 2/O A did not notice Ship B starboard ahead since Ship A turned to starboard at around 03:07:20 when Ship B turned to port at around 03:06:30 and was approaching to Ship A to pass it by on the starboard side.

(iv) The situation of look-out by 2/O A could not be clarified since 2/O A died in the accident.

(v) It is probable that, since Ship A began increasing the turning angular velocity to the starboard side since around 03:09:15, 2/O A noticed that Ship A was approaching to Ship B at around 03:09 and made a direction of taking helm hard to starboard.

(2) Ship B

(i) It is probable that, on Ship B, 2/O B and A/B B took charge of the watch on the bridge and Ship B navigated southeast offshore Turugizaki by automatic steering, heading northeast.

(ii) It is probable that 2/O B first recognized Ship A at around 4M port ahead by radar and a starboard sidelight of Ship A by binoculars and that, since it seemed that both ships were in crossing situation, 2/O B that Ship A would alter the course to avoid Ship B

(iii) It is probable that, since Ship A approaching about 2M port ahead seemed not trying to avoid Ship B, 2/O B on Ship B decided to turn to port and pass by Ship A on the starboard side and turned the course setting dial counterclockwise and then Ship B turned to port.

(iv) It is probable that, when Ship B turned to port and proceeded straight, 2/O B noticed that Ship A at around 0.5M starboard ahead was turning to starboard, decided that collision could not be prevented even if Ship B turned to starboard at that timing, directed A/B B to make port 20°, and shortly flashed a daylight signaling light twice to Ship A.

(v) It is probable from the above (iii) and (iv) that 2/O B did not conduct look-out properly.

(vi) It is probable that 2/O B found four or five flashes from Ship A, thought that Ship A was trying to point out that Ship B's turning to port was inappropriate, and then directed A/B B to take helm hard to starboard and to proceed full astern.

3.2.4 Analysis on communication

From 2.1.2, 2.1.4, and 3.2.3, the situation was as follows.

(1) It is probable that 2/O B on Ship B used a daylight signaling light to make two flashes to Ship A immediately before the collision.

(2) It is probable that, when Ship B was about to pass by Ship A on the starboard side because 2/O B that Ship A did not try to alter the course to avoid Ship B, 2/O B on Ship B did not use light signal, sound signal, or VHF to Ship A.

(3) Therefore, it is somewhat likely that Ship A could have noticed Ship B and the accident could have been prevented if Ship B had used light signal, sound signal, or VHF at an early timing and communicated about intension of the maneuvering.

3.2.5 Analysis on the use of AIS information

From 2.1.2, 2.1.4, 2.5.3, 2.5.5, and 3.2.4, the situation as follows.

(1) It is probable that 2/O B did not expect Ship A's turning to starboard since 2/O B tried to turn to port and pass by Ship A on the starboard side.

(2) It is somewhat likely that, since AIS information of Ship A indicated that the destination of Ship A was offshore Kobe-ku Hanshin Port, 2/O B could have asked Ship A about the maneuvering by using VHF and have taken appropriate responses if he had used the AIS information.

(3) It is probable that, since Ship B had a the AIS display mounted on a chart table located at the rear side of the bridge, it was not easy for a bridge watch to operate the AIS display and use AIS information at night.

(4) It is therefore somewhat likely that, if an AIS display is set on the bridge front or others for the bridge watch to use AIS information easily, 2/O B could have responded appropriately using the AIS information of Ship A.

3.2.6 Analysis on the watch on bridge

From 2.1.2, 2.7.2, 2.8, 2.9, 2.12, 3.1.3, 3.1.4, and 3.2.3, the situation was as follows.

(1) It is probable that the past similar accidents occurred in the time range when north-bound ships and south-bound ships gathered and the accident occurred at the time when north-bound ships gathered.

(2) It is probable that the place of the accident and those of the past similar accidents were where many ships navigating between West Japan and Tokyo Bay alter courses, coming close to and moving away from many ships navigating between East Japan and Tokyo Bay, and that the place of the accident and those of the past similar accidents were the area to which Maritime Traffic Safety Law was applied.

(3) It is probable that Master A was not on the bridge of Ship A when the accident occurred.

(4) It is probable that since 2/O B on Ship B received the direction of notifying Master B when Ship B reached the entrance of Nakanose traffic route, Master B was not on the bridge when the accident occurred.

(5) It is somewhat likely that, since many north-bound ships usually gather at the time when the accident occurred and many ships alter course, coming closer to and moving away from each other, in the sea area where the accident occurred and since Maritime Traffic Safety Law was applied to this area, Ship A and Ship B could have avoided the accident if the master had not only let the officer to maneuver the ship but had taken the conn.

3.2.7 Analysis on the accident occurrence

From 3.1.1, 3.1.3, and 3.2.3, the situation was as follows.

(1) Ship A

(i) It is probable that, after Ship A navigated out of the south exit of the Uraga Suido traffic route, Master A left the bridge at around 02:45 and 2/O A and A/B A_1 took charge of the watch on the bridge and Ship A navigated by automatic steering at about 13kn southeast offshore Turugizaki, Miura City, Kanagawa Prefecture, Japan, heading south-southwest.

(ii) It is probable that, on Ship A, under the direction from 2/O A to make starboard 10°, A/B A_1 made starboard 10° manually and then at around 03:07:20, Ship A turned to starboard at the position about 1.31M from Ship B starboard ahead.

(iii) It is somewhat likely that 2/O A did not notice Ship B starboard ahead since Ship A turned to starboard after Ship B turned to port.

(iv) The situation of look-out by 2/O A could not be clarified since 2/O A died in the accident.

(v) It is probable that Ship A took helm hard to starboard at around 03:09 but collided with Ship B.

(2) Ship B

(i) It is probable that, on Ship B, 2/O B and A/B B took charge of the bridge watch and Ship B navigated southeast offshore Turugizaki by automatic steering at about 13kn, heading northeast.

(ii) It is probable that 2/O B first recognized Ship A at around 4M port ahead by radar and a starboard sidelight of Ship A by binoculars and that, since it seemed that both ships were in crossing situation, 2/O B that Ship A would alter the course to avoid Ship B.

(iii) It is probable that, since Ship A 2M port ahead seemed not trying to avoid Ship B, 2/O B on Ship B decided to turn to port and pass by Ship A on the starboard side and turned the course setting dial counterclockwise and then Ship B turned to port at the position about 1.66M from Ship A at around 03:06:30.

(iv) It is highly probable that Ship B was proceeding straight from 03:08:10 to 03:9:31.

(v) It is probable that, on Ship B, 2/O B noticed that Ship A at around 0.5M starboard ahead was turning to starboard and directed A/B B to make port 20° and shortly flashed a daylight signaling light twice to Ship A, and that Ship B turned to port at the position about 0.32M from Ship A.

(vi) It is probable that, since 2/O B kept proceeding straight without noticing Ship A's turning to starboard until Ship A came to the position about 0.5M starboard ahead, 2/O B did not make look-out properly.

(vii) It is probable that, on Ship B, 2/O B found four or five flashes from Ship A and that Ship A was trying to point out that Ship B's turning to port was inappropriate, that 2/O B gave a direction to take helm hard to starboard and to proceed full astern, and that Ship B's turning to port stopped when the heading was 030° and Ship B collided with Ship A.

