MA2011-11

MARINE ACCIDENT
INVESTIGATION REPORT

November 25, 2011

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.

Norihiro Goto
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:	Car carrier; CYGNUS ACE
IMO number:	8808082
Gross tonnage:	10,833 tons
Vessel type and name:	Multi-purpose cargo ship; ORCHID PIA
IMO number:	8715352
Gross tonnage:	4,255 tons
Accident type:	Collision
Date and time:	Mar.10, 2009; around 02:13 (local time, UTC+9 hours)
Location:	Eastward offshore Oshima, Oshima-cho, Tokyo, Japan 087°true, 7.6 nautical miles from Ryu-o-Saki lighthouse (approximately 34°41.6'N; 139°35.7' E)

October 27, 2011

Adopted by the Japan Transport Safety Board

Chairman Norihiro Goto

Member Tetsuo Yokoyama

Member Kuniaki Shoji

Member Toshiyuki Ishikawa

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1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

Car carrier CYGNUS ACE departed from Mikawa Port, Aichi Pref. for Yokohama Ku, Keihin Port, Kanagawa Pref. with her master and 18 crew members. Multi-purpose cargo ship ORCHID PIA departed from Kashima Port, Ibaraki Pref. for Yeosu Port, Republic of Korea with her master and 15 crew members. The two vessels collided with each other at eastward offshore Oshima island, Tokyo at around 02:13, March 10, 2009. At the time of the collision, the CYGNUS ACE was proceeding southeastward, to adjust the time of arrival at Yokohama Ku, while the ORCHID PIA was proceeding southwestward.

As a consequence of the accident, ORCHID PIA was sunk and all of the crew (16 people) went missing. The CYGNUS ACE sustained damage in the bow section including ruptures leading to flooding, but no casualties to her crew.

1.2 Outline of the Accident Investigation

1.2.1 Appointment of Investigators

The Japan Transport Safety Board designated an investigator-in-charge and other investigators to investigate this accident on March 10, 2009.

1.2.2 Collection of Evidence

On-site investigation and interviews were conducted on March 10, 2009.

Additional interviews were conducted on March 13, March 16, and August 4, 2009 respectively.

Written reply to the questionnaires were collected on March 31, April 10, June 02, July 06, September 09, October 13 and 16, November 19, December 09, 2009 and January 05, 2010 respectively.

1.2.3 Tests and Research by Other Institutes

In conducting the investigation and analysis of the accident, the Board commissioned the National Maritime Research Institute (NMRI) to look into the detailed positioning of the two vessels at the time of the collision, as well as into the processes by which major damage developed in the CYGNUS ACE and by which the ORCHID PIA was sunken.

1.2.4 Comments from Parties Concerned

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

1.2.5 Comments from Flag State of the CYGNUS ACE and others involved

Comments on this report were invited from the flag State of the CYGNUS ACE and the management company of the CYGNUS ACE.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

Development of events leading to the occurrence of the accident is as described below, based on the archived data of the Automatic Identification System (AIS) *1 pertaining to the Vessels CYGNUS ACE (hereinafter referred to as "Vessel A" except for chapter 5) and ORCHID PIA (hereinafter referred to as "Vessel B" except for chapter 5) as received by the Tokyo Wan Vessel Traffic Service Center (hereinafter referred to as "Tokyo MARTIS") of the Japan Coast Guard (hereinafter referred to as "AIS data"); the archived data of the Voyage Data Recorder (VDR) *2 equipped on board Vessel A (hereinafter referred to as "VDR data"); and the interview with the master (hereinafter referred to as "Master A"), second officer (hereinafter referred to as "Officer A"), able seaman on bridge watch at the time of the accident (hereinafter referred to as "Seaman A"), chief engineer (hereinafter referred to as "Chief Engineer A") and third engineer (hereinafter referred to as "Engineer A") of Vessel A .

As for information concerning Vessel B, interviews with the crew members and VDR data are not available as the Vessel sank after the accident and the entire crew is missing.

Time of the events is indicated in the Japan Standard Time (JST) corresponding to 9 (nine) hours ahead of the Universal Time Coordinated (UTC)*3.

2.1.1 Events Leading to the Accident According to the AIS Data of Both Vessels and the VDR data of Vessel A

(1) Movements of Vessel A

Navigational conditions of Vessel A for the duration of 01:46 to 02:14 on March 10, 2009 were as described below:

{1} As of about 01:46, Vessel A was positioned in the vicinity of latitude 34°47'46.1" N;

*1 "Automatic Identification System (AIS)" is a device used by vessels to transmit and exchange call sign, type, name, position, course, speed, destination, navigational status and other safety-related information with other vessels and land-based navigational aid facilities, etc.

*2 "Voyage Data Recorder (VDR)" is an on-board device to record navigation-related data including the ship's position, course and speed as well as international device telephone (VHF) communications and conversations within the bridge within retrievable capsules.

*3 Universal Time Coordinated (UTC) is the standard time used in regulating time on a global basis. UTC is basically equivalent to GMT (Greenwich Mean Time) determined on the basis of astronomical observations, but is based on the measurement of atomic clock, determining the International System of Units (SI unit) second as the duration of 9,192,631,770 cycles of radiation produced by a cesium 133 atom.

longitude 139°30’18.3” E, proceeding with a Course Over Ground (COG) 143° (true bearing, likewise hereinafter), heading 146° with speed (Speed Over Ground – SOG, likewise hereinafter) at 17.3 kn.

{2} As of about 02:00, Vessel A was positioned in the vicinity of latitude 34°44’21.5” N; longitude 139°32’58.3” E, proceeding with COG 147°, heading 148° and SOG at 17.3 kn.

{3} As of about 02:05:26, Vessel B attempted to communicate with Vessel A via international device telephone (hereinafter referred to as “VHF”) by transmitting the message “CYGNUS ACE, THIS IS ORCHID PIA, COME IN PLEASE”. As of about 02:05:37, Vessel B repeated her transmission.

As stated in Section 2.1.5(2) below, the transmission was sent by the second officer on board Vessel B (hereinafter referred to as “Officer B”).

{4} As of about 02:08:34, a dual-tone beeping alarm was sounded, terminating with a “peep” sound at about 02:08:44.

{5} As of about 02:09:52, a dual-tone beeping alarm was sounded, terminating with a “peep” sound at about 02:09:57.

{6} As of about 02:10, Vessel A was positioned in the vicinity of latitude 34°41’54.6” N; longitude 139°34’51.0” E, proceeding with COG 147°, heading 146°, SOG at 17.3 kn. The bearing and speed respectively shifted to COG 134°, heading 128° and SOG 16.7 kn as of about 02:11, and further to COG 115°, heading 107°, and SOG 15.9 kn as of about 02:12.

{7} As of about 02:12:15, short beeping alarm was sounded.

{8} As of about 02:13, Vessel A was positioned in the vicinity of latitude 34°41’32.0” N; longitude 139°35’37.5” E, proceeding with COG 086°, heading 071°, and SOG 14.4 kn.

{9} As of about 02:13:26, Vessel A was positioned in the vicinity of latitude 34°41’34.3” N; longitude 139°35’44.6” E, proceeding with COG 064°, heading 046°, and SOG 13.1 kn. A series of crashing noises (rattle, rattle, rattle, bang, bang, bang, boom) was recorded. As of about 02:13:34, heading veered to 046°, decelerating to 9.9 kn.

{10} As of about 02:13:51, the phrases “WHAT HAPPENED ?” and “THIS ONE IS ･･･ COURSE･･･” were recorded.

{11} As of about 02:13:59, a loud noise was recorded.

{12} As of about 02:14, Vessel A was in the vicinity of latitude 34°41’35.7” N; longitude 139°35’45.5” E, COG veered to 038°, heading 359° with SOG down to 0.6 kn.

{13} As of about 02:14:12, Vessel A was positioned in the vicinity of latitude 34°41’35.7” N; longitude 139°35’45.5” E. COG was 308°, heading 354° and SOG 0.0 kn.

(2) Movements of Vessel B

Navigational conditions of Vessel B for the duration of 01:47 to 02:14 on March 10, 2009 were as described below:

{1} As of about 01:47, Vessel B was positioned in the vicinity of latitude 34°43'42.0" N; longitude 139°41'17.1" E, proceeding with COG 241°, heading 240°, and SOG 11.7 kn.

{2} As of about 02:00, Vessel B was positioned in the vicinity of latitude 34°42'28.1" N; longitude 139°38'36.3" E, proceeding with COG 239°, heading 239° and SOG 12.1 kn.

{3} As of about 02:03, Vessel B was positioned in the vicinity of latitude 34°42'11.0" N; longitude 139°37'59.6" E, proceeding with COG 240°, heading 240°and SOG 11.2 kn. The ship's head then gradually veered rightward.

{4} As of about 02:05::, Vessel B was positioned in the vicinity of latitude 34°41'59.1" N; longitude 139°37'30.3" E, proceeding with COG 250°, heading 248° and SOG 10.9 kn.

{5} As of about 02:07, Vessel B was positioned in the vicinity of latitude 34°41'52.5" N; longitude 139°37'09.1" E, proceeding with COG 252°, heading 250° and SOG 10.7 kn.

{6} As of about 02:10, Vessel B was positioned in the vicinity of latitude 34°41'41.1" N; longitude 139°36'28.8" E, proceeding with COG 255°, heading 256° and SOG 10.4 kn.

{7} As of about 02:13, Vessel B was positioned in the vicinity of latitude 34°41'35.9" N; longitude 139°35'54.2" E, proceeding with COG 264°, heading 268° and SOG 10.0 kn.

{8} As of about 02:13:24, Vessel B was positioned in the vicinity of latitude 34°41'35.8" N; longitude 139°35'49.9" E, proceeding with COG 271°, heading 270° and SOG 9.9 kn. As of about 02:13:32 the position, course and speed of the Vessel were changed, in the vicinity of latitude 34°41'35.8" N; longitude 139°35'48.3" E, to COG 281°, heading 270° and SOG 5.4 kn.

{9} Heading of Vessel B was maintained at 270° until about 02:13:39 with SOG declining to 3.8 kn, and then the Vessel veered to COG 295°, heading 249° and SOG 4.6 kn in the vicinity of latitude 34°41'36.9" N; longitude 139°35'46.9" E as of about 02:14:04. AIS signals from Vessel B were then disrupted.

(See Table 1: AIS data, Vessel A; attached Table 2: AIS data, Vessel B; Table 5: VDR data, audio records)

2.1.2 Events Leading to the Accident According to the Statements of Crew Members of Vessel A

Vessel A, boarded by her master (hereinafter referred to as "Master A") and 18 crew members, departed from Mikawa Port for Yokohama Ku of the Keihin Port (hereinafter referred to as "Yokohama Ku") at around 15:18 on March 09, 2009.

As of about 00:00 on March 10, Vessel A was proceeding northeastward toward the northern waters off Oshima with Officer A and Seaman A taking over the watch from the third officer. At that time, the course was 041°, and speed was approximately 16 kn, with the engine running at approximately 142 rpm.

Vessel A arrived at a position to the north of Oshima as designated by Master A on the chart with a "CALL CAPT" marking at about 01:00, when Officer A reported via ship telephone her arrival to Master A, who then went up to the bridge in response to the report.

Upon reaching the designated area to the northeast of Oshima, Master A confirmed the ship's position, and altered her course to approximately 147°, heading for the area eastward off Oshima with relatively low traffic density. The course change was made in an attempt to adjust the estimated time of arrival of the Vessel at Yokohama Ku, which was scheduled for 06:00. Master A then left the bridge at about 01:45.

Officer A assumed watch over the Vessel, positioning Seaman A as lookout on the starboard wing of the steering house (hereinafter referred to as the "starboard wing") which was leeward of the Vessel at the time. The door between the steering house and the starboard wing was closed. The starboard VHF device was set to Channel (ch) 16, and Vessel A was sailing under automatic steering. No.1 radar equipped with Automatic Radar Plotting Aids (ARPA)*4 was set to S band*5 with a range of six nautical miles (M) off-centered rearward by 3M*6. The CPA/TCPA Alarm*7 trigger threshold of the Closest Point of Approach (CPA) *8 function for ARPA was in the range of two to three M.

According to Master A, CPA was previously set to 0.5 M.

At about 02:00, Officer A noticed on ARPA two vessels crossing at approximately four to five M of the port bow. The course/speeds of the two vessels were confirmed to be COG 250°/ approx. 10kn for the preceding vessel (hereinafter referred to as "Vessel C"), and COG 245°/ approx. 13kn for the following Vessel B. Accordingly, Officer A adjusted the course and speed to approximately 145°and 17.0 kn.

Officer A recognized that the CPA for Vessel C was to be 0.85M, occurring in approximately seven minutes and the CPA for Vessel B was approximately 0.6M occurring approximately 10 minutes, which suggested Vessel C and then Vessel B would successively pass ahead of Vessel A.

Officer A determined by the radar images of the both vessels that they were almost

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*4 Automatic Radar Plotting Aids (ARPA) is a computerized device for automatically processing the direction/distance of movement of targets detected on radar, enabling the course, speed, CPA/TCPA as well as their predicted future position to be monitored. ARPA also sounds alarms in case risk of collision exists.

*5 "S-band" is a radar frequency using wavelengths longer (10cm) than the X-band (3cm) radar. S-band is considered to be less susceptible to attenuation and therefore possesses a longer detection range, and is also less influenced by sea clutter.

*6 Radar generally has a function to offset the center (own position) of the display. Center is offset rearward in relation to the ship's direction, thereby providing a longer range ahead in the radar display.

*7 The CPA/TCPA Alarm is a function to warn the observer of targets expected to approach within the range of the specified CPA and TCPA using audible/visual signals.

*8 Closest Point of Approach (CPA) indicates the distance between two (own and other) vessels when the two will be closest. "Time to CPA (TCPA)" signifies the time remaining until CPA.

identical in size, and confirmed with binoculars that the both vessels were indicating two masthead lights (white) and starboard light (green).

At about 02:05, Officer A confirmed the ship's position at the chart table, entering the result (latitude 34°44.4' N; longitude 139°33.0' E) in the ship's logbook.

When the ARPA sounded the CPA/TCPA alarm at about 02:08, Officer A thought that Vessel B would pass ahead of Vessel A uneventfully around 02:14 based on her movement at the time.

As the two vessels closed in to a distance of approximately 1 to 2 M, Officer A noticed Vessel B, which had shown a starboard light (green) up to then, suddenly veering right to begin approaching, showing both sidelights (red and green). As the two vessels approached to approximately 0.7M, Officer A attempted to communicate with Vessel B on VHF 16ch to confirm her intentions, but got no response.

As a large going-along vessel (hereinafter referred to as "Vessel D") was sailing to the starboard of Vessel A at a distance of 4 to 5 M, Officer A was compelled to gradually divert the course of Vessel A to port instead of to starboard by successively activating the portward steering button with the autopilot still engaged. Meanwhile, Vessel B maintained her approach, posing a collision risk.

As Seaman A was stationed as lookout on the starboard wing, Officer A disengaged the autopilot about 1 minute prior to the collision, steering hard port.

While in the process of turning to port, the bow section of Vessel A collided with the mid-port section of Vessel B.