3.3 Analysis on rescue and damage relief measure

From 2.1.3 and 3.1.9, it is probable that the rescued crews of Ship A, namely C/O A, 3/O A, A/B A_2, A/B A_3, O/S A_1, O/S A_2, 1/E A, 3/E A, Oiler A_1, and Oiler A_2, except A/B A_1 who was on the bridge and rescued by the rescue boat of Ship B, were rescued by the patrol boat and Ship C because they stayed outside the accommodation area from the beginning of the foundering of the bow until 04:00 when the entire hull sank under the sea and they boarded, after Ship A foundered, the liferaft and wood board.

3.4 Analysis on Influence of Oil Spill to the Environment and its Removal

3.4.1 Influence of oil spill on the environment

It is probable from 2.10.1 and 2.10.2 that the fuel oil of Ship A partially spilled from an air vent pipe of each tank, reached the coasts in Chiba Prefecture and Kanagawa Prefecture, and gave damages to the fishery to these two prefectures, resulting in partial suspension on of fishery.

3.4.2 Analysis on oil removal

It is probable from 2.10.3 that the fuel oil of Ship A kept spilling out until the air vent pipe of each tank was closed and the oil removal works such as oil dispersing by water discharge or oil collecting were conducted until October 27 by the patrol boats and oil removal company's ships arranged by Company A_1.

4 CONCLUSIONS

4.1 Probable Causes

It is probable that the accident occurred because, when Ship A was navigating in south-southwest direction and Ship B was navigating in northeast direction at night and the both ships came closer to each other, Ship A turned to starboard, Ship B turned to port and kept proceeding straight, and the both ships collided with each other.

It is somewhat likely that Ship A turned to starboard because 2/O A of Ship A did not notice Ship B in the starboard ahead.

It is probable that Ship B kept proceeding straight because, after Ship B turned to port for passing by Ship A on the starboard side, 2/O B of Ship B did not conduct look-out properly and hence could not notice that Ship A in the starboard ahead turned to starboard.

4.2 Other Discovered Safety-Related Matters

It is somewhat likely that Ship A could have noticed Ship B and the accident could have been prevented if Ship B had used light signal, sound signal, or VHF at an early timing and communicated about intension of the maneuvering.

It is therefore somewhat likely that, if Ship B had had an AIS display on the bridge front or others for the bridge watch to use AIS information easily, 2/O B could have responded appropriately using the AIS information of Ship A and might predict Ship A's turning to starboard.

It is somewhat likely that Ship A and Ship B could have prevented the accident if their masters had not let only the officers maneuver the ships but take the conn of the ships.

5 SAFETY ACTIONS

It is probable that the accident occurred because, when Ship A was navigating in south-southwest direction and Ship B was navigating in northeast direction at night in the baymouth of Tokyo Bay southeast-offshore Tsurugizaki and the both ships approached closer to each other, Ship A turned to starboard, Ship B turned to port and kept proceeding straight, and the both ships collided with each other.

Therefore the following measures need to be taken to prevent similar accidents.

(1) Ship operators shall at all times make look-out properly.

(2) Ship operators shall use light signal, sound signal, or VHF at an early timing and communicate about intention of the maneuvering.

(3) The ship owner and others shall install an AIS display on the bridge front for the bridge watch to use AIS information easily, and the bridge watch shall use the AIS information effectively.

(4) The baymouth of Tokyo Bay is usually congested with ships, and many of them alter course, coming closer to and moving away from each other. Since Maritime Traffic Safety Law is applied to this area, the ship owners and others shall consider specific measures for ship masters to go to the bridge and take the conn depending on situations in the baymouth of Tokyo Bay.

5.1 Safety Actions Taken

5.1.1 Actions taken by Company A_2

After the accident, Company A_2 notified the ships under their management to follow the followings.

.1 Master has a responsibility to set proper Bridge Watch and ensure a proper vessel lookout. The Bridge Watch set shall be clearly and logged in Deck Logbook.

.2 A change of Bridge Watch Condition (i.e., from Bridge Watch I to Bridge Watch II does not automatically change the command. Upon a change of Bridge Watch Condition, the command will still remain with the Deck Watch Officer who had it before the change of Bridge Watch condition. Any subsequent change of command must be orders verbally, acknowledged, and logged in deck Logbook.

.3 All personnel, including officers and unlicensed seamen who may be assigned to any duty station in any Bridge Watch, shall understand fully the duties excepted of them. It is Master's responsibility to ensure that all officers and crew members are properly-trained.

.4 When underway, Bridge Watch Condition shall be set at Master's direction and discretion according to prevailing conditions as follows:

Bridge Watch Condition

A-Open Waters:

Clear weather, little or no traffic - I

Clear weather, higher density traffic - II

Restricted visibility, little or no traffic - II

Restricted visibility, higher density traffic - II or III

B-Restricted Water (Limited Manoeuvring Room):

Clear weather, little or no traffic - II

Clear weather, higher density traffic - II or III

Restricted visibility, little or no traffic - II

Restricted visibility, higher density traffic - II or III

C-Entering or Leaving Port:

Clear weather, little or no traffic - II

Clear weather, higher density traffic - II or III

Restricted visibility, little or no traffic - II or III

Restricted visibility, higher density traffic - II or III

D-At Any Time When the Following Condition Exist:

High navigational intensity plus collision avoidance - II or III

5.1.2 Actions taken by Company B_2

After the accident, Company B_2 revised the navigation procedure in the safety management manual in the following way.

(1) During the night navigation, the Master shall be provided the Night Order in handwritten format to duty officers before going to take a rest.

(2) To ensure the ship's safe navigation, the Master should follow the regulation (Table-1

Master Calling Point) which set by D.P. (Revision items of Table-1 can control be effected date)

(3) During navigation, Duty officer should operate Two Radar when situation of chapter 4.2.1 is applied or similar situation is expected.

(4) The chief engineer should always keep the main engine ready for use and educate in the newly joined duty officer and thereafter educate the all duty officers at least more than once per quarter about operation and characteristics of the main engine.

5.2 Safety Actions Required

Companies A_2 and B_2 are desired to take the following countermeasures to prevent collision accidents similar to the present one.

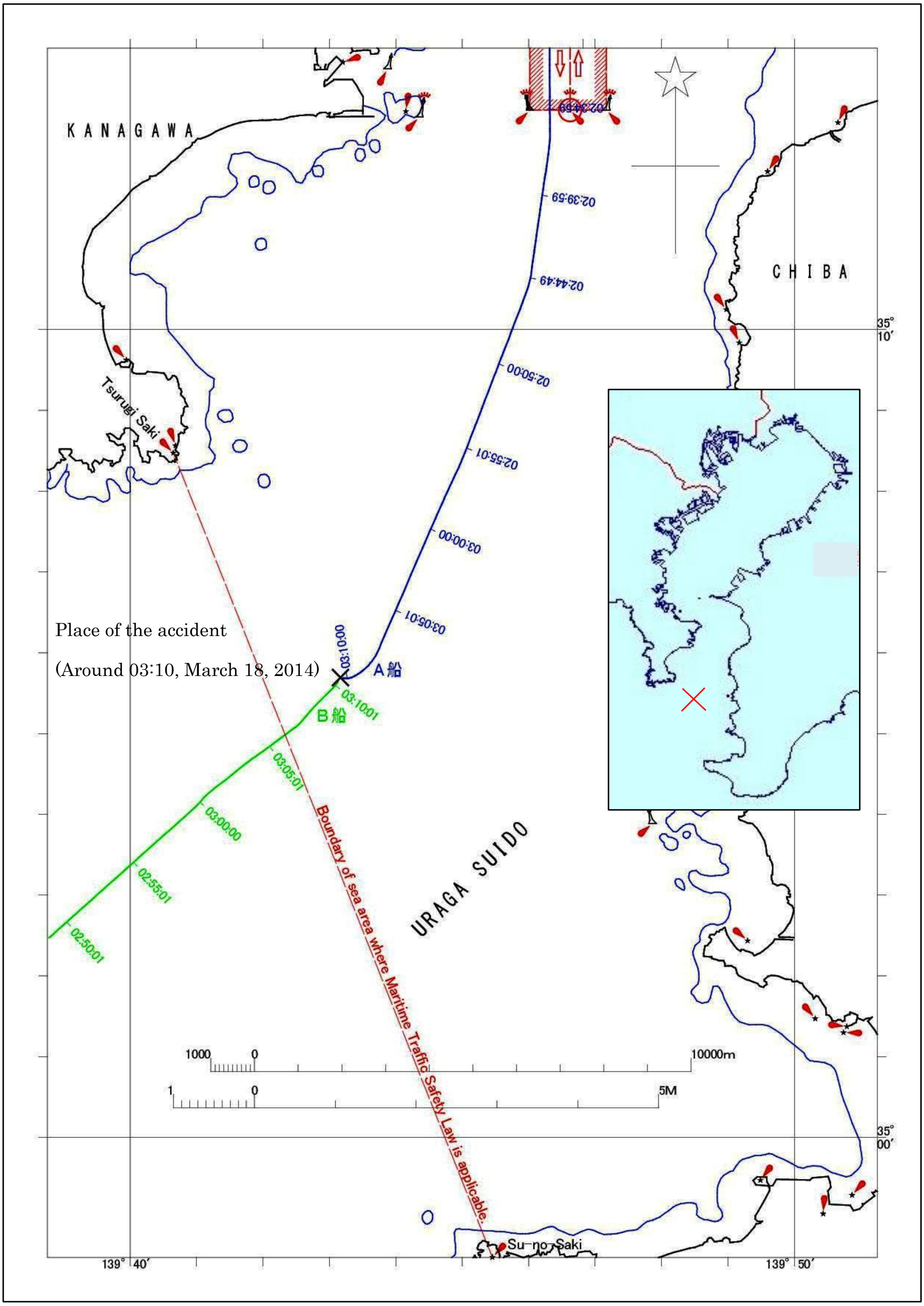
(1) Company A_2

The baymouth of Tokyo Bay is usually congested with ships, and many of them alter course, coming closer to and moving away from each other. Since Maritime Traffic Safety Law is applied to this area, Company A_2 shall consider specific measures for ship masters to go to the bridge and take the conn depending on situations in the baymouth of Tokyo Bay.

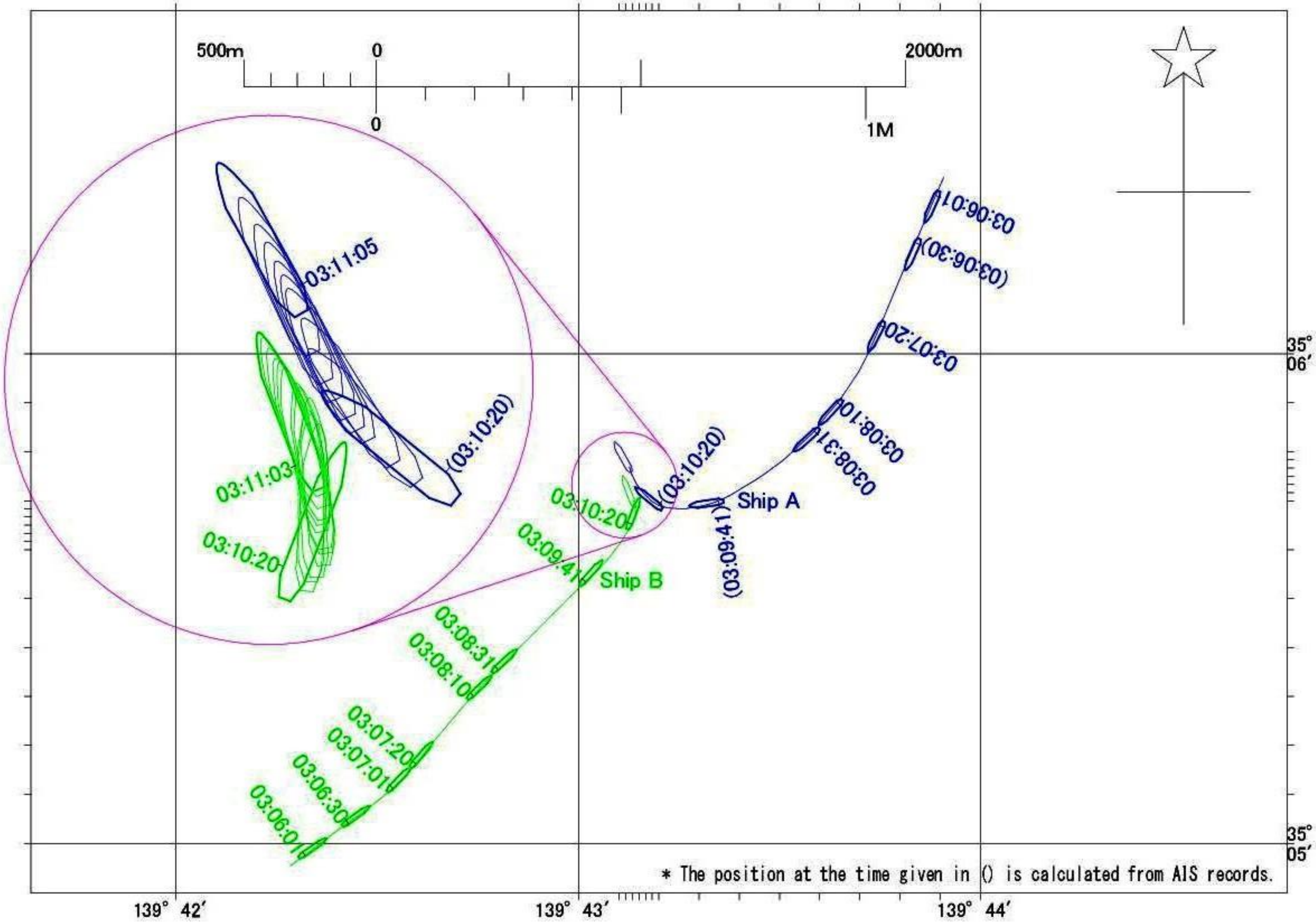
(2) Company B_2

Company B_2 shall set an AIS display on the bridge front for the bridge watch to use AIS information easily, and instruct the bridge watch to use the AIS information effectively.