2.1.3 Events Following the Accident

While resting in his cabin, Master A felt an intense impact and immediately went up to the bridge, but was unable to assess the situation as the lights had gone out. Upon questioning the Officer A "WHAT HAPPENED?," Master A came to realize Vessel A had collided with another vessel. Virtually simultaneously, Master A identified the port (red) light of vessel B to the starboard side of the ship's bow at an angle of about 30 to 45 degrees, proceeding along the starboard side of the ship. Based on the navigation light arrangements of Vessel B, Master A assumed Vessel B could not be a passenger ship or a large crude-oil carrier, but a general cargo ship on coastal or oceangoing services. Master A manually took helm of vessel A at that time.

After the collision, Officer A stood stupefied behind No.1 radar, unable to cope with the situation.

While on duty within the engine room, Engineer A felt the impact of the collision and reduced the engine speed from 142 rpm to 70 rpm at his discretion, then increased it to in-harbor full ahead speed of 100 rpm.

Seaman A entered the steering house from the starboard wing and manned the helm, relieving Master A.

Master A assumed command and notified the crew of the station for collision by the public addressor, calling all hands to the steering house with the exception of the two watchmen in the engine room, and then began the assessment of damage. After confirming that there were no casualties, Master A instructed the crew to check on the conditions of the tanks as well as the bow thruster room and cargo holds as for their flooding or damage. The collision was then notified to the 3rd Regional Coast Guard Headquarters (hereinafter referred to as "3rd Regional HQ") via VHF communication.

Master A received a report from Engineer A that the engine was operating normally, and ordered the engineer to maintain the engine speed at 100 rpm, thereby keeping the current course. In order to avoid a collision with another vessel, Vessel A proceeded with the searchlight and deck lanterns switched on.

Due to adverse weather conditions, the wind was extremely strong, and Master A lost sight of Vessel B soon after the collision, and noted that the radar blip representing Vessel B, which had been displayed to the stern of Vessel A, vanished out of the range of display.

Approximately 5 minutes after the collision, Master A received a report from the boatswain about leaks in the bow thruster room, and notified the 3rd Regional HQ of the conditions of Vessel A as "NOW UNDERWAY, CHECKING MY DAMAGE." Approximately 25 minutes later, Master A confirmed Vessel A was in no imminent danger of sinking and reported "I CAN STOP LEAKING, I HAVE NO DANGER OF SINKING."

Considering that Vessel B probably sank after the collision, all hands manned their own stations and Vessel A engaged in search and rescue operations in the general area of the collision at about 03:00 with the pilot ladders on both sides lowered close to the water level and additional deck lanterns switched on.

Vessel A abandoned the search and rescue operations at about 12:30 with the approval of the 3rd Regional HQ and proceeded to Yokohama Ku, berthing at Daikoku Pier around 17:00.

The collision occurred at about 02:13:26, March 10, 2009 in the waters bearing 087°, 7.6 M off Ryu-o-Saki lighthouse.

(See Figure 1: Waters in the vicinity of Oshima; Figure 2: Presumed navigational route diagram (from about 30 minutes prior to the collision to the time of the collision); Figure 3: Presumed navigational route diagram (from about 15 minutes prior to the collision to the time of the collision); Figure 5: Change in bearing of the two vessels immediately after the collision; Figure 14: Relative position of the two vessels upon coordination of the waterline; Reference Diagram: Wakes assuming the two vessels proceeded without veering (from 15 minutes prior to the collision to the time of the collision))

2.2 Injuries to Persons

The entire crew of Vessel B (16 people) went missing.

No casualties occurred among the crew of Vessel A.

2.3 Damage to Vessels

(1) Damage to Vessel A

{1} According to the information provided from the ship management company responsible (RCL SHIP MANAGEMENT PTE LTD – hereinafter referred to as "Company A" except for chapter 5) including statement from the staff, photographs of the damage and repair schedules, damage to Vessel A were as described below:

Ruptures in several locations of the bow section resulted in leaks, and damage including dents were also present in the starboard bow bulwark and port bow ramp way and others.

a Ruptures in the bow section of Vessel A above the waterline:

(a) Foremost bow section near the waterline; length: approx. 4.1 meter; height: approx. 1.0 meter

(b) Starboard bow section (No.2 ballast tank, approx. 13.0 meter astern of the foremost rupture, approx. 2.0 meters above the waterline); length approx. 6.0 meters; breadth approx. 1.2 meters

b Damage to Vessel A below waterline:

(a) Starboard bow section

Rupture major-- length approx. 1.35 meters; breadth approx. 0.2 meter

minor-- length approx. 0.90 meter; breadth approx. 0.4 meter

Dents (Significant damage to lower areas of the bulbous bow)

length approx. 1.6 meters; breadth approx. 0.6 meter; depth approx. 0.15 meter

length approx. 1.1 meters; breadth approx. 0.9 meter; depth approx. 0.15 meter

length approx. 2.0 meters; breadth approx. 0.4 meter; depth approx. 0.07 meter

(b) Port bow section

No ruptures caused

Dents (Significant damage to lower areas of the bulbous bow)

length approx. 1.3 meters; breadth approx. 1.1 meters; depth approx. 0.06 meter

length approx. 0.6 meter; breadth approx. 0.5 meter; depth approx. 0.04 meter

According to statement of the staff of Company A and repair schedules provided, Vessel A underwent temporary repairs at Yokohama Ku and permanent repairs at a dockyard in Shanghai, People's Republic of China.

{2} Master A's Statement on the damage was as follows:

a Ruptures in the foremost bow section of Vessel A were probably caused by the ship's bow striking the derrick boom of Vessel B, where the tip of the boom was latched above the cargo hatch with wires (hereinafter referred to as "parked"; see Figure 12).

b Ruptures on the starboard bow section of Vessel A were probably caused by the ship's bow striking the accommodation (bridge section) of Vessel B.

c Pulleys and other components found entangled with the starboard anchor of Vessel A was probably ripped off from the middle or uppermost part of the derrick post on Vessel B.

d The bow section of Vessel A riding the crest of the wave probably ran over Vessel B which was in the wave trough, causing Vessel B to sink immediately thereafter.

(2) Damage to Vessel B

{1} Extent of damage incurred by Vessel B are unknown.

{2} Numerous pulleys and wires previously equipped on the derricks and derrick booms of Vessel B were found entangled to the starboard anchor of Vessel A.

(Refer to Figure 21: Damage to the bow section of Vessel A; Photograph 1: Damage incurred by Vessel A (1); Photograph 2: Damage incurred by Vessel A (2); Photograph 3: Damage below the waterline of Vessel A (starboard);(Photograph 4: Damage below the waterline of Vessel A (port))

2.4 Actions against Oil Spill

(1) the Japan Coast Guard

According to the Japan Coast Guard, the oil spill resulting from the accident was as follows:

{1} Situation of the spilled oil

The sunken Vessel B had onboard 34 kilo liters (kl) of light fuel oil and 183 kl of fuel oil. The Japan Coast Guard confirmed oil spill in a location approximately 800 meters northwest of the site of the accident at a depth of approximately 1,200 meters.

{2} Situation of the drifting oil

The spilled oil formed numerous lotus-leaf shaped films, mostly categorized as scale D in color classification[*9] with some ranging from scales C to E. A portion of the spillage drifted ashore along the southern coastline of the Boso Peninsula.

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*9 "Color classification" is a method of categorization for oil films, gradually decreasing in film thickness from A to E. Scale A: Brown or dark brown; B: Dark tone of rainbow; C: Light tone of rainbow; D: Silver-white with hues of rainbow; E: Silver-white

{3} Spillage control

The Japan Coast Guard dispatched patrol vessels to the area, to implement spillage control by discharging sea water and agitating the spilled oil by navigating through it. Additionally, the National Strike Team of the Japan Coast Guard engaged in spillage control activities for the oil drifted ashore along the coastline of Katsu-ura Bay in Chiba Pref. Oil drifted ashore in various fishery harbors and beaches along the affected area formed thin oil films of scale E or below in color categories.

(2) Chiba Prefecture

According to Chiba Prefecture, they took the following actions against the spillage:

{1} Upon receiving reports on the collision and subsequent oil spill, Chiba Prefecture set up a municipal emergency countermeasure headquarters on March 13, to engage in spillage control efforts including collection of oil films drifted ashore in coordination with local communities and fisheries cooperatives along the coastline extending from Tateyama-City to Onjuku-Town to Boso Peninsula from March 14. Offshore spillage was categorized as scale E or below, and controlled by navigational agitations of the spilled oil.

{2} As disposal of the oil spill for the most part was accomplished by April 2, the municipal emergency countermeasure headquarters was disbanded.

(3) Responses of the Management Company for Vessel B

According to the Japan Coast Guard, the ship management company responsible for Vessel B (SEOK CHANG MARITIME CO,LTD., hereinafter referred to as “Company B”) dispatched a spillage control ship to dispose of the spillage by using oil dispersants in the vicinity of the spillage source, concurrently cooperating in the spillage control efforts along the coastline of Boso Peninsula.

(See to Figure 20: Conditions of oil spill)

2.5 Crew Information

(1) Gender, Age and Competency Certificate

{1} Master A – nationality: Kingdom of Thailand; male; age: 39

Documentary proof of application for an endorsement under STCW regulation I/10—1st grade maritime officer (Republic of Panama)

Date of issue: April 6, 2000

Date of expiry: June 6, 2011

{2} Officer A – nationality: Republic of the Union of Myanmar ; male; age: 48

Documentary proof of application for an endorsement under STCW regulation I/10—2nd grade maritime officer (Republic of Panama)

Date of issue: November 14, 2007

Date of revalidation: November 27, 2007

Date of expiry: January 25, 2011

{3} Seaman A – nationality: Kingdom of Thailand ; male; age: 31

Qualification certificate—No certificate

{4} Master, Vessel B – nationality: Republic of Korea; male; age: 54

2nd grade maritime officer (Republic of Korea)

Date of issue: July 12, 2001

Date of revalidation: July 12, 2006

Date of expiry: July 11, 2011

{5} Officer B – nationality: Republic of Korea; male; age: 35

1st grade maritime officer (Republic of Korea)

Date of issue: July 6, 2007

Date of expiry: July 5, 2012

(2) Primary Seagoing Experience and others

According to the statements of Master A, Officer A and Seaman A, and the crew list of Vessel B, they had following experience:

{1} Master A

Initially serving as a cadet on an oceangoing cargo ship in 1991, Master A served as officer/master on various cargo ships. Appointed as master of the Vessel A six years before, he was on the third voyage as the master of the Vessel A after having spent some time on leave of absence. With port calls to Yokohama on a regular basis of twice a month, Master A had considerably rich experience in entering there. His health condition was good at the time of the accident.

{2} Officer A

Initially serving as an able seaman on a cargo ship in 1985, he was appointed 3rd officer in 2002 and then promoted to 2nd officer. Officer A also had an opportunity to assume command of a vessel in 2007. Officer A came into the employment of Company A on January 16, 2009, and was appointed 2nd officer for Vessel A at that time. This was his second voyage in the waters to the east of Oshima, the first being the voyage on January 25 of the same year. During the first voyage, similar time adjustments were made under the instructions of the master by proceeding southeast along the eastern waters off Oshima. His health condition was good at the time of the accident, and he was farsighted with age, however, he did not require any reading glasses while on watch. Officer A had about 5 hours of sleep prior to the accident.

{3} Seaman A

Approximately 10 years ago Seaman A began his career as an ordinary seaman. He had been stationed to lookout and helm duty as an able seaman since around 2006. He was assigned to Vessel A on July 21, 2008 as able seaman, and was in good health condition at the time of the accident.

{4} Master and 2nd Officer of Vessel B

The master of Vessel B (hereinafter referred to as "Master B") had been placed in command of Vessel B since September 5, 2007.

{5} Officer B

Officer B was assigned to Vessel B as 2nd officer on August 18, 2008.

2.6 Vessel Information

2.6.1 Particulars of Vessels

(1) Vessel A

IMO number	8808082
Port of registry	Panama (Republic of Panama)
Owner	Orchid Navigation S.A. (Republic of Panama)
Management company	Company A (Republic of Singapore)
Classification society	Nippon Kaiji Kyokai
Gross tonnage	10,833 tons
L x B x D	134.86m x 20.00m x 14.09m
Hull material	Steel
Engine	Diesel engine x 1
Output	7,060kW (maximum continuous rating)
Propulsion	5-blade fixed pitch propeller x 1
Date of launch	June 29, 1988
Category	Car carrier
Capacity of vehicles on board	Trailers (length 11.20m x width 2.50m) equivalent – 82 vehicles Passenger vehicle (length 4.42m x width 1.89m) equivalent -- 200 vehicles
Crew complement	19 (nationality – Kingdom of Thailand: 14; Republic of Indonesia: 2; Republic of the Union of Myanmar: 3)

(2) Vessel B

IMO number	8715352
Port of registry	Busan (Republic of Korea)

Owner	PIA SHIPPING CO.,LTD. (Republic of Korea)
Management company	Company B (Republic of Korea)
Classification society	Korean Register of Shipping
Gross tonnage	4,255 tons
L x B x D	111.60m x 15.10m x 8.70m
Hull material	Steel
Engine	Diesel engine x 1
Output	2,868kW (maximum continuous rating)
Propulsion	3-blade fixed pitch propeller x 1
Date of launch	October 30, 1988
Category	Multi-purpose cargo ship*10
Crew complement	16 (nationality -- Republic of Korea: 7; Republic of Indonesia: 9)

2.6.2 Loading Conditions

(1) Vessel A

According to the statement from Master A, Vessel A was loaded with 12 vehicles (8 trailers and 4 power shovels totaling to about 128 tonnes) at the time of departure from Mikawa Port, with draft of approximately 4.5 meters at the bow and 5.3 meters at the stern.

(2) Vessel B

According to the staff of Company B, Vessel B, boarded by Master B, Officer B and 14 other crew members, was loaded with approximately 5,050 tons of steel products (210 steel coils), consisting of approximately 2,432 tons in No.1 Cargo Hold and approximately 2,618 tons in No.2 Cargo Hold at the time of departure from Kashima Port around 15:25, March 9, 2009. Her draft was approximately 4.95 meters at the bow and 6.10 meters at the stern. Her destination was Yeosu Port, Republic of Korea.

2.6.3 Other Relevant Equipment Information

(1) Vessel A

Vessel A is a car carrier which has three vehicle decks (upper, freeboard and lower cargo hold decks), with two ramp way each located in the bow and stern sections of the port side. She is equipped with two radar systems (one of which incorporates ARPA), a GPS plotter, AIS, VDR and two VHF devices within the steering house. The VHF devices are located on each side, to the front of the steering house. The fore-mast on the bridge

*10 "Multi-purpose cargo ships" are designed to carry various types of cargo in cargo holds and containers loaded on exposed decks. These vessels are often equipped with cargo handling gear.

and the aft-mast are equipped with masthead lights, and two sidelights were positioned above the front of the bridge on both sides. A stern light was also present.

According to the Statement of Master A, the port VHF device was switched off at the time of the accident, but all other devices were in operation, with no problems in the hull, engine, or onboard equipment.

(2) Vessel B

According to statement of the staff of Company B, Vessel B was a multi-purpose cargo ship with two cargo holds, equipped with three portal derricks, numbered from bow to stern as No.1, No.2, and No.3 derricks, respectively incorporating one, two and one derrick booms. The steering house of the vessel was equipped with two radar systems, one GPS plotter, one AIS, one VDR and two VHF devices.

According to the statement of Officer A, he saw Vessel B's 2 masthead lights and both sidelights turned on.