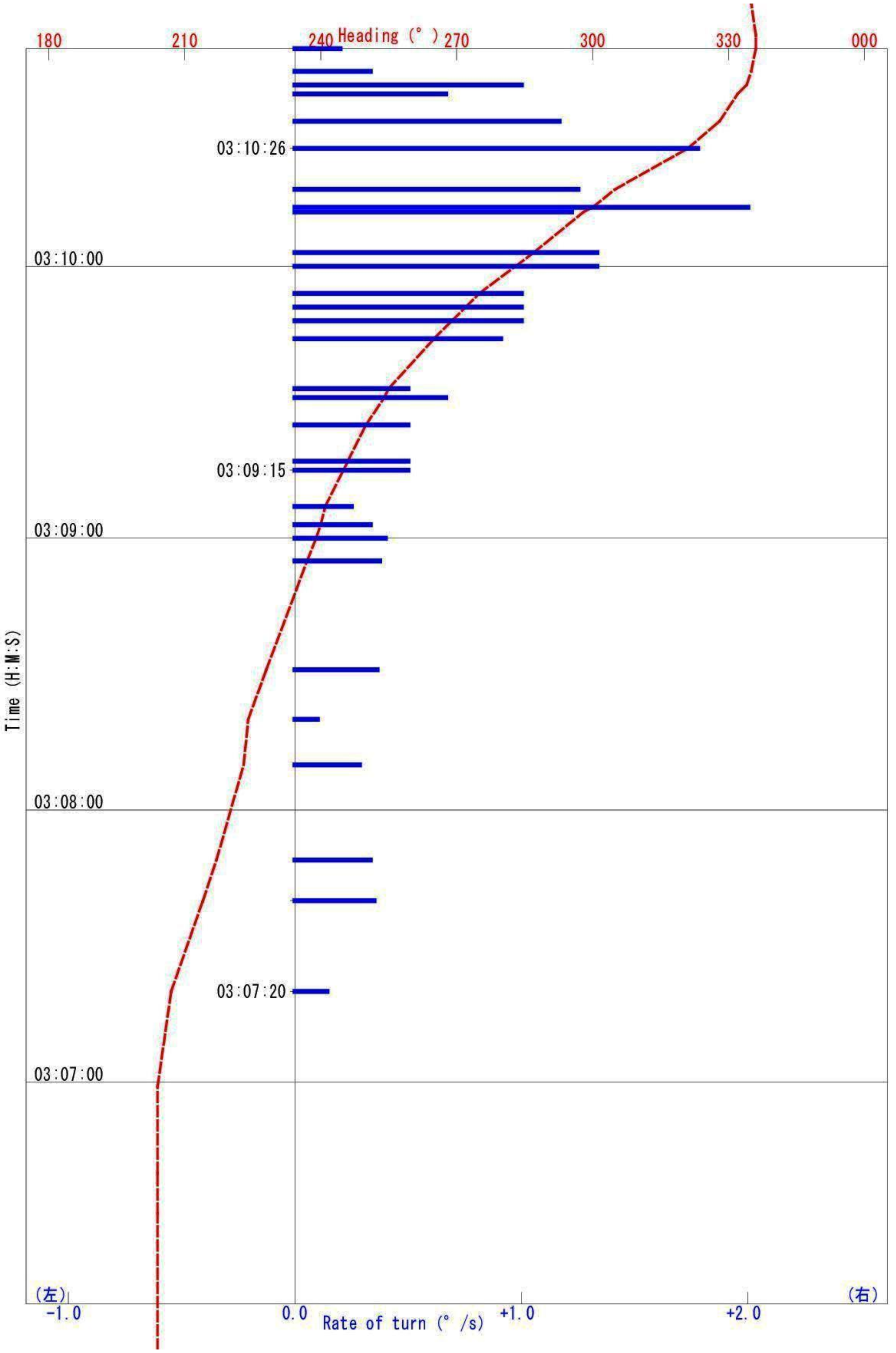
Attached Fig. 1　Navigation course



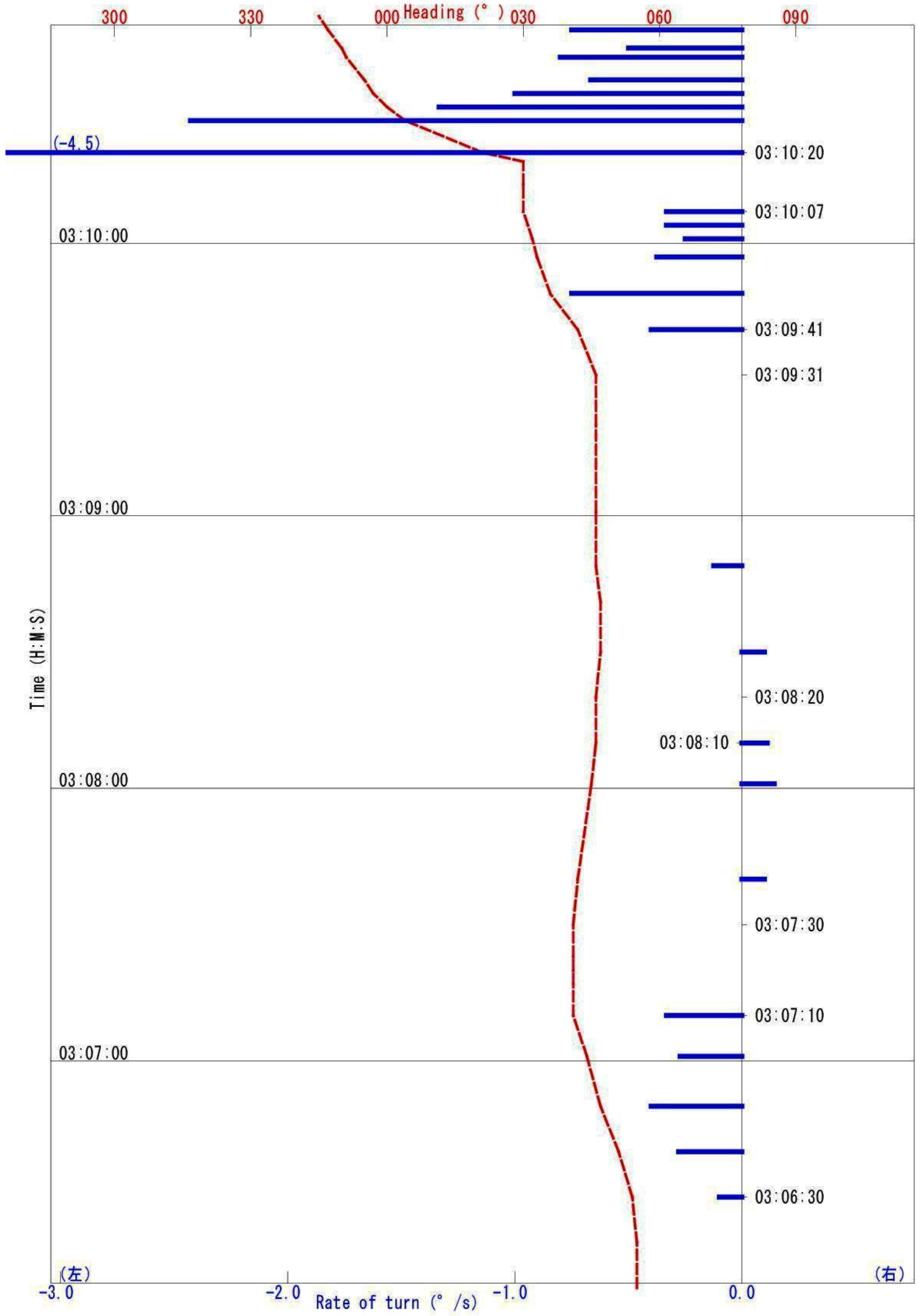
Attached Fig. 2 Situation of Ship A and Ship B approaching each other



Attached Fig. 3　Heading and turning angular velocity of Ship A



Attached Fig. 4 Heading and turning angular velocity of Ship B



Report
of analytical research on the sinking after collision accident off the Miura Peninsula

September, 2015

National Research and Development Corporation: National Maritime Research Institute

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1. Introduction

1.1. The purpose of research

This analysis research is aimed for analyzing the mechanism that led the ship A to foundering by estimating the stability of the ship A after the accident in order to contribute to the investigation of the collision accident of the ship A and the ship B which occurred off the Miura Peninsula on March 18, 2014.

1.2. Overview of the research

The figures and drawings used in this analysis research were provided by the Japan Transport Safety Board.

(i) Estimation of the stability performance just before the accident

The stability of vessel A at the time of the accident was estimated from the estimated center of gravity of the vessel A based on the amount (weight) of the fuel, fresh water, and draft at the time of departure, and consumption of fuel and fresh water.

(ii) The volume of the flooded water from the damage (hole) estimated based on the results of the underwater survey of vessel A

The shape of the broken hole was estimated from the results of diving survey, the volume of the flooded seawater was estimated taking into account of the attitude change of the vessel due to the flood of seawater has been calculated.

(iii) Estimation of the impact of the flooded seawater on the balance of the hull weight and buoyancy, based on the loading condition of vessel A

The attitude change of vessel A was estimated based on the seawater volume obtained from the loading condition and from (ii).

(iv) Investigation on the mechanism of sinking based on the condition of vessel A immediately before the accident and the flooded seawater due to the collision.

The mechanism that lead to the sinking was studied from the results of the above.

2. Estimated stability at the time of the accident

The center of gravity of vessel A has been estimated based on the estimated condition of the vessel at the departure time of the day of the accident that was estimated from the loading plan, the statement of the chief officer, and the "Stability Information for Master and Loading Manual" The stability of vessel A in that situation was also estimated.

2.1. Ship's particulars

The principal particulars of vessel A is shown in Table 2-1.

Table 2-1 The principal particulars

LENGTH (O.A.)	129.90 m
LENGTH (P.P.)	122.00 m
BREADTH (MLD)	23.00 m
DEPTH (MLD)	16.00 m
GROSS TONNAGE	12,630 t
NET TONNAGE	5,054 t

2.2. Verification of the data used for the stability estimation

A stability calculating program owned by the National Maritime Research Institute (hereinafter referred to as "NMRI") was used in this analytical research. comparison of the GZ curve with that in the "Stability Information for Master and Loading Manual," provided by the shipyard of the vessel is shown in Figure 2-1 in order to review the validity of the data input to the program. Comparison was made under the condition of draft at 9.5m and G_0= 2.0m.

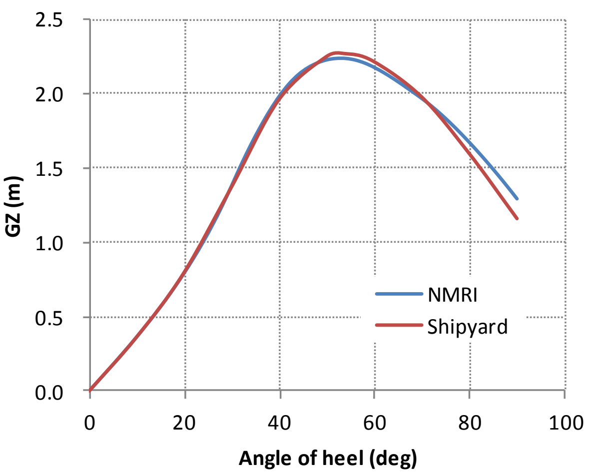


Figure 2-1 GZ curve at full load departure condition

The vertical axis indicates righting lever (GZ) and the horizontal axis indicates heel angle (φ).

In Figure 2-1, the results in the above-mentioned manual is shown in red, and the results calculated by the program is shown in blue.

Although slight difference can been seen between them when heel angle is at or above 50°, this was caused by the handling of the shapes of the upper part structure and no influence on the further analysis can be anticipated, it is decided to use this input data to continue the analysis.

2.3. estimation of departure condition

From the draft and cargo plan at the time of departure, the draft and stowage condition at the time of departure was estimated. Estimated figures are shown in Table 2-2 and 2-3.

Table 2-2 Draft at the departure

da (m)	df (m)	dm (m)
8.3	7.6	7.95

Table 2-3 Cargo

	amount of cargo (t)
No.1 Cargo Hold	6,617.4
No.2 Cargo Hold	5,439.2
Total	12,056.6

The amount of loaded fuel oil and fresh water at the time of departure was estimated referring the values in "departure condition (full load)" described in the "Stability Information for Master and Loading Manual."

Table 2-4 The center of gravity and draft at the time of departure

W (t)	mid-G (m)	KG (m)	GG_0 (m)	da (m)	df (m)	dm (m)
17,615.1	-1.85	8.00	0.18	8.30	7.64	7.97

(mid-G: Positive value indicates forward from midship)

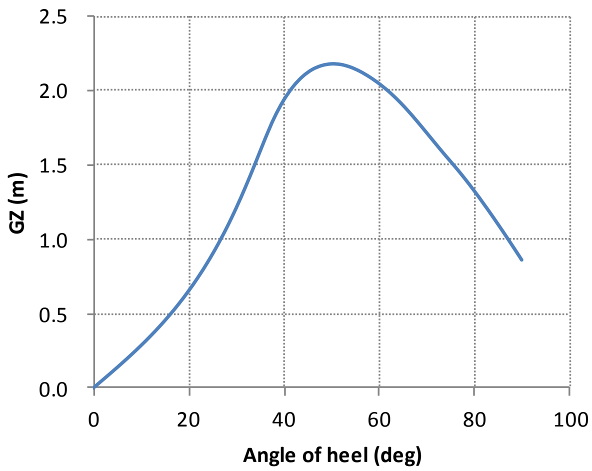


Figure 2-2　GZ curve at the time of departure

Using the above data, the estimated results of center of gravity and the draft at the time of departure are shown in Table 2-4. The GZ curve at that time is shown in Figure 2-2. From these results, it is confirmed that the vessel A had sufficient stability at the time of departure.

3. Estimate of the volume of flooded seawater from the damage (broken hole)

The volume of seawater flooded into "No.1 CARGO HOLD" based on shape of the hole of vessel A was estimated.

3.1. shape of the broken hole

The broken hole shape that was described in the results of diving survey of vessel A is shown in Figure 3-1. The dimensions of the hole was made based on this figure. In order to calculate the area, it is necessary to determine the height and width of the broken hole. The width of the broken hole is expressed as a function of the depth (mold) considering the direction of the depth (mold) of vessel A as a base. This enables to determine the area of the broken hole from the depth (mold). As a result, total area of the broken hole is estimated as about 71 m^2.

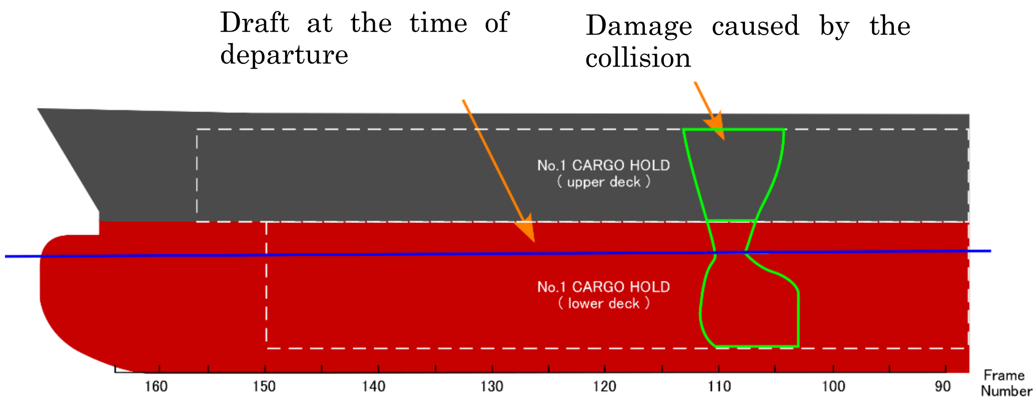


Figure 3-1 Shape of the hole

3.2. flooded compartment

The flooded compartment was estimated from the general arrangement, the midship section and other drawings. Hole is considered to be generated between the frame no. 103 and no. 112 from Figure 3-1. The compartment corresponding to these numbers is "No.1 CARGO HOLD". According to the midship section of vessel A, height of 10m from the bottom is double hull structure whose outside is "W.B.T" and inside is "No.1 CARGO HOLD". Depending on the situation of the collision with vessel B, there is a possibility that the flooded seawater does not reach to the "No.1 CARGO HOLD". For this reason, the collision situation of vessel A and vessel B was examined.