(See Figure 9: General arrangements of both vessels; Figure 10: Equipment layout and watch status for Vessel A; and Figure 11: Equipment layout for Vessel B)

2.6.4 Vessel Maneuverability

(1) Vessel A

According to the maneuverability data, the maneuverability performance of Vessel A while proceeding at the maximum service speed (19.9 kn, 158 rpm) in ballast is as described below:

{1} Minimum stopping time and distance

From full astern command to dead stop

Duration	4"12'
Stopping distance	1,392 m

{2} Turning performance

	Rudder port 35°	Rudder starboard 35°
Maximum advance (90° turn)	504 m	526 m
Maximum transfer (180° turn)	521 m	555 m
Steady tactical diameter	434 m	462 m

(2) Vessel B

According to statement of the staff of Company B, the turning performance of Vessel B while proceeding at the maximum service speed (14.3 kn, 200 rpm) in ballast is as described below:

	Rudder port 35°	Rudder starboard 35°
Advance (90° turn)	337 m	327 m
Transfer (90° turn)	206 m	183 m
Maximum transfer	434 m	409 m

2.6.5 Specifications of Derricks on Vessel B

According to the statement of staff of Company B, the specifications of the derricks equipped on Vessel B are as described below:

(1) Safe Working Load (SWL) – 25 tons

(2) Derrick booms (common to No.1, No.2 and No.3 derricks)

Length: approx. 18.0 meters

Diameter: base – approx. 55 cm; middle – approx. 55 cm; top – approx. 41 cm

Material: Steel

(3) Top portions of the derrick booms were equipped with fixing brackets (boom fittings and cargo pieces) for attachment of pulleys and wires.

(4) Derrick posts (No.1; No.2 and No.3)

Height: approx. 17.6 to 19.15 meters, width – approx. 7.0 to 11.0 meters

Diameter: base – approx. 1.3 m; middle – approx. 1.1 m; top – approx. 1.05 m

(5) Position of derrick posts

No. 1 derrick -- approx. 11 meters from foremost section of ship's bow

No. 2 derrick -- approx. 48 meters from foremost section of ship's bow

No. 3 derrick -- approx. 86 meters from foremost section of ship's bow

(6) Access platform with a height of approximately 4.0 meters from the deck, and approximately 6.3 meters (L) by 14.0 meters (W) in size was attached to the base of No.2 derrick.

(See Figure 12: Deck layout for Vessel B; Figure 13: Summary of derricks on board Vessel B)

2.7 Weather and Sea Conditions

2.7.1 Estimated and Observed Weather Conditions, Warnings and Advisories

(1) Estimates by Japan Meteorological Agency (JMA)

According to the estimates by the Forecast Division of JMA, the weather and sea conditions in the vicinity of the site of the accident were as follows:

21:00, March 9

Wind direction (WDIR) NNE-ENE, Wind speed (WS) 10-20kn; Wave (direction NNE-ENE, cycle 4-6sec, height[*11] 1-2m), swell (direction ENE-ESE, cycle 8-10sec, height 1-2m), composite wave height approx. 2 meters

03:00, March 10

WDIR N-NE, WS 25-35kn

09:00, March 10

WDIR N-NE, WS 15-25kn; Wave (direction N-NE, cycle 5-7sec, height 2-3m), swell (direction ENE-ESE, cycle 8-10sec, height 1-2m), composite wave height approx. 3 meters

(2) Observed Weather Conditions

Weather conditions observed at the time of the accident by the Oshima Weather Station, Tokyo District Meteorological Observatory situated approximately 25 kilometers to the northwest of the site of the collision were as follows:

02:00 WDIR SE, WS 7.9 m/s

03:00 WDIR SE, WS 8.8m/s; weather – rain, visibility – 10 km

(3) Warnings and Advisories

{1} According to the Forecast Division of JMA, the warnings and advisories in effect around the date and time of the accident were as follows:

Northern Sea off Kanto [*12] [*13]

March 8	17:35	Ocean wind warning (until 15:00 Mar/9)
March 9	05:40	Ocean gale warning (until 03:00 Mar/10)
	11:30	Renewed (until 09:00 Mar/10)
	17:30	Renewed (until 15:00 Mar/10)
	23:25	Renewed (until 21:00 Mar/10)
March 10	02:40	Renewed (until 00:00 Mar/11)
	05:35	Ocean windstorm warning (until 03:00 Mar/11)
	08:20	Renewed (until 09:00 Mar/11)

{2} According to the Asia-Pacific surface weather chart (finalized version) based on the

[*11] "Wave height" in this case indicates the significant wave height (the average wave height of the one-third largest waves observed for a specified duration).

[*12] "Sea off Kanto" is defined as a region extending 300 M offshore from the coastline falling to the south of the line drawn at bearing 90 ° from the prefectural boundary between Fukushima and Ibaraki, and east of the line drawn from the boundary between Kanagawa and Shizuoka through the point 139° 18' E, 34° 54' N to 138° 50' E, 34° 20' N, then veering to bearing 180° from this point.

[*13] "Northern Sea off Kanto" indicates the waters to the north of latitude 34° within the Sea off Kanto.

observations conducted at 21:00, as well as the land/ocean weather and forecast, which were announced at 23:25 on March 9 by JMA, the ocean gale warnings applicable to the Sea off Kanto were summarized as follows:

A developing atmospheric depression (1004 hPa) in (latitude 31°N, longitude 136°E) is proceeding due east at 25 kn (approx. 45 km/h). North wind expected to gradually increase within Sea off Kanto to reach a maximum wind speed of 45 kn (approx. 23 m/sec) within the next 12 hours.

(4) Predominant wave directions and wave heights

According to the Ocean Wave Analysis Chart – Asia (AWPN), the predominant wave directions and the wave heights prevailing at the site of the accident were as follows:

March 9 09:00 Predominant wave direction east; wave height approx. 2.5 m

March 10 09:00 Predominant wave direction NNE; wave height approx. 3.5 m

(5) Wave conditions

According to the Ocean Wave Analysis Chart – Japan (AWJP), the wave conditions prevailing at the site of the accident from 09:00 Mar/9 to 09:00 Mar/10 were as follows:

{1} March 9, 09:00

Wave direction ESE, cycle 9 sec, wave height 2.0 m, WDIR NNE, WS 14 kn (approx. 7.0 m/sec) at F observation point NNW approximately 9.5 M from the site of the accident (Sagami Bay: latitude 34°50' N, longitude 139°30' E).

{2} March 10, 09:00

Wave direction ESE, cycle 9 sec, wave height 2.4 m, WDIR N, WS 24 kn (approx. 14.0 m/sec) at F observation point.

(6) Observations by the Japan Coast Guard

According to the Japan Coast Guard, the weather conditions in the vicinity of the site of the accident were as follows:

{1} At approximately 03:25, Mar.10

Weather rain, wind NNE, WS 16 m/sec with visibilities ranging from 500 to 1,000 meters.

{2} At approximately 14:20, Mar.10

Atmospheric temperature 14.5 degrees Celsius

Seawater temperature 14.8 degrees Celsius

2.7.2 Observation by Crew

According to the statements of Officer A and Master A, the weather and sea conditions in the vicinity of the site of the accident were as follows:

(1) Officer A

It was raining but not very hard, and the visibility was about four to five M. WDIR was NNE, wind force 6 to 7 (WS 10.8 to 17.1 m/sec). Ocean waves were rough (waves were rather high).

(2) Master A

At the time, Vessel A was experiencing 5 degree rolls to the side, but this was not so violent. Visibility was about 2 to 3 M.

(See Figure 17: Summary of weather and sea conditions)

2.8 Characteristics of the Area

2.8.1 Current in the Area

(1) The nautical publications for south/east Honshu issued by the Japan Coast Guard describe the current in the area as follows:

{1} Nojima-zaki – Inubou-saki

{2} Tsurugi-saki – Irou-zaki

When Kuroshio Current is flowing east-northeast from Zenisu to Miyake-jima, bifurcation of the current occurs, flowing in from between Izu peninsula and Oshima. In these circumstances, the current flows NE in the region between Izu and Oshima , NE to SE in the region between Oshima and Tsurugi-saki, and SE in the region between Oshima and Suzaki. On average, the current speed is 1 to 2 kn, but often exceeds 3 kn.

(2) Preliminary reports and coastal flow charts issued by the 3rd Regional HQ of the Japan Coast Guard summarize the current flow in the vicinity of the site of the accident as follows:

March 6 – 12　NE flow, approx. 0.6 to 0.9 kn

March 13 – 19 SE flow, approx. 1.0 to 1.9 kn

2.8.2 Course Settings in the Ocean Area Surrounding Oshima

The nautical publications for south/east Honshu issued by the Japan Coast Guard describe the course settings in the area as follows:

(1) West bound

Off coast of Tsurugi-saki or off coast of Nojima-zaki to Mikomoto island

{1} When passing north of Oshima

Proceed at 237° from area approximately 3 M SSE of Tsurugi-saki lighthouse, veer to 218° when Oshima lighthouse is approx. 5 M at bearing 147°, and then proceed to the points approximately 4 M to the SE of Mikomoto Island lighthouse.

{2} When passing south of Oshima

Proceed at 204° from area approximately 4 M SSE of Tsurugi-saki lighthouse, veer to 255° when Ryu-o-saki lighthouse (34°41.1' N, 139°26.6' E) is approx. 3 M at bearing 330°, and then proceed to the points approximately 3 M to the southeast of Mikomoto Island lighthouse.

(Omitted)

When navigating from the direction of Nojima-zaki, proceed at 244° from the area approximately 5 M SSE of Awa-Shirahama harbor lighthouse (34°54.9' N, 139°56.1' E), proceeding to the points approximately 3 M to the SE of Ryu-o-saki lighthouse. Follow navigational instructions in the above paragraph therefrom.

(2) East bound

Trace the respective west bound courses in the opposite direction.

2.8.3 Marine Traffic in the Vicinity of the Site of the Accident Based on AIS Data

According to the AIS data, marine traffic in the vicinity of the site of the accident from 00:00 to 06:00 on the day of the accident (March 10), the day one week before the accident (March 3) and the day one week after the accident (March 17) was as described below:

The area to the north of Oshima was congested by vessels navigating between the entrance to Tokyo Bay and the area to the south of Izu Peninsula. A traffic of vessels navigating between southern offshore of Nojima-zaki and southern offshore of Izu Peninsula was present in the area to the south of Oshima, where some other vessels were also sailing between Tokyo Bay and eastern Oshima. Traffic was relatively less heavy in the eastern waters adjacent to Oshima.

(See Figure 18: Marine traffic in the vicinity of Oshima (1); Figure 19: Marine traffic in the vicinity of Oshima (2))

2.9 Vessels Navigating in the Vicinity of the Site of the Accident

(1) Officer A

According to the statement of Officer A, the navigating vessels were as follows:

Two vessels were crossing the course of Vessel A to bow port (the preceding Vessel C and the following Vessel B) around 02:00, with the two vessels basically going along. Vessel C was maintaining approximately 250° at about 10 kn, and the following Vessel B was at about 245° with a speed of approximately 13 kn. Another large vessel (Vessel D) was sailing along with Vessel A about 4 to 5 M to the starboard.

(See Figure 15: Relative positioning of vessels according to the statement of Officer A)

(2) AIS data

According to the AIS data, the following AIS-equipped vessels were navigating within about 10 M of the site of the accident at the time:

{1} A north bound container ship (9,590 G/T), positioned 4.2 M away at 69° to starboard bow of Vessel A at about 02:04 and 3.0 M away at 91° to starboard bow of Vessel A at about 02:08.

{2} A south bound cargo-passenger ship (4,965 G/T), positioned 3.0 M away at 43° to starboard bow Vessel A at about 02:08

{3} A north bound container ship (60,876 G/T), positioned 6.6 M away at 24° to port bow of Vessel A at about 02:08.

{4} A container ship (91,427 G/T) on the drifting, positioned 5.3 M away at 20° to port stern of Vessel A at about 02:08.

{5} An east bound tanker (999 G/T), positioned 10.0 M away at 69° to port bow of Vessel A at about 02:08.

(See Figure 16: Marine traffic in the sea waters in the vicinity of the site of the accident, based on AIS data)

(3) Officer A's responses to this situation around accident time which was reconstructed based on the AIS and the VDR data

In relation to the Officer A's statement on the situations prior to the accident According to the above paragraph (1), Officer A gave a graphic explanation on the situations, using radar images handwritten based on his own memory. After his explanation, the situation was reconstructed based on the AIS data and VDR data according to the above paragraph (2) and in 2.10.2(2) below to ask for his statement. No contradictory statement was presented by Officer A.

2.10 Lookout Situations on Vessel A

2.10.1 First Sighting of Vessel B

(1) According to the statement of Officer A, Vessel B was first detected about 02:00 at a distance of 4 M to port bow on No.1 radar which was set to display a range of 6 M, with the center offset rearward by 3 M. The radar blip representing Vessel B indicated that the size of Vessel B was almost identical with Vessel C sailing along in front of her. Upon visual confirmation of the ship's lights using binoculars, both of the vessels were showing two masthead lights (white) and a starboard light (green).

(2) According to the statement of Seaman A, he did not notice Vessel B until immediately before the collision. He only noticed the navigation lights of Vessel B just two to three seconds prior to the accident.

2.10.2 Confirmation of Vessel B's Movement

(1) According to the statement of Officer A, upon his confirmation of Vessel B's movement on No.1 radar, he had the impression that Vessel B would uneventfully pass ahead of Vessel A around 02:14.

(2) Changes in bearings and distances based on VDR data

According to the VDR data, the bearings and distances to Vessel B as observed from Vessel A were as follows:

{1} Bearing approx. 111°, distance approx. 3.9 M as of about 02:03

{2} Bearing approx. 110°, distance approx. 3.2 M as of about 02:05

{3} Bearing approx. 108°, distance approx. 2.5 M as of about 02:07

{4} Bearing approx. 104°, distance approx. 1.8 M as of about 02:09

{5} Bearing approx. 093°, distance approx. 1.0 M as of about 02:11

{6} Bearing approx. 076°, distance approx. 0.3 M as of about 02:13

The bearing/distance transmission from Vessel B ceased to be displayed at about 02:15:40.

(See Table 3: Changes in bearings/distances to Vessel B as seen from Vessel A based on VDR Data)

2.11 Master A's Evaluation of Officer A and others

2.11.1 Master A's Evaluation of Officer A

According to the statement of Master A, upon work with Officer A for about two months prior to the accident, Master A was of the opinion that Officer A, although having properly fulfilled his responsibilities on the initial voyage, was not so competent in terms of knowledge or skills as compared to other personnel with whom Master A had previously worked. However, the Master A did not see any particular problem with the qualifications and expertise of Officer A, nor any need for re-training / guidance.

2.11.2 Instructions in Effect at the Time of the Accident

According to the statement of Master A, Master A marked his instructions: "CALL CAPT" on the chart in use at that time, designating the position where to call him, before he left the bridge. As he frequently returned to the bridge, he did not make a specific entry of the instructions to the crew on watch in the night orderbook.

2.12 Radar Usage on Vessel A

(1) Radar Usage

According to the statement of Officer A, No.1 radar was in use with the range set to six

M and the center offset rearward by three M. The radar was adjusted to display range scale rings at one M intervals. No.2 radar was placed on stand-by at that time.