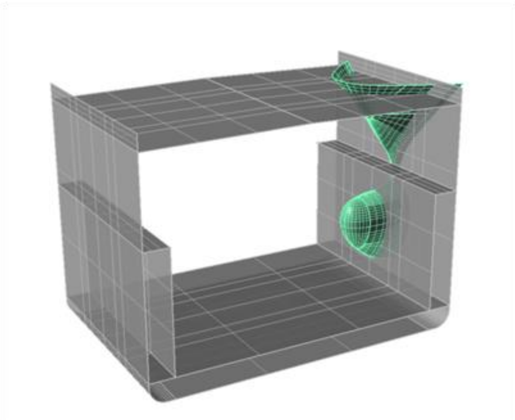


Figure 3-2 Estimate of the collision situation of ship A with ship B
(If ship B penetrated into the vicinity of the bow bulb)

the photograph of vessel B at the time of arrival at the port shows that there were damages on the stem and the hull, and from these, it is estimated that the fore part of vessel B, almost whole part of bulbous bow, penetrated vessel A. Considering the estimated shape of the bow of the vessel B based on the general arrangement and the bow structure drawings, and above situation of the collision , it is estimated that about half of the bow bulb of vessel B penetrated inner plate of the double hull structure. (Figure 3-2)

Therefore, it is considered that the inflow of seawaterto the "No.1 CARGO HOLD" of vessel A was occurred by the collision with the vessel B.

Because vessel A loaded heavy cargos, not whole of the "No.1 CARGO HOLD" (14,019 m^3) was occupied with the flooded seawater. Therefore, the volume of cargo hold in the calculation should be corresponds to the volume of seawater possible to flood into the cargo hold. Volume of the cargo was estimated to be 843 m^3 based on the weight and density (7.85 t/m^3), and eliminated from the volume of the cargo hull.

3.3. volume of floodwater from the broken hole

Estimation of the flood volume of flooded seawater from the broken hole. The volume of the seawater flooded through the broken hole is calculated by following formula.

$$\Delta v = \Delta t \times \mu \times A \times \sqrt{2gh}$$

Δv stands for the volume of flooded water, Δt stands for infinitesimal time and 5 seconds was used in this calculation. μ stands for the flow coefficient (0.6) at the opening, A stands for the dimension of the opening, and h is determined by the difference in the height of surfaces of the flooded seawater in the cargo hull and sea.

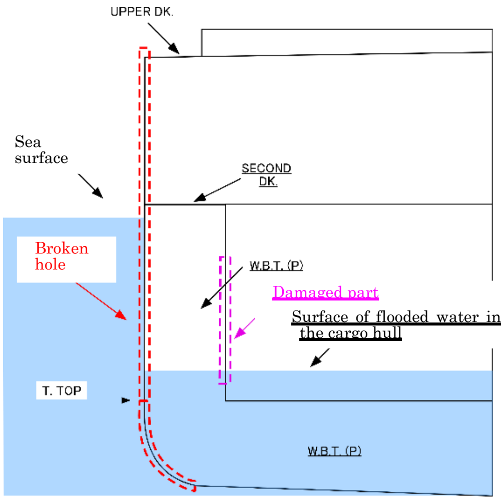


Figure 3-3 Positions of broken hole, sea surface,
and surface of the flooded seawater in the cargo hull

However, since the cargo hull was filled with air at the beginning of the flooding, separate estimation is required for the air part and the underwater part in the cargo hold. (Figure 3-3) In this calculation, total volume of flooded water in the cargo hold was estimated as the mass of volumes of flooded water to each part that were separately calculated using the height of seawater surface in the hull at a time. The time series is calculated at interval of 5 seconds, and the volume of flooded water is assumed to be the same for each 5 seconds.

When seawater flood into vessel A, sinkage or posture change of hull will occur depending on the change of the volume of flooded seawater. These values corresponding to the flooded volume was calculated at each step in this program. Heel was separately calculated form the balance of the stability and the heeling moment. Therefore, when determining the flooded volume, the position of the broken hole should be estimated considering these values, and in this calculation, the volume of the flooded seawater was estimated in consideration of amount of sinkage, heel and trim of the hull. Figure 3-4 shows time series variation of obtained volume of the flooded seawater. The vertical axis represents the flooded volume (m3), while the horizontal axis represents the elapsed time (in seconds). The results of diving survey only describes the hole on the outer hull plate of the vessel. Therefore, shape of the broken hole on the inner hull plate which separates the "No. 1 CARGO HOLD" and the "W.B.T." is assumed as the same as calculated shape of the hole on the outer hull plate.

As the flooded volume became about 866 m^3 in 5 seconds after disconnection of vessel B and exceeds the capacities of the WBT No.2 (P) and the No. 3 WBT (P) located in the part of the ship where the collision occurred, therefore it is estimated that these tanks were filled with water within 5 seconds from the beginning of flooding. The tilt moment generated by this flooding is estimated as 2715.6 t-m. It is estimated that ship listed to the port side by this heeling moment. It is estimated that all flooded seawater came into the cargo hull after 5 seconds from beginning of flooding. The volume of flooded water in the cargo hull was estimated to be about 3,450 m^3 at 20 seconds, about 6.170 m^3 at 40 seconds, and about 8,970 m^3at 60 seconds after the beginning of flooding.

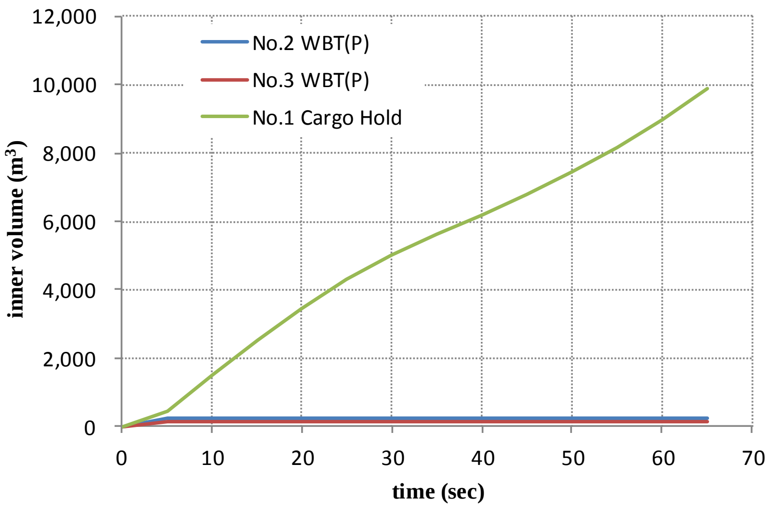
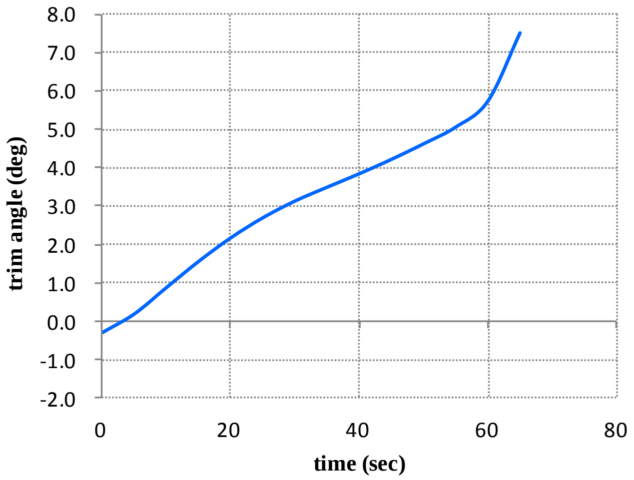
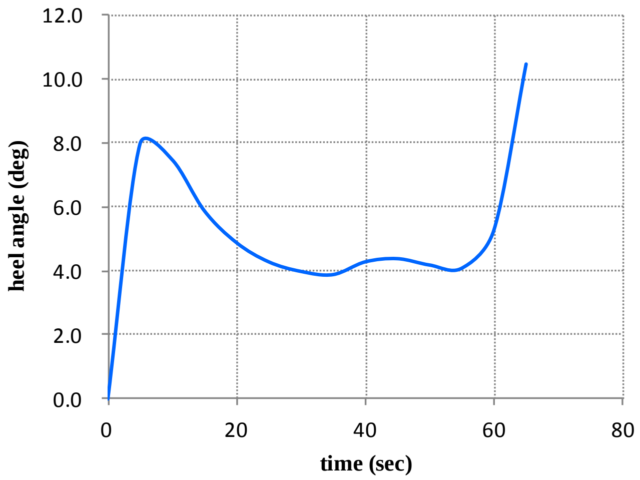