(2) Settings for CPA/TCPA Alarm of the ARPA

According to the statement of Officer A, the CPA/TCPA alarm of the ARPA system was set to approx. two to three M, causing the system to sound an alarm in the event other vessels entered the designated range. The alarm was triggered when Vessel C, preceding Vessel B, passed ahead of Vessel A.

According to the statement of Master A, the Closest Point of Approach (CPA) for the CPA/TCPA alarm was set to 0.5 M, but the guard ring*14 functionality was not set on.

2.13 Operation of ARPA by Officer A

According to the statement of Officer A, CPA and TCPA become available by pressing the button to enable the device to display previous course of vessels. Risk of collisions may be assessed based on the data obtained by adjusting the vector. However, Officer A had no knowledge on the means by which to alter the true and relative vectors for Vessel B on the ARPA device.

2.14 VHF Communications between Vessels A and B

(1) According to the statement of Officer A, initially, Vessels B and C located to the port bow were both showing two masthead lights and starboard lights (green). Suddenly, both sidelights (red and green) became visible for the following Vessel B. At about 02:12, Officer A called Vessel B on the VHF Channel 16 and asked “WHAT ARE YOUR INTENTIONS?” but received no response. The distance to Vessel B closed into approximately 0.7 to 0.8 M by that time. Officer A had not checked the name of the approaching vessel on the AIS device installed in the front portion of the steering house. He had no recollection of hearing inbound communications from Vessel B to Vessel A on the VHF.

(2) Situations reproduced from the VDR data were as follows:

Officer B on board Vessel B made two attempts to communicate with Vessel A by calling “CYGNUS ACE, THIS IS ORCHID PIA, COME IN PLEASE” on the VHF at about 02:05:26 and about 02:05:37. VDR data do not indicate any recorded responses from Vessel A to Vessel B, nor any calls from Vessel A attempting to communicate with Vessel B.

*14 “Guard Ring (or Guard Zone alert)” is a function to alert the operator aurally and visually of all identifiable targets transiting the guard zone (distance range) set by the operator.

2.15 Audio Information Recorded in VDR Data

(1) Recorded Voices

According to the VDR data, the audio information recorded within Vessel A's steering house consisted of VHF calls from Vessel B to Vessel A, various alarms generated by the equipment installed in Vessel A's steering house, noises resulting from the collision, and conversations among the crew. Blasts from whistles were not included in the data.

(See Table 5: VDR data, audio records)

(2) Speakers of the Recorded Voices

{1} According to the statement of Master A, the two calls made by VHF from Vessel B to Vessel A around 02:05 were clearly identifiable within the VDR data of Vessel A. It was Master A, Officer A and other crew members within the steering house whose voices were recorded at about 02:13.

{2} According to the statement of the staff of Company B, the person who made the VHF calls from Vessel B to Vessel A at about 02:05:26 and 02:05:37 was identified as Officer B on board Vessel B.

(3) Audio Signals from Various Onboard Equipment

{1} According to the statement of manufacturers of the equipment installed on Vessel A, the most probable source of the short bursts of "peep" sounds beginning around 02:12:15 and continuing until about 02:16:08 is considered an alarm signal notifying reception of "Distress MSG (messages)" for the Digital Selective Calling (DSC) functionality incorporated into MF/HF (Medium-Frequency / High-Frequency) devices. Although such alarms are often triggered by false distress calls, it is considered probable that the alarm in this instance was activated by the reception of an actual distress message.

{2} According to the statement of Master A, the dual-toned alarms activated around 02:08:34 and again around 02:09:52 seem to be CPA/TCPA alarms, while the succeeding "peep" sounds recorded at about 02:08:44 and 02:09:57 seem to be signals indicating the alarms were cut.

2.16 Watch Duty on Vessel A

2.16.1 Knowledge about Sea Area in the Vicinity of the Site of the Accident

According to the statement of Master A, the sea area in the vicinity of the site of the accident is regarded as an open sea (available for general navigation) relatively less congested by vessels, and not as a sea area of high traffic destiny. At the time of the accident, Master A intended to proceed southward to the southeastern end of Oshima and alter her course toward the entrance of Tokyo Bay.

According to the statement of Officer A, he had prior experience in navigating within the area, so he was not particularly concerned.

2.16.2 Watch Duty at the Time of the Accident

(1) Officer A

According to the statement of Officer A, he had 5 hours of sleep before coming on duty, and did not feel sleepy. He confirmed the ship's position at about 02:00, entering the data in the ship's logbook. He then manned the station behind No.1 radar to stand watch.

According to the statement of Seaman A, Officer A was without doubt on watch duty in the steering house up to the time of the collision. As the door between the steering house and the starboard wing was closed, however, Seaman A did not have a conversation with Officer A on watch duty.

According to the statement of Master A, although Officer A did not respond to the VHF calls from Vessel B, the officer must have been stationed within the steering house. The master also suggested Officer A was supposed to be positioned close to the chart table at around 02:05 to confirm the ship's position, but even he did not know why Officer A had not responded to the calls from Vessel B.

(2) Seaman A

According to the statement of Seaman A, he was standing watch on the starboard wing from about 10 minutes before the collision, and the door between the wing and the steering house was closed. He did not have binoculars on hand. He only noticed Vessel B approaching just before the collision and did not have enough time to warn Officer A. The door to the steering house was opened by Seaman A when he entered the room after the collision.

2.16.3 Regular Stations for Seamen during Watch

Statements provided by Master A, Officer A and Seaman A are as follows:

On board Vessel A, seamen, not limited to Seaman A, stood on watch duty for lookout on either of the port or starboard bridge wings, depending on the prevailing conditions such as wind directions. Such stations, not unique to Vessel A, were adopted as a company policy.

When Officer A stationed Seaman A as lookout on the port wing, he did not give the seaman specific instructions to report the situations.

2.16.4 Communication among Crew Members on Watch Duty

According to the statement of Officer A, he communicated with Seaman A in English. While Seaman A was not very proficient in English, Officer A did not find their communication so difficult, because use of body languages (gestures, physical languages) could sufficiently facilitate communication with the Seaman A.

According to the statement of Seaman A, Seaman A either had no particular difficulties in communication with Officer A, because they could make themselves understood through use of nautical English terms.

According to the statement of Master A, Seaman A was not proficient in English, and Officer A and Seaman A could hardly communicate with each other, which may have been a problem in the context of BRM[*15]. Officers including Officer A were able to sufficiently communicate with the other seamen. Under normal circumstances, mutual understanding between officers and seamen could sufficiently be established by combined use of gestures, although they had very few opportunities to engage in such conversations.

2.17 Situations of the Collision

2.17.1 Relative Positioning of Vessels A and B

According to the statement of Master A, the port light (red) of Vessel B was moving along the starboard side of Vessel A as he arrived on the bridge after the collision. This suggests Vessel B was positioned adjacent to Vessel A for a certain length of time, and he considered it highly probable that Vessel A had run over Vessel B.

2.17.2 Impacts of the Collision

According to the statement of Officer A, Vessel A experienced a significant jolt at the time of the collision. While holding the steering wheel to hard port, Officer A felt himself careening to the port side.

According to the statement of Master A, he experienced the collision while reading on the bed in his cabin. The ship shook as if by an earthquake, accompanied by a loud noise. Several books left on the bed fell to the floor.

According to the statement of the Chief Engineer A, he mentioned a loud crashing sound at the time of the collision. The vessel pitched with heavy downward vibrations.

2.18 Search and Rescue Operation for Vessel B

According to the Japan Coast Guard and VDR data, search and rescue operation was carried out as follows:

(1) Establishment of Rescue Headquarters

In response to the collision, the Japan Coast Guard organized a countermeasures HQ

[*15] "Bridge Resources Management (BRM)" is a concept requiring the adequate utilization of resources including personnel, equipment and information available within the bridge to facilitate the safe navigation of vessels.

within the 3rd Regional HQ and a local HQ within the Shimoda Coast Guard Office, both by 03:30, March 10. At 06:00, "Countermeasures Headquarters for Major Scale Marine Collision & Missing Accident East of Oshima within the Third Coast Guard Office Region" was established within the 3rd Regional HQ.

(2) VHF Communications

{1} At about 02:14:42, Tokyo MARTIS attempted to contact Vessel A with the call "CYGNUS ACE, CYGNUS ACE. THIS IS TOKYO MARTIS, TOKYO MARTIS," then to Vessel B with the call "ORCHID PIA, ORCHID PIA. THIS IS TOKYO MARTIS" at about 02:15:02 and about 02:15:28. Neither of the vessels responded to these calls.

{2} At about 02:16:47, the 3rd Regional HQ established communications with Vessel A, and obtained information that "she had collided with another vessel."

(3) Search and Rescue Operation Using Vessels/Aircrafts

{1} By 08:45, March 10, five patrol vessels and three aircrafts were dispatched to the site of the accident by the Japan Coast Guard, as well as one vessel and two aircrafts from the Japan Maritime Self-Defense Force (JMSDF). A Full-time search and rescue operation was carried out until sundown on March 16, with a total of 30 vessels and 35 aircrafts participating in the operation.

(See Table 4: Search and rescue activities)

{2} Commercial vessels which participated in the search and rescue operation included one container ship and one cargo ship, besides Vessel A.

(4) Recoveries

Two inflatable two life rafts and two lifeboats, all unmanned, were recovered by about 14:00 on March 10, along with three life buoys, six life jackets and one self-igniting light*16. It was confirmed that all of them were on Vessel B.

2.19 Safety Management of the Vessels Involved

According to Company A and Company B, the both companies were granted Document Of Compliance (DOC) by satisfying the requirements stipulated in the International Safety Management (ISM) Code*17, and both Vessels A and B were issued with Safety Management Certificates (SMC).

*16 Self-igniting light is attached to a lifebuoy to help a person in the water to find it at night.

*17 International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM code) was adopted as IMO assembly resolution on November 4, 1993 with the aim of enhancing the safety of ship operation and the protection of marine environment. The code was incorporated into the annex to the International Convention for the Safety of Life at Sea (SOLAS) 1974, and came into effect on July 1, 1998 after the amendment of the Convention in 1994. ISM code applies to all passenger ships and other vessels of 500 gross tonnage and upwards engaged in international voyages.

(1) Company A and Vessel A

{1} Document Of Compliance (DOC)

Certification: Nippon Kaiji Kyokai

Certification date: December 7, 2006

Expiration date: December 9, 2011

{2} Safety Management Certificate (SMC)

Certification: Nippon Kaiji Kyokai

Certification date: May 5, 2004

Expiration date: May 4, 2009

(2) Company B and Vessel B

{1} Document Of Compliance (DOC)

Certification: Korean Register of Shipping

Certification date: September 1, 2006

Expiration date: August 31, 2011

{2} Safety Management Certificate (SMC)

Certification: Korean Register of Shipping

Certification date: August 8, 2006

Expiration date: August 7, 2011

2.20 Safety Management Manual for Vessel A

The Safety Management Manual (hereinafter referred to as "SMM") adopted by Company A contains the following provisions.

Chapter 19 SHIPBOARD OPERATION PROCEDURES ("Watchkeeping Arrangement" (RSM-S-0311))

19.1.3 Navigational equipment

3.1 The watchkeeping officer shall make effective use of all navigational equipment that can be used during navigation.

3.3 The watchkeeping officer shall not hesitate in using the rudder, propulsion machinery and sound signal apparatus, when circumstances so require.

19.1.4 Responsibility of the watchkeeping officer

4.1 The watchkeeping officer, as a proxy for the Master, has the responsibility for always ensuring safe navigation of the ship. The watchkeeping officer shall strictly obey the applicable rules for avoiding collision at sea at all times.

4.4 The watchkeeping officer shall follow the Master's Night Order Book (Bridge Orders Book), international conventions and rules and regulations of all states while discharging watchkeeping duties. The Master, before retiring to his cabin at night, shall always enter the Master's Night Order Book, confirm the persons scheduled for watch, and obtain their signatures.

4.5 When a situation prescribed in the other procedures or instructions and based on the Master's instructions occurs, or the occurrence of the situation is predicted, the watchkeeping officer shall report the condition to the Master at an hour such that the Master has adequate time to judge the situation and confer a decision.

CHAPTER 20 Shipboard Operation Procedures ("Bridge Watchkeeping Instructions" (RSM-S-0311))

20.1 Watchkeeping items to be observed

(1) The watchkeeping officer shall read the Master's instructions entered in the Instructions, sign the book before starting his watch duty, and perform the navigational watch according to these Instructions.

(2) If the watchkeeping officer feels uneasy at sea, and the condition is According to the Instructions or According to others, he shall immediately report to the Master and receive instructions.

(6) The watchkeeping officer shall always maintain an appropriate look-out by making use of visual and audible means, and all other means available at his disposal so that he can make appropriate judgments about the condition of the surroundings, and the risk of collision with another ship. He shall use binoculars during look-out duty, even at night.

(7) If the watchkeeping officer recognizes the presence of another ship or its navigation lights in the vicinity, he shall immediately confirm a change in the bearing of the ship on the compass and judge the risk of collision.

In relation to the above, an inquiry was sent to Company A concerning the safety management protocols for its vessels, requesting for elaboration on the levels of communication among the crew on watch duty under normal circumstances, which in fact did not seem adequate, and on the onboard training/guidance systems provided by the Company. Company A did not provide any responses to the inquiry.

2.21 Port State Control (PSC)

PSC inspections conducted for the vessels involved found out the following:

(1) Vessel A

The inspection of Vessel A by the port state control officer of Hakata Port, Fukuoka Pref.

on February 20, 2009 identified 4 deficiencies pertaining to navigational safety and ISM code. Corrective actions were requested, although none of the deficiencies were so significant as to detain the vessel.

(2) Vessel B

The inspection of Vessel B by the port state control officer of Kashima Port on December 10, 2008 identified 3 deficiencies including partially defective life boats and flaws in the loadline. Corrective actions were requested, although none of the deficiencies were so significant as to detain the vessel.

2.22 Emergency Position Indicating Device Beacon Installed on Vessel B

(1) Signal Transmission

According to the Japan Coast Guard, distress signals from the Emergency Position Indicating Device Beacon*18 (EPIRB) on board Vessel B were not detected at the time of the accident, and the EPIRB was not found by subsequent search activities.

(2) Inspection Results

According to the Korean Register of Shipping, EPIRB was installed in the aft section of the starboard wing of Vessel B. In compliance with the provisions of the relevant convention, the beacon was subject to inspection on an annual basis. Inspection items of the beacon include confirmation of the operation of the automatic release unit, visual examination, automatic activation and expiry date of the battery. EPIRB on board Vessel B was inspected by the Korean Register of Shipping on October 12, 2008. The contents and results of the inspection were as described below:

Visual examination	No particular problem
Expiry date of the battery	September, 2012
Expiry date of the release unit	September 2010
Maintenance in land-based facilities (interval not to exceed 5 years)	
Maintenance performed	September 21, 2008

The maintenance company service EPIRB units in accordance with the applicable laws/regulations of the Republic of Korea. The particular unit was serviced at Pusan, Republic of Korea by the company on October 10, 2008 and the automatic activation functionality test was reported as satisfactory.

*18 "Emergency Position Indication Device Beacons (EPIRB)" is an equipment designed to transmit distress signals and the position of ships in distress to coast stations of search and rescue organizations via satellite communication using 406 MHz band.

2.23 Research by National Maritime Research Institute

The outline of the course of the events leading to this accident was revealed from the AIS data of the two vessels involved, and the VDR data recovered from Vessel A. However, an elaborate research was deemed necessary in order to clarify the movements of the vessels at the time of the collision, causes of the unnatural damage incurred by Vessel A, and reasons why Vessel B sank so rapidly. Detailed research of the following aspects were commissioned to the National Maritime Research Institute (hereinafter referred to as "NMRI"), with the results According to Sections 2.23.2 to 2.23.5.

(1) Determination of the ship's tracks and details of the relative positioning of the two vessels at the time of collision.

(2) Locations and situations of the collision of the two vessels, with then prevailing weather conditions taken into consideration

(3) Development of damage to Vessel A and the mechanism by which Vessel B sank

During the research, the situations of the collision were reproduced using the NMRI's Bridge Simulator for Navigation Risk Research.

2.23.1 Prerequisites for Research

(1) Relationship among time stamps incorporated in AIS/VDR data and UTC

Time stamps incorporated into AIS and VDR data were in UTC with timing based on GPS-synchronized clock signals. Upon precise comparison between VDR time stamps and AIS data maintained by the Japan Coast Guard, it was revealed that the time stamps on VDR data were advanced than actual UTC by 2 seconds, while the time stamps on AIS data were more delayed than UTC by 2 seconds. As both of the data were recorded with time indications slightly deviating from actual UTC, the time indication employed in the report of the research conducted by NMRI was based on actual UTC.

(2) Weather and sea conditions in the vicinity of the site of the accident

In reproducing the situations of the collision, the weather and sea conditions prevailing at the time of the accident were estimated on the basis of the estimated wave data obtained from the Japanese coastal localized wave estimation database in addition to the Asia-Pacific surface weather chart (finalized version), the Ocean Wave Analysis Chart – Asia (AWPN), the Ocean Wave Analysis Chart – Japan (AWJP) and various meteorological warnings/advisories in effect. Estimated wave data obtained from the Japan Weather Association database of wave hindcast around the coastal areas of Japan was localized to latitude 34°42' N, longitude 139°36' E, approximately 870 meters northeast of the site of the accident, for 03:00, March 10. The resulting meteorological data at the time of the accident was as described below:

Wave direction	ESE (113°)
Wave cycle	8 sec
Wave height	2.24 meters
Wind direction	NE
Wind speed	23.3 kn (approx. 12.0 m/sec)
Visibility	3 to 5 M

2.23.2 Analysis on the Navigation Lights Arrangement of Vessel B

According to the general arrangement and exterior images, the position of masthead lights on Vessel B is as described below:

(1) Fore-masthead light

The light was installed on the upper portion of No.1 derrick post located approximately 11 meters aft of the bow, at a height of approximately 26.5 meters from the ship's bottom.

(2) Aft-masthead light

The light was installed on the upper portion of the aft-mast located approximately 84 meters aft of the bow, at a height of approximately 31.6 meters from the ship's bottom.

From about 02:12:04 to about 02:12:25, the aft-masthead light equipped on Vessel B was hidden behind the derrick posts and other gear with angles-of-view at 177 to 183 degrees and was difficult to recognize from the steering house of Vessel A (eye height: about 17 meters).

2.23.3 Analysis on Relative Positioning of the Two Vessels at the Time of the Collision

(1) Motions of the two vessels

Based on the weather and sea conditions estimated in Section 2.23.1, the motions of the two vessels at the time of the accident are assumed to be as described below:

	Vessel A	Vessel B
Angle of pitch	0.81°	1.62°
Angle of roll	5.6°	2.8°
Vertical motion	0.2 m	0.45 m

(2) Running over situations

It is considered probable that the lower section of the bulbous bow (ship's bottom) of Vessel A collided with the middle part of the port side of Vessel B, in front of No.2 derrick about 4.3 meters below the upper deck, destroying the hull plating. The impact probably caused Vessel B to list to the starboard side when Vessel A ran onto the deck of Vessel B.

(See Figure 4: Changes in the bearings/speeds of the two vessels; Figure 6: Status of the collision (simulated images (1)); Figure 7: Status of collision – enlarged (simulated images (2)); Figure 8: Status of collision – enlarged (simulated images (3)))

2.23.4 Analysis on Causes for Primary Damage to Vessel A

(1) Ruptures in the bow section near the waterline

It is considered probable that the damage was caused by contact with the tip of the forward-facing boom for Vessel B's No.2 derrick.

(2) Ruptures in the starboard bow

It is considered probable that the damage was caused by contact with the upper section of the platform attached to the derrick post of Vessel B's No.2 derrick.

(3) Ruptures in the foremost section of the bulbous bow

In multi-purpose cargo ships like Vessel B, longitudinally extended frames are often integrated into the hull structure as reinforcement members. It is considered probable that the damage was the result of the bulbous bow section contacting with the upper portion of such members.

2.23.5 Research on Events Leading to the Sinking of Vessel B

It is considered probable that, at the time of the collision, Vessel B was run over by Vessel A, causing the hull of Vessel B to plunge downward by about 2 meters. The combination of the static load and the pressure exerted by Vessel A could have resulted in application of up to 3,000 tonnes of load onto the midship of Vessel B's hull, causing the hull to break, and thereby sinking the vessel within a matter of minutes.

(See Table 6: Result of analysis by NMRI (summary))

3 ANALYSIS

3.1 Situation of the Accident Occurrence

3.1.1 Course of the Events

According to 2.1 and 2.10 through 2.16, the course of the events is as described below:

(1) Vessel A

{1} It is considered probable that Officer A relieved the 3rd officer from bridge watchkeeping at about 00:00 on March 10 together with Seaman A, while the vessel maintained her northeast bound course.

{2} It is considered probable that Master A arrived at the bridge at about 01:00 after having received a telephone call from Officer A reporting that the vessel arrived at the position to the north of Oshima that was marked on the chart as "CALL CAPT" position.

{3} It is considered probable that Master A altered the course to approximately 146° in order to adjust the ETA at Yokohama Ku to the scheduled arrival time of 06:00 after having confirmed the position of the vessel, and then left the bridge at about 01:45.

{4} It is considered probable that Officer A stationed Seaman A on the starboard wing as lookout, closed the door between the starboard wing and the steering house, and manned the station behind No.1 radar with the apparatus set to 6 M range with the center offset rearward by 3 M, allowing the vessel to proceed southeast under autopilot.

{5} It is considered highly probable that Vessel A was passing through the area 058° to Ryu-o-saki lighthouse at a distance of 6.2 M at about 02:00, maintaining COG approx. 147° and SOG approx. 17.4 kn.

{6} It is considered highly probable that Vessel A was passing through the area 066° to Ryu-o-saki lighthouse at a distance of 6.3 M at about 02:03, maintaining COG approx. 148° and SOG approx. 17.5 kn.

{7} It is considered probable that Officer A confirmed the ship's position at the chart table, making entry of the position in the ship's logbook at about 02:05, when the vessel was positioned in the area 071° to Ryu-o-saki lighthouse at a distance of 6.4 M.

{8} It is considered highly probable that, Officer A did not respond to two attempted calls to Vessel A from Vessel B on the VHF.

{9} It is considered highly probable that Officer A stopped the CPA/TCPA alarm at about 02:08 when it sounded while the vessel was positioned in the area 078° to Ryu-o-saki lighthouse at a distance of 6.6 M.

Additionally, it is considered somewhat likely that the CPA/TCPA alarm settings were approximately 0.5 M and 5 minutes respectively.

{10} It is considered probable that Officer A stopped the second CPA/TCPA alarm at about 02:10 when the vessel was positioned in the area 083° to Ryu-o-saki lighthouse at a distance of 6.9 M, and then began turning the vessel to port by repeatedly pressing the steering button on the autopilot by one degree each time.

{11} It is considered probable that Seaman A maintained lookout on the starboard wing, but did not notice the approaching Vessel B until a few seconds before the collision.

{12} It is considered probable that Officer A switched to manual steering at about 02:13, steering the vessel to hard port in anticipation of a risk of collision with Vessel B.

{13} It is considered highly probable that Vessel A collided with Vessel B while Vessel A was turning to port.

(2) Vessel B

{1} It is considered highly probable that Vessel B was proceeding southwest with COG approx. 241° , heading approx. 240° and SOG approx. 11.7 kn at about 01:47.

{2} It is considered highly probable that Vessel B was passing through the area 082° to Ryu-o-saki lighthouse at a distance of 10.0 M at about 02:00, maintaining COG approx. 239° , heading approx. 239° and SOG approx. 12.1 kn.

{3} It is considered highly probable that Vessel B started turning to starboard at about 02:03, when the vessel was positioned in the area 083° to Ryu-o-saki lighthouse at a distance of 9.4 M.

{4} It is considered highly probable that Vessel B made two attempts to call Vessel A on the VHF at about 02:05 when Vessel B was positioned in the area 084° to Ryu-o-saki lighthouse at a distance of 9.1 M. It is considered probable that it was Officer B who called Vessel A twice on the VHF.

{5} It is considered highly probable that Vessel B was passing through the area 085° to Ryu-o-saki lighthouse at a distance of 8.6 M at about 02:08, maintaining COG approx. 248° , heading approx. 247° and SOG approx. 11.4 kn.

{6} It is considered highly probable that Vessel B was passing through the area 086° to Ryu-o-saki lighthouse at a distance of 7.8 M at about 02:10, maintaining COG approx. 255° , heading approx. 256° and SOG approx. 10.4 kn.

{7} It is considered highly probable that Vessel B collided with Vessel A while Vessel B was turning to starboard.

3.1.2 Date and Time and Location of the Accident

According to 2.1, it is considered highly probable that the date and time of the accident occurred at around 02:13, March 10, and the location was in the vicinity of the area 087° to Ryu-o-saki lighthouse at a distance of 7.6 M.

3.1.3 Situation of the Collision

According to 2.1, 2.3 and 2.23.4(2), it is considered probable that the bow section of Vessel A contacted with the port middle section of Vessel B at an angle of about 45° , causing Vessel A to run onto Vessel B.

3.2 Causal Factors of the Accident

3.2.1 Status of the Crew

(1) Vessel A

According to 2.5, Master A and Officer A both had documentary proof of application for an endorsement under STCW regulation I/10 issued by the Republic of Panama.

It is considered probable that Officer A's health condition was good at the time of the accident.

(2) Vessel B

According to 2.5, Master B and Officer B had seamen's competency certificate issued by the Republic of Korea.

The physical/mental conditions of Officer B at the time of the accident are not known.

3.2.2 Situation of the Vessels

(1) Vessel A

According to 2.6.3 and 2.21, it is considered probable that the hull, the engine and equipment on board Vessel A were in good working conditions at the time of the accident, although some corrective actions were requested at the PSC inspections.

(2) Vessel B

According to 2.6.3 and 2.21, it is considered probable that the hull, the engine and equipment on board Vessel B were in good working conditions at the time of the accident, although some corrective actions were requested at the PSC inspections.

3.2.3 Light Exhibition by Vessel B and Visibility from Vessel A

According to 2.10.1 and 2.23.2, the situations were as described below:

(1) Light exhibition by Vessel B

It is considered probable that Vessel B was exhibiting 2 masthead lights as well as both sidelights and stern light.

(2) Visibility from Vessel A

It is considered probable that the aft-masthead light of Vessel B was hidden behind No.3 derrick when viewed from Vessel A. It is also considered probable that the light was temporarily not visible from the steering house of Vessel A for the duration of about 02:12:04 to about 02:12:25 due to the ship motions. However, it is considered probable that the temporary loss of visibility did not affect the navigational judgment of Officer A as Vessel A had already started turning to port at about 02:10.

3.2.4 Weather and Sea Conditions

According to 2.7 and 2.23.1(2), it is considered probable that the conditions of weather and sea at the time of the accident were as described below:

Weather: rain; Wind Direction: NNE; Wind-Force: 6; Visibility: approx. 5 M; Wave

Direction: ESE (113°); Wave Height: approx. 2.2 meters.

3.2.5 Ocean Current Conditions

According to 2.8.1, it is considered probable that the ocean current in the vicinity of the site of the accident flowed NE at the speed of approx. 0.6 to 0.9 kn from the day of the accident to March 12, and SE at the speed of approx. 1.0 to 1.9 kn from March 13 through 19.

3.2.6 Analysis on Casualties

(1) Vessel A

According to 2.2, there were no casualties among the crew of Vessel A.

(2) Vessel B

According to 2.2 and 2.23.5, it is considered somewhat likely that all of the 16 crew members on board Vessel B went missing, because Vessel B was caused to sink in such a short time.

3.2.7 Analysis on Damage

(1) Vessel A

According to 2.3, 2.17.1, 2.23.4, 2.23.5 and 3.1.3, it is considered somewhat likely that Vessel A sustained damage as described below:

{1} Dents in the foremost section of the bow in the vicinity of the waterline

These dents were caused by the foremost section of the bow of Vessel A contacting with the tip of the forward boom of No.2 derrick on Vessel B, which was parked on the port side above the cargo hatch.

{2} Ruptures in the starboard bow section

These ruptures were caused by the starboard section of the bow of Vessel A contacting with the upper port section of No. 2 derrick post platform on Vessel B.

{3} Ruptures in the lower foremost section of the bulbous bow

These ruptures were caused when Vessel A ran onto the port deck of Vessel B, contacting with the side edges of the hull and the cargo hatch area.

{4} Pulleys and wires entangled on the starboard anchor

Pulleys and wires fitted at the mid/top sections of No.2 derrick post or at the tips of the derrick booms on Vessel B got entangled with the starboard anchor of Vessel A.

{5} Dents and scratches on the port bow section

These dents and scratches were caused when the port bow section and forward ramp way of Vessel A violently contacted with the numerous pulleys and wires equipped on Vessel B.

Because Vessel B sank within several minutes after Vessel A ran onto her without any further contacts, Vessel A sustained no damage in the middle to astern sections of the bottom hull.

(2) Sinking of Vessel B

According to 2.3, 2.10.2, 2.17.2 and 2.23.5, it is considered somewhat likely that Vessel B sank in the following way.

{1} When Vessel A ran onto Vessel B, Vessel B subsided by approximately two meters with about 3,000 tonnes of load applied.

{2} Vessel B's hull gave in at the midship, causing her to sink.

{3} Vessel B sank within several minutes after the collision.

3.2.8 Marine Traffic in the Vicinity of the Site of the Accident (Eastward Offshore Oshima)

According to 2.8.2 and 2.8.3, it is considered probable that the east of Oshima is an area where the traffic of vessels navigating between Nojima-zaki and south of Oshima intersects the traffic of vessels navigating between Tokyo Bay and southern waters off Oshima.

3.2.9 Watchkeeping on Bridge

(1) Lookout Arrangements and Maneuvering of Vessels

According to 2.1, 2.10, 2.13 and 3.2.9(3) below, the lookout arrangements and maneuvering of the vessels were as follows:

{1} Vessel A

a According to the statement of Officer A, he first detected Vessel B on the radar off the port bow of Vessel A at about 02:00, and that the ARPA indicated that Vessel B was to pass ahead of Vessel A. Based on the movements of the two vessels, however, it is considered probable that Vessel B would in fact pass astern of Vessel A. Additionally, it is considered probable that Officer A was in a position to visually identify the masthead lights of Vessel B.

b Officer A stated that in response to the CPA/TCPA alarm at about 02:08, he confirmed the position of Vessel B and assumed that Vessel B would pass ahead of Vessel A uneventfully around 02:14. Contrary to the Officer A's statement, however, the compass bearing of Vessel B in relation to Vessel A shifted approximately 5° leftward from about 02:00 to about 02:08. Vessel B started turning to starboard at about 02:03, causing the bearing to shift leftward by approximately 4° in relation to Vessel A by 02:08. During this period of time, Vessel B's course changed to starboard by approximately 7°, and she further continued her starboard turn. It is considered highly probable, therefore, that Vessel B was in fact in a position to pass astern of Vessel A.