Figure 3-4 The time series variation of the flooded seawater volume

4. Estimation of attitude change of ship A

Attitude change of vessel A such as sinkage of hull is caused by the above-mentioned flooding. The time series variation of each posture change are shown in Figure 4-1. The vertical axis stands for, from the top to the bottom, the heeling angle (deg), the trim angle (deg), and sinkage of hull (m), and the horizontal axis stands for the elapsed time (seconds).





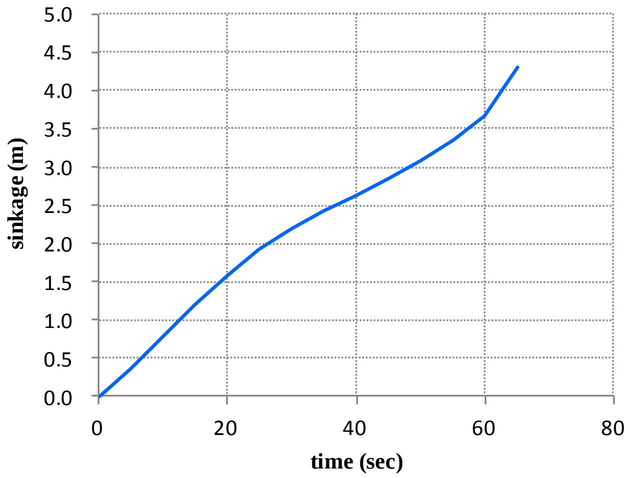


Figure 4-1 the time series variation of attitude change

It is estimated that the vessel A was sailing with aft trim before the accident, and since the vessel B collided at the "No.1 CARGO HOLD" in the foreside and flooded seawater stayed in the fore side, the fore trim proceeded as time passed. From these results, it is estimated that the fore trim increases at almost constant angular velocity up to around 60 seconds, and it became unstable and rapidly proceeded after 60 seconds.

Tilt moment is generated by the flooded water in the "W.B.T." on the port side immediately after flooding started and caused port heeling of the hull. Then, as volume of the flooded seawater into cargo hull increases and displacement increases, influence of heeling moment was reduced and heeling angle decreases. After that, it is estimated that heeling angle became unstable after 60 seconds and rapidly increased.

Amount of hull sinkage indicates the amount of increase in midship draft. The based is the draft before the flooding. It is estimated that the hull sank in proportion to the volume of flooded seawater as volume of the flooded seawater is almost constant in this calculation. The sinkage of hull is estimated as about 1.2 m at 20 seconds later, about 2.4 m at 40 seconds later, and about 3.4m at 60 seconds later.

Illustration of attitude change of the hull estimated from these results is shown in figures from 4-2 to 4-6. From this result, it is hard to assume heel direct cause of the sinkage of hull, only trim was considered.

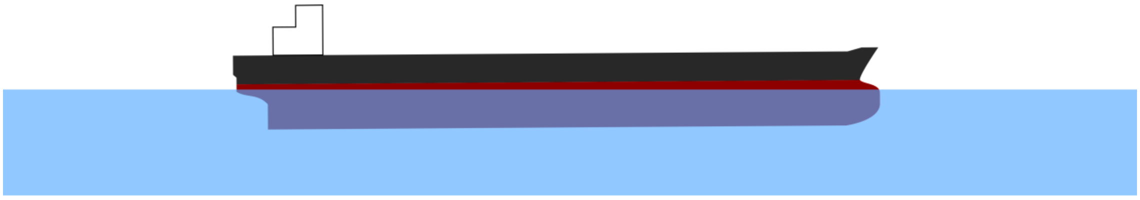


Figure 4-2: Just before the start of flooding (trim angle: -0.3 deg.)

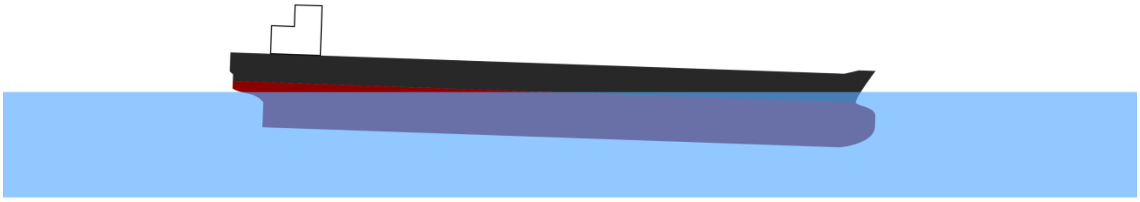


Figure 4-3: 20 seconds later since the start of flooding (trim angle: 2.2 deg.)

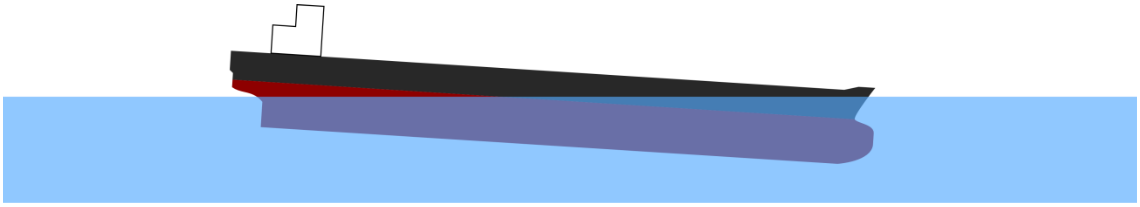


Figure 4-4: 40 seconds later since the start of flooding (trim angle: 3.8 deg.)

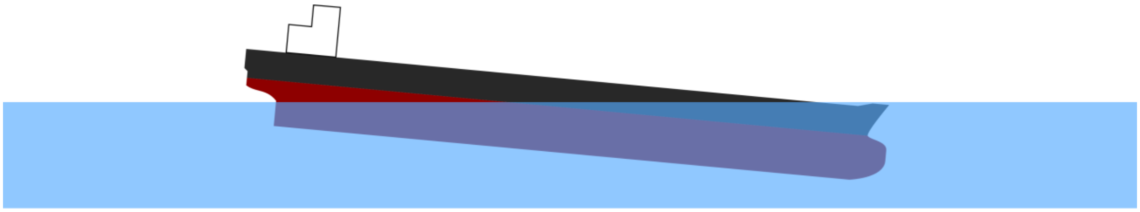


Figure 4-5: 60 seconds later since the start of flooding (trim angle: 5.7 deg.)