It is considered probable, therefore, that since Officer A, due to his lack of expertise in handling of ARPA, was unable to perform watchkeeping duties properly over the radar, he did not notice either that Vessel B was in fact in a position to pass astern of Vessel A.

c It is considered highly probable that when the CPA/TCPA alarm sounded first at about 02:08 and then at about 02:10, Officer A stopped the both alarms.

d It is considered probable that, after stopping the second alarm, Officer A started a left turn to avoid collision by repeatedly pressing the steering button on the autopilot to turn Vessel A by 1° each time.

e It is considered probable that Officer A did not maintain a proper lookout for Vessel B through appropriate use of the ARPA, because when stopping the CPA/TCPA alarms, he assumed that Vessel B would pass ahead of Vessel A and did not notice that the compass bearings of Vessel B had veered leftward in relation to Vessel A.

Although visibility of the sidelights of Vessel B led him to believe Vessel B started turning to port, it is considered probable that Vessel B was approaching Vessel A on the port side, probably showing two masthead lights (white) and the starboard light (green) to Vessel A. This also suggests that Officer A did not maintain a lookout for Vessel B in a proper manner.

f It is considered probable that at about 02:13 Officer A perceived an imminent risk of collision with closely approaching Vessel B and switched to manual steering and steered to hard port, but collided with Vessel B while Vessel A was turning to port.

g As Officer A usually had Seaman A on the same watch shift to lookout duty on the wings and assigned Seaman A to lookout on the starboard wing at the time of the accident with the door to the steering house closed, it is considered probable that Officer A did not have a conversation with Seaman A prior to the accident.

{2} Vessel B

a It is considered probable that Officer B became aware of presence of Vessel A by 02:05 as he attempted to call Vessel A twice on the VHF.

It is unknown whether Officer B became aware of presence of Vessel A by means other than AIS.

b Vessel B started slightly changing her course to starboard at about 02:03, and it is considered highly probable that she continued such small alterations of course even after the attempted calls to Vessel A, until immediately before the collision. Reasons for such maneuvering of Vessel B remain unknown.

(2) VHF Communications

According to 2.1, 2.14 and 2.15, the following VHF communications were exchanged between Vessels A and B:

{1} Vessel A

a It is considered highly probable that Vessel A was called twice by Vessel B on the VHF at about 02:05, but did not respond.

Officer A attempted to call Vessel B, however, it is considered highly probable that actually no attempt was made on board Vessel A to call Vessel B as no such voice is recorded in the VDR data.

b It is considered probable that since Officer A was at the chart table making entry to the ship's logbook when Vessel B called Vessel A on the VHF, he could not respond to the calls from Vessel B.

{2} Vessel B

It is considered highly probable that Vessel B called Vessel A twice with the VHF at about 02:05. It is also considered probable that it was Officer B who called Vessel A.

(3) Use of Navigational Equipment

According to 2.1, 2.13, and 2.14, it is considered probable that use of navigation equipment on Vessels A and B was as described below:

{1} Vessel A

Officer A was not sufficiently experienced in handling of ARPA and did not effectively use the functions of the equipment. He did not identify the name of Vessel B with the AIS, nor did he confirm the maneuvering intentions of Vessel B by contacting her on the VHF.

{2} Vessel B

Officer B identified the name of Vessel A with the AIS in view of the fact that he attempted to call Vessel A on the VHF.

(4) Communications between the Bridge Crew Members on Duty on Vessel A

According to 2.1 and 2.16.2 through 2.16.4, it is considered probable that adequate communications were not available between Officer A and Seaman A in view of the fact that Seaman A was assigned to lookout duty on the starboard wing.

(5) Alarms and sounds within the Steering House of Vessel A

According to 2.1 and 2.15, various equipment were emitting receiver signals, alarms and other sounds intermittently within the steering house of Vessel A. It is considered probable that the audio signals recorded in the data included: CPA/TCPA alarms and confirmation tones for its switch off, AIS reception signal tones and GMDSS signal tones.

3.2.10 Visibility of Vessel B's Lights from Vessel A and Changes in Compass Bearings

According to 2.1 and 2.10.2, the visibility situations were as follows:

(1) It is considered probable that Vessel B's masthead lights were visible to Vessel A in the vicinity of 112° , 5.0 M at about 02:00, and in the vicinity of 111° , 3.9 M at about 02:03 when Vessel B started turning to starboard; Vessel B's masthead lights and starboard sidelight were also visible to Vessel A in the vicinity of 110° , 3.0 M at about 02:05. In addition, it is also considered probable that the masthead lights and starboard sidelight of Vessel B were visible to Vessel A in the vicinity of 107° , 2.2 M at about 02:08 when the first CPA/TCPA alarm was stopped, and in the vicinity of 101° , 1.5 M at about 02:10 when Vessel A began her turn to port.

(2) It is considered probable that the compass bearings of Vessel B as viewed from Vessel A shifted leftward by approximately 2° between about 02:00 and about 02:05, and by approximately 5° between about 02:00 and about 02:08; the leftward shifting between about 02:05 and about 02:08 was estimated to be approximately 3° .

It is considered probable that, should the compass bearings of Vessel B had been measured by Vessel A between about 02:00 and about 02:05 or about 02:08, when both vessels had been inside of one another, Vessel A could have determined that Vessel B was passing astern of Vessel A. However, it is considered probable that compass bearings alone cannot sufficiently determine the distance of passage, and it is also considered somewhat likely in view of the night-time visibility and sizes of the two vessels that they judged that a risk of collision existed.

It is considered probable that the compass bearings of Vessel B as viewed from Vessel A veered leftward by approximately 9° between about 02:05 and about 02:10; besides, by approximately 6° between about 02:08 and about 02:10.

It is considered probable that Vessel A could have noticed that Vessel B would pass astern of Vessel A if Vessel A had confirmed Vessel B's movement with the radar and other available means when the first CPA/TCPA alarm was stopped at about 02:08. It is also considered somewhat likely that Vessel A started her port turn to avoid collision at about 02:10 when the second CPA/TCPA alarm was stopped. Vessel A was required to take actions so as to pass Vessel B at a safe distance in accordance with Article 8, Section 4 of the Act on Preventing Collisions at Sea (hereinafter referred to as the "Prevention Act"). Such maneuvers require confirmation of the movement of Vessel B (compass bearings as seen from Vessel A, distances and their changing rates, etc.) in order to determine the course alteration to make. It is considered somewhat likely, therefore, that should the movement of Vessel B had been confirmed with the radar and other available means, Vessel A could have realized that it was more evident that Vessel B was to pass further astern of Vessel A than at about 02:08 and there was no risk of collision.

3.2.11 Vessel A's Responses to the Collision

According to 2.1.3, Vessel A took the following actions after the collision:

(1) Usage of the ship's engines

After the collision, Vessel A continued her navigation with the engine running at 100 rpm.

(2) Search and rescue efforts implemented by Vessel A

After the collision, Vessel A switched on the searchlights and deck lanterns, searching for Vessel B. However, it was not before about 45 minutes after the collision that Vessel A launched full-scale search and rescue operations.

3.2.12 Effects of the Surrounding Conditions on Maneuvering of the Vessels

According to 2.1 and 2.9, it is considered somewhat likely that the vessels' surrounding conditions were as follows:

(1) Vessel A

{1} Head-on vessel oncoming to the starboard bow of Vessel A

Although there was a north-bound container ship proceeding to the starboard bow of Vessel A, she caused no effects on Vessel A's maneuver as she was positioned approximately 2.5 M astern of the starboard abeam of Vessel A when Vessel A started her port turn at about 02:10.

{2} Vessels C and D

There were the presence of Vessel B and Vessel C preceding Vessel B to the port side of Vessel A, and Vessel D sailing along with Vessel A to the starboard side. However, there were no records of Vessels C and D in the AIS data; moreover, the possibility that some coastal vessels might have been sailing in the vicinity of the site of the accident around that time was very low, it was concluded that Vessels C and D did not actually exist.

(2) Vessel B

Although there was a north-bound container ship to the port of Vessel B, she was proceeding on a course to be able to pass by Vessel B at a distance of approximately 4 to 5 M, and she did not affect Vessel B's maneuvering.

3.2.13 Safety Management System on board Vessel A

According to 2.1, 2.10 through 2.16, 2.20 and 3.2.9, the safety management system adopted on board Vessel A was as follows:

(1) Officer A

The Safety Management Manual (SMM) for Vessel A prescribed operation procedures such as effective use of all navigational equipment, use of rudder and propulsion machinery without hesitation when deemed necessary, use of sound signal apparatus by whistles and light signals by daylight signaling lamps, proper lookout by sight and all available means, and judgment of collision risk. It is considered probable that Officer A did not comply with the procedures laid down in the SMM.

(2) Master A

{1} It is considered probable that Master A did not comply with the procedures of SMM in providing proper instructions to Officer A by entering in the Night Order Book the instructions based on the conditions of the sea area where to navigate prior to leaving the bridge at about 01:45.

{2} It is considered somewhat likely that Master A did not regularly provide Officer A with adequate guidance/directions on safe navigation.

{3} Master A knew that seamen stood on lookout duty on the bridge wing on Vessel A, and it is considered somewhat likely that Master A was aware that such assignments might pose some problems in the context of compliance with the SMM and onboard communications.

3.2.14 Analysis on the Navigation Law

According to 2.1, 3.1.1 and 3.2.9, Vessels A and B were found in the following navigational conditions:

As Vessels A and B collided within the territorial waters of Japan to the east of Oshima, it is considered probable that the accident was subject to the provisions of the Prevention Act.

It is considered probable that the courses of the two vessels intersected with each other, with Vessel A having Vessel B on the port side, and Vessel B having Vessel A on the starboard side. Visibility at the time was approximately 5 M, and it is considered probable that the both vessels were in sight of one another. It is not known whether Vessel B observed Vessel A by sight.

According to Article 5 of the Prevention Act, every vessel shall at all times maintain a proper lookout so as to make a full appraisal of risks of collision with other vessels in any condition of visibility. Furthermore, Article 7 provides that every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists upon consideration of the provisions set forth in Sections 7-2 through 7-5.

When the first CPA/TCPA alarm was sounded at about 02:08, Officer A confirmed the movement of Vessel B but did not keep proper lookout with the radar and other available means. It is considered somewhat likely that when the second CPA/TCPA alarm sounded at about 02:10, Officer A, assuming that Vessel B would pass ahead of the ship's bow, turned Vessel A to port without keeping proper lookout nor noticing that compass bearings of Vessel B had shifted to the left.

It is considered probable that Vessel B identified the name of Vessel A with the AIS, but it is not known whether Vessel B noticed Vessel A in other ways.

Article 8 of the Prevention Act provides that any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel and that if necessary a vessel shall take such actions as stopping her means of propulsion.

Although it is considered somewhat likely that Vessel A started attempts at about 02:10 to avoid collision with Vessel B, making small alterations of course to port by 1° each time by pressing the course-changing button on the autopilot repeatedly.

It is considered highly probable that Vessel B continued making small alterations of course to starboard from about 02:03 until immediately before the collision.

It is also considered highly probable that neither of the vessels attempted to change their speeds until immediately before the collision.

Based on the foregoing analyses, it is considered probable that Vessel A could not make definite navigational decisions in the absence of proper lookout.

3.2.15 Analysis on the Accident Occurrence

According to 2.1, 2.10, 2.11 and 3.2.1 through 3.2.9, the events leading to occurrence of the accident were as follows:

(1) Vessel A

{1} It is considered probable that Officer A on the bridge watchkeeping duty was positioned behind the radar, assigned Seaman A on the starboard wing as lookout, closed the door between the wing and the steering house, and navigated Vessel A to proceed southeast offshore eastern Oshima under autopilot.

{2} It is considered probable that, while Vessel A was maintaining COG at approx. 147° and SOG at approx. 17.4 kn, Officer A detected, on the radar set to a 6 M range and center offset rearward by 3 M, Vessel B proceeding at 36° off the port bow of Vessel A at a distance of 5.0 M, and could visually recognize the masthead lights of Vessel B at about 02:00.

{3} It is considered highly probable that Officer A did not respond to the call made by Vessel B on the VHF at about 02:05. It is considered somewhat likely that Officer A was at the chart table making entry on the ship's logbook, when the call was made.

{4} It is considered probable that Officer A attempted to confirm the movement of Vessel B when the CPA/TCPA alarm set to 0.5 M sounded at about 02:08, but did not maintain a proper lookout using radar and other means available owing to his lack of experience in handling of the ARPA, and did not notice the leftward variation of Vessel B's compass bearings.

{5} It is considered probable that Officer A, assuming that Vessel B would pass ahead of Vessel A, did not maintain a proper lookout without noticing the leftward shift of Vessel B's compass bearings, and attempted to avoid collision with Vessel B by making small alterations of course to port with the autopilot on when the second CPA/TCPA alarm sounded at about 02:10. It is considered probable that Vessel B was showing two masthead lights (white) and the starboard sidelight (green) to Vessel A at that time.

{6} It is considered probable that Officer A switched to manual steering at about 02:13, steering the vessel to hard port in anticipation of a risk of collision with Vessel B.

{7} It is considered probable that Seaman A maintained lookout on the starboard wing, and did not notice Vessel B approaching to the port side of Vessel A until a few seconds before the collision.

{8} It is considered probable that Officer A on bridge watchkeeping duty did not comply with the procedures stipulated in the SMM for effective use of all available means including eyesight and ARPA to assess a risk of collision with Vessel B.

{9} It is considered probable that Master A did not comply with the provisions of the SMM in providing appropriate instructions to Officer A by entering his instructions within the Night Order Book based on the situation.

{10} It is considered somewhat likely that Master A did not regularly provide Officer A with adequate guidance/instructions including use of necessary precautions for the safety of navigation.

{11} It is considered somewhat likely that the accident might have been prevented if Officer A had responded to the VHF calls from Vessel B, enabling the both vessels to understand their navigational intentions.

(2) Vessel B

{1} It is considered highly probable that Vessel B was proceeding south of Oshima with COG at approx. 241° and SOG at approximately 11.7 kn at about 01:47.

{2} It is considered highly probable that Vessel B started a succession of small alterations of course to starboard at about 02:03, when the vessel was positioned at 084° to Ryu-o-saki lighthouse at a distance of 9.2 M. The maneuver was continued until immediately before the collision, but the reason for such starboard turns remains unknown. It is considered somewhat likely that Vessel A's port turn to avoid collision with Vessel B without noticing her starboard turn were made in relation to the succession of small alterations of course to starboard.

{3} It is considered highly probable that Vessel B made two attempts to call Vessel A on the VHF at about 02:05.

{4} It is considered somewhat likely that the accident might have been prevented if Vessel B had used sound signals to call Vessel A's attention to Vessel B's starboard turn when Vessel A did not respond to the VHF calls.

Based on the foregoing analyses, it is considered probable that the two vessels collided with each other while, approaching on intersecting courses, Vessel A attempted to avoid collision with Vessel B approaching to the port side of Vessel A by implementing small alterations of course to port using the autopilot, and Vessel B repeated small alterations of course to starboard until immediately before the collision.

It is considered probable that Vessel A did not maintain an proper lookout for Vessel B by radar and other available means, which prevented Vessel A from judging the movement of Vessel B correctly.

It is considered somewhat likely that Vessel B made her small alterations of course to starboard until immediately before the collision in order to avoid a crossing situation where involving a risk of collision with Vessel A as defined in Article 15 of the Prevention Act. However, it is considered somewhat likely that the series of maneuvers were not appropriate actions to avoid collision if Vessel B was aware of the risk of collision with Vessel A.

3.3 Analysis on Post Accident Events.

3.3.1 Sinking of Vessel B

According to 2.1, 2.6, 2.21, 2.23.3, 2.23.5, 3.2.2 and 3.2.7, it is considered probable that the hull of Vessel B was in good condition prior to the collision. However, it is considered probable that the vessel's age of approximately 21 years, the nearly fully loaded cargo of steel materials, and the fact that the bow section of Vessel A ran onto the nearly midship of the hull all contributed to the breakage of the hull, causing Vessel B to sink within several minutes after the collision.

3.3.2 Search and Rescue Efforts for the Crew of Vessel B

(1) Vessel A

According to 2.1.3, Vessel A after the collision continued to proceed without stopping her engine immediately, and it is considered somewhat likely that the search and rescue effort by Vessel A for the crew of Vessel B were delayed slightly. It is considered probable that Vessel A should have stopped her engine immediately.

(2) Actions Taken by Search and Rescue Organizations

According to 2.1 and 2.18, relevant organizations responded to the accident as follows:

{1} Tokyo MARTIS called Vessel A approximately 1 minute 15 seconds after the collision, and to Vessel B approximately 1 minute 55 seconds after the occurrence of the accident on the VHF. They called each of the vessels 4 times by vessel names or call signs but it is considered highly probable that neither of the vessels responded.

{2} The 3rd Regional HQ of the Japan Coast Guard communicated with Vessel A approximately 3 minutes 20 seconds after the occurrence of the accident, and learned from Vessel A that she collided with another ship. It is considered highly probable that the 3rd Regional HQ and Shimoda Coast Guard Office immediately responded to the accident by setting up Countermeasures Headquarters respectively.

(3) EPIRB Distress Signals

According to 2.22, it is considered probable that no distress signals were transmitted from the EPIRB unit equipped on board Vessel B.

It is considered somewhat likely that the distress signals were not transmitted because the beacon did not float up, the reason for which is unknown.

3.4 Oil Spill from Vessel B

(1) Source of Oil Discharge

According to 2.4(1) and 3.1.2, it is considered probable that the source of oil discharge was located approximately 800 meters northwest of the site of the accident.

(2) Flowing Direction of Drifting Oil

According to 2.4(2), 2.8.1, 3.1.2 and 3.2.5, it is considered somewhat likely that the spilled oil initially drifted to the northeast, arriving at the southern coastline of Boso Peninsula, and then changed the flowing direction to the southeast in accordance with the shifting of the current.

(3) Spillage control

According to 2.4, it is consider probable that the spilled oil including drifted ashore in the southern coast of Boso Peninsula were removed by cleanup works.

4 PROBABLE CAUSES

It is considered probable that the accident was caused by the two vessels colliding with each other while proceeding on intersecting courses at eastward offshore Oshima at night, as the southeast-bound Vessel A attempted to avoid collision with the south-west bound Vessel B by implementing small alterations of course to port using the autopilot, and Vessel B repeated small alterations of course to starboard until immediately before the collision.

It is considered probable that the small alterations of course to port using the autopilot which were implemented by Vessel A to avoid collision could be attributed to Officer A's inexperience in handling the ARPA and to Officer A's assumption that Vessel B would pass ahead of Vessel A as he did not maintain a proper lookout for Vessel B resulting in the leftward veering of the compass bearing of Vessel B unnoticed.

It is considered somewhat likely that the succession of small alterations of course to starboard implemented by Vessel B until immediately before the collision is related to Vessel A's port turn to avoid collision with Vessel B without noticing Vessel B's starboard turn.

5 SAFETY RECOMMENDATIONS

The accident was caused by the two vessels, CYGNUS ACE and ORCHID PIA, colliding with each other while proceeding on intersecting courses at eastward offshore Oshima at night.

In this accident, CYGNUS ACE did not maintain proper lookout for ORCHID PIA and attempted to avoid collision with ORCHID PIA by successions of small alterations of course to port using the autopilot, which constituted the cause of the collision.

In view of the result of this accident investigation, the Japan Transport Safety Board recommends the Panama Maritime Authority and RCL SHIP MANAGEMENT PTE LTD to implement the following measures:

The Panama Maritime Authority should direct RCL SHIP MANAGEMENT PTE LTD to instruct the masters and crew members under its management to comply with the provisions of "the Safety Management Manual" established in accordance with the International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention.

RCL SHIP MANAGEMENT PTE LTD should make sure to instruct the masters and crew members under its management to operate vessels strictly in accordance with "the Safety Management Manual."

Figure 1: Sea area in the vicinity of Oshima

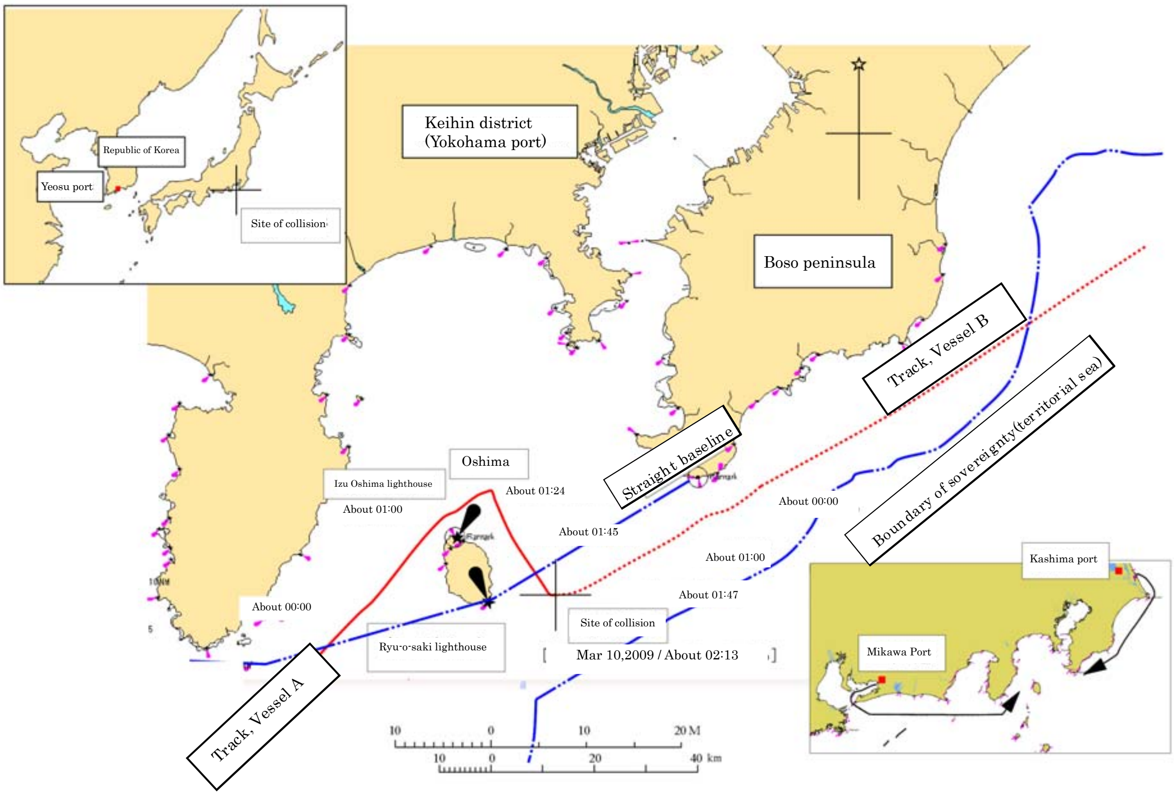


Figure2: Presumed navigational route diagram

(from about 30 minutes prior to the collision to the time of the collision)

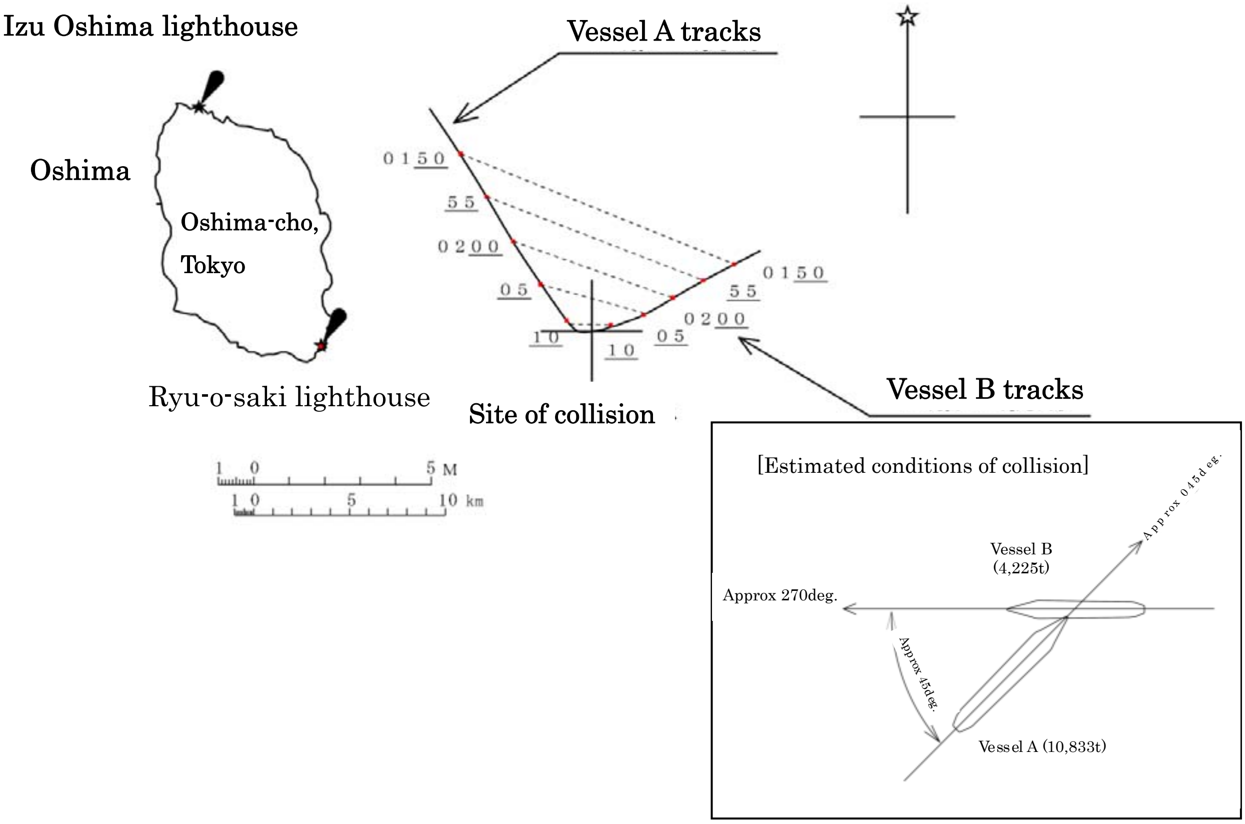


Figure3: Presumed navigational route diagram

(from about 15 minutes prior to the collision to the time of the collision)