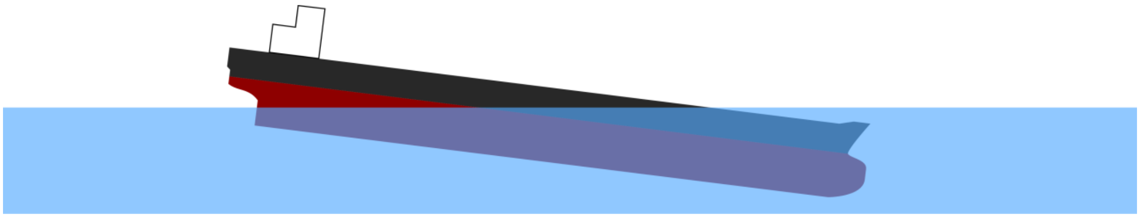


Figure 4-6: 65 seconds later since the start of flooding (trim angle: 7.5 deg.)

From these figures, it is estimated that the bow sank at an almost constant rate as the flooded seawater to the "No.1 CARGO HOLD" increased, and, at about 60 seconds later, the upper side of the bow came below the sea surface. After that, the bow sank further and fore side hatch of the "No.1 CARGO HOLD" came below the sea level at 65 seconds later. The hatch covers of vessel A were not watertight, it was possible that seawater flooded from the hatch after hatch came below the sea level.

5. Study on the mechanism of sinkage

The mechanism that lead to the sinkage was studied based on the above analysis.

5.1. Influence of stability

The change in the GZ curve from the start of flooding is shown in Figure 5-1 and the change in the metacenter height is shown in Figure 5-2 and Table 5-1. The vertical axis is meant for the righting lever and the metacentric or other heights, and the horizontal axis is meant for the heeling angle.

It was observed that, although the vessel had sufficient righting lever before the beginning of flood (0 sec), as time passed, increase of volume of the flooded water caused sinkage of the hull and reduction of the freeboard, and reduced the righting lever. However, the value of righting lever at and after 65 seconds is still positive, and it is estimated that this situation did not lead to capsize of the vessel A.

The distance between the apparent center of gravity take in to account of free water effect and metacenter (G_0M) before beginning of flooding was 1.36(m) and was sufficient. Although it once increased to 1.42(m) at 20 seconds later from the start of the flooding, the free water effect became remarkable with the increase of the flooded seawater, and decreased to 0.39m at 65 seconds later. This shows that above mentioned rapid attitude change was caused by this reduction of G_0M. It is estimated that the vessel A did not capsized as the value of G_0M is still positive.

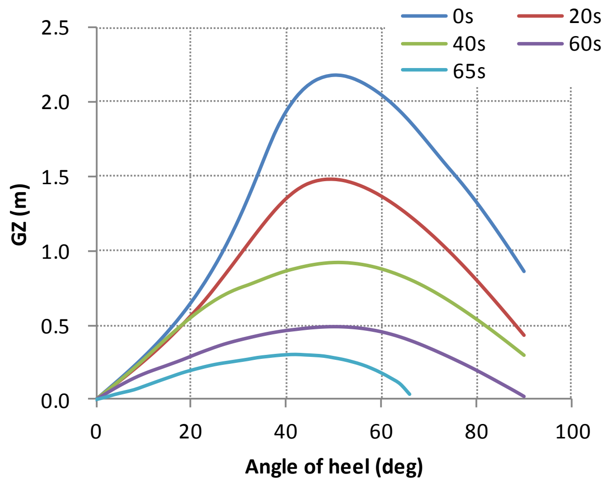


Figure 5-1 Change in the GZ curve

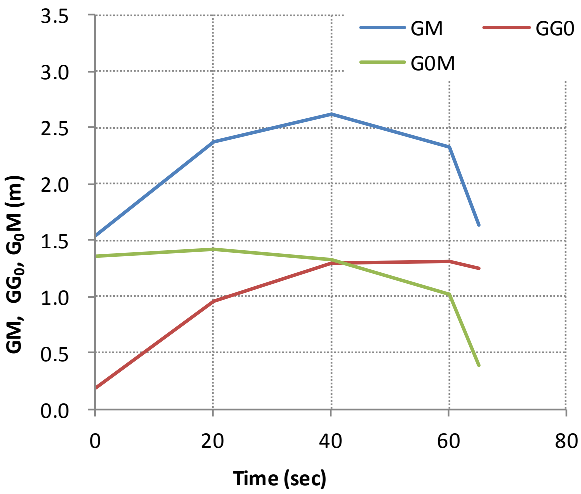


Figure 5-2 Change in metacenter and other height

Table 5-1 Change in metacenter and other height.

	0 sec	20 sec	40 sec	60 sec	65 sec
GM (m)	1.54	2.38	2.61	2.33	1.63
GG_0 (m)	0.18	0.96	1.29	1.32	1.25
G_0M (m)	1.36	1.42	1.32	1.02	0.39

5.2. Balance with buoyancy

Above analysis did not describe after 65 seconds, and it is because the balance with buoyancy could not calculated. The amount of flooded seawater increased as time passed and the volume of flooded seawater into the cargo hull reached to about 9,900m^{3}at 65 seconds later. The hull weight at that time was about 28,650 t. the volume of the seawater flooded through the broke hole in 5 seconds in between 65 seconds at which attitude of hull changed and 70 seconds is calculated as almost 1,200 tons, and it is estimated that lack of buoyancy which could resist to the increase of the hull weight led the hull to capsize.

6. Conclusion

This analysis research is to contribute to the investigation of the collision accident of vessel A and vessel B occurred on March 18, 2014 at off the Miura Peninsula and carried out for (i) estimation of the stability just before the accident, (ii) estimation of the volume of seawater flooded through the damage (broken hole), (iii) estimation of the attitude change of vessel A, and (iv) examining the mechanism of the sinking.

Summary of the information obtained by this study are as follows:

A) Departure condition and the stability at that time of departure of vessel A was estimated based on the draft at the time of departure and loading plan. As the result, vessel A had sufficient stability at the time of departure.

B) Volume of seawater flooded through the broken hole was estimated as about 3,450 m3 at 20 seconds later, about 6.170 m3 at 40 seconds later, and about 8,970 m3at 60 seconds later based on the results of underwater survey.[3]

C) It is estimated that flooding was occurred at the "No.1 CARGO HOLD" located at the fore half of the hull, and bow trim proceeded with the elapse of time. Although heel of about 8 degrees was generated in the beginning of flooding due to water inflow to the "No.2 WBT (P)" and "No.3 WBT (P)" located near the broken hole, heeling angle was reduced as the volume of flooded seawater increased.

D) G_0M of vessel A ship at the time of departure was 1.36 (m), however, it substantially reduced to 1.02 (m) at 60 seconds and 0.39 (m) at 65 seconds later from start of the flooding. It is estimated that the rapid attitude change of hull between 60 seconds to 65 seconds was generated along with this.

E) The volume of flooded seawater in 5 seconds estimated from the hull attitude of 65 seconds was about 1,200 t and buoyancy was not sufficient to cope with this increase of the hull weight. It is estimated that, therefore, the vessel A sank at 65 seconds.