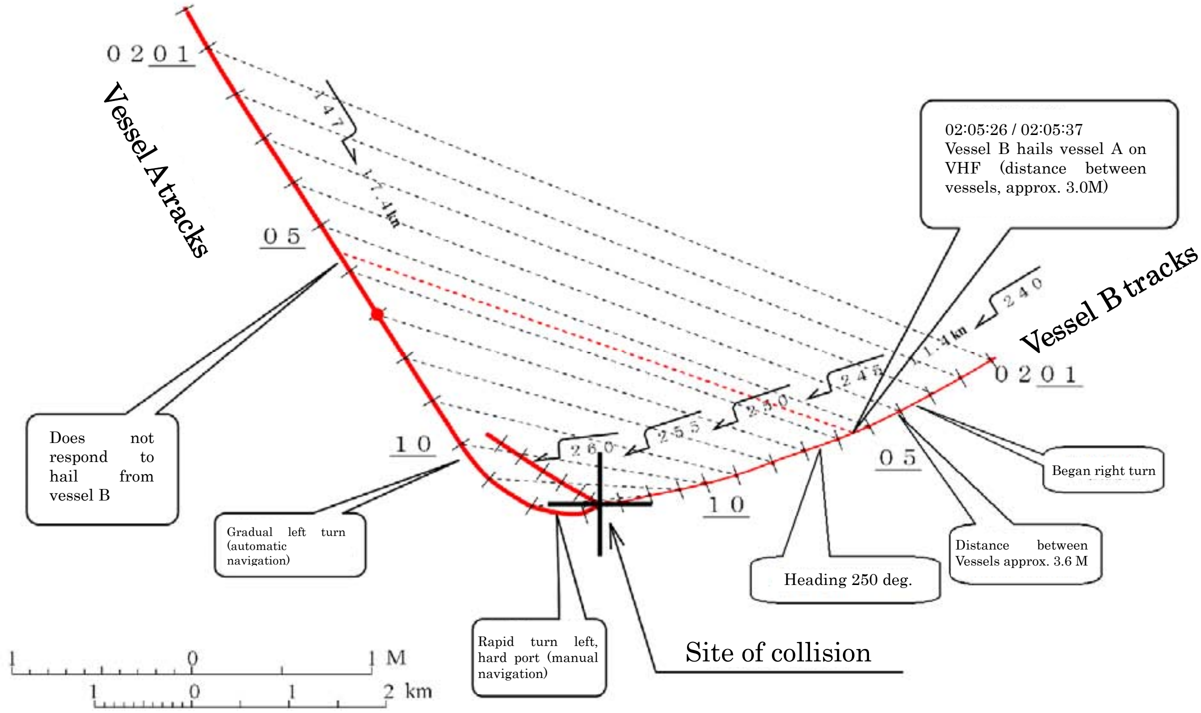


Figure 4: Changes in the bearings/speeds of the two vessels

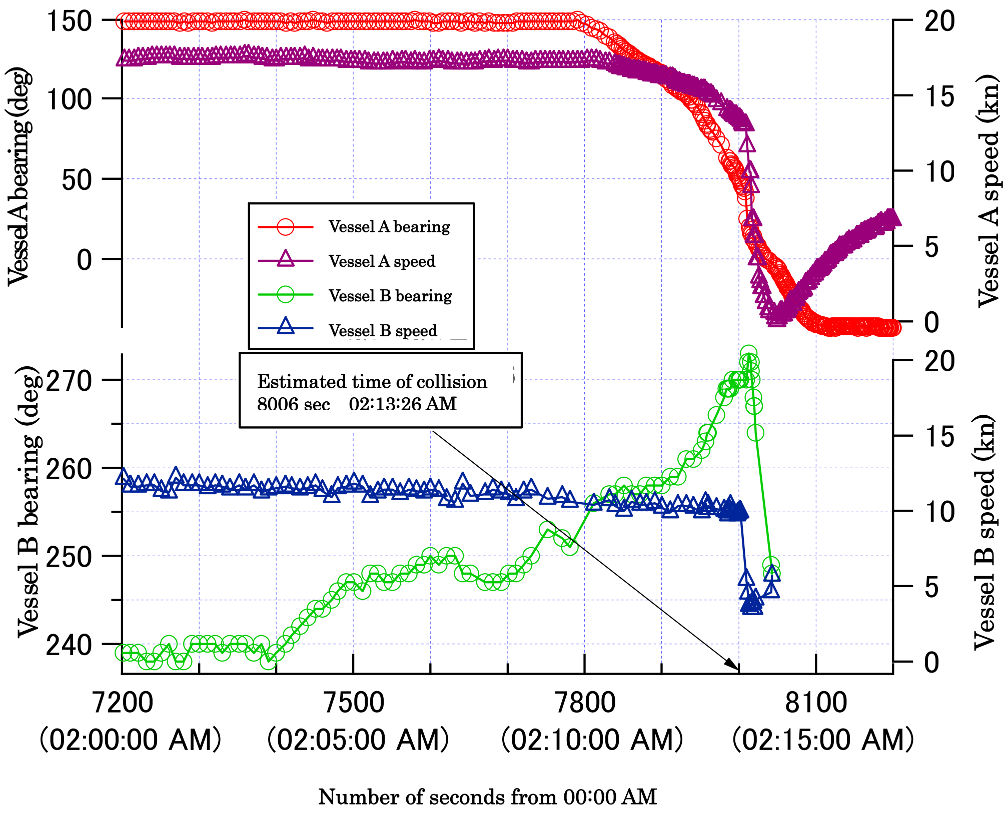


Figure 5: Change in bearings of the both vessels immediately after the collision

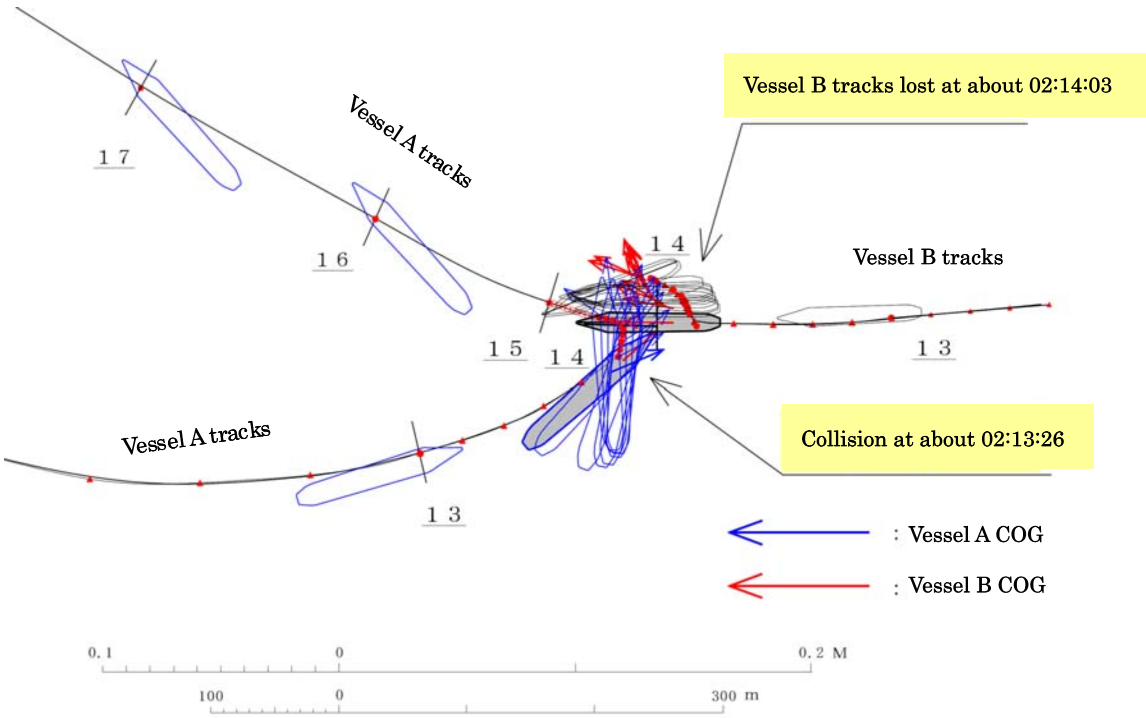


Figure 6: Status of collision (simulated image (1))

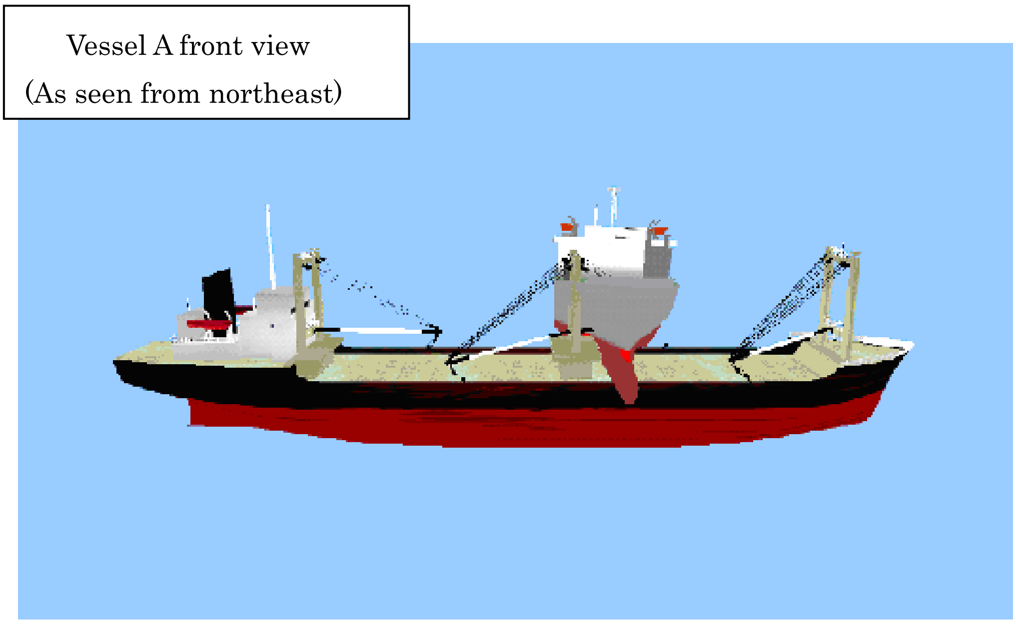


Figure 7: Status of collision - enlarged (simulated image (2))

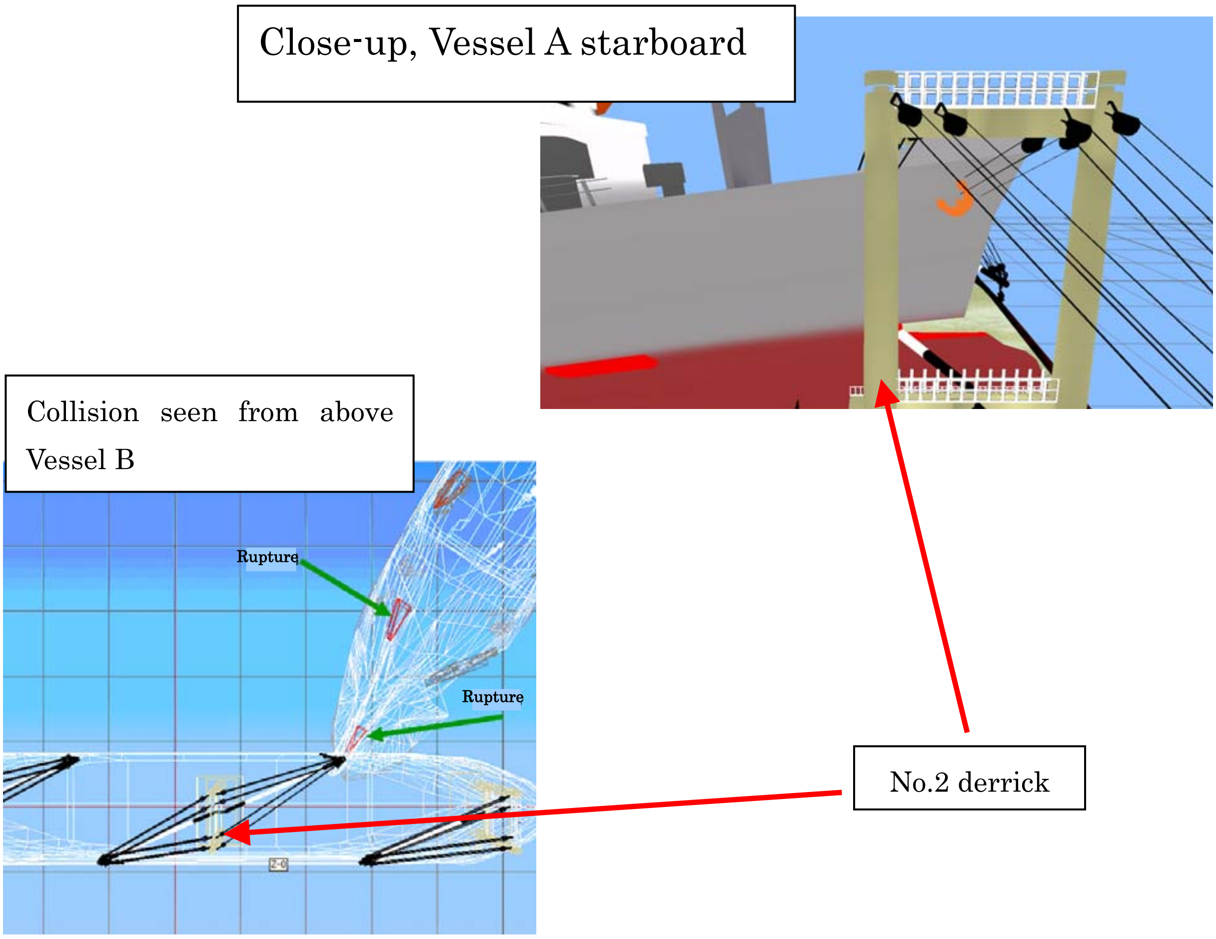


Figure 8: Status of collision – enlarged (simulated image (3))

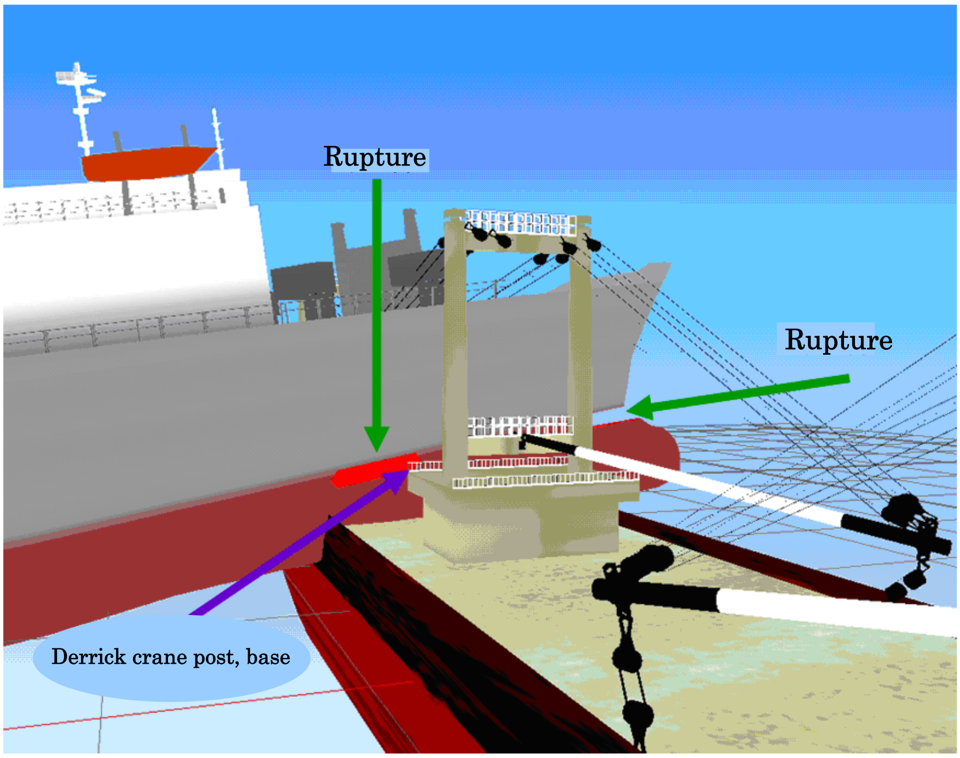


Figure 9: General arrangements of both vessels

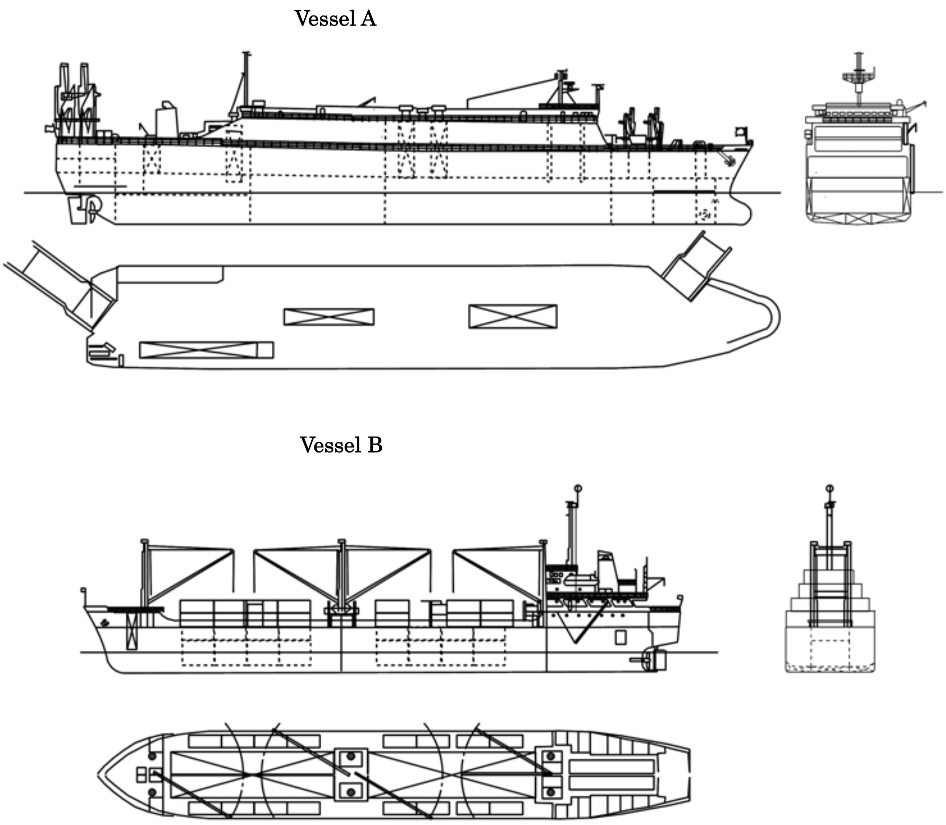


Figure 10: Equipment layout and watch status of vessel A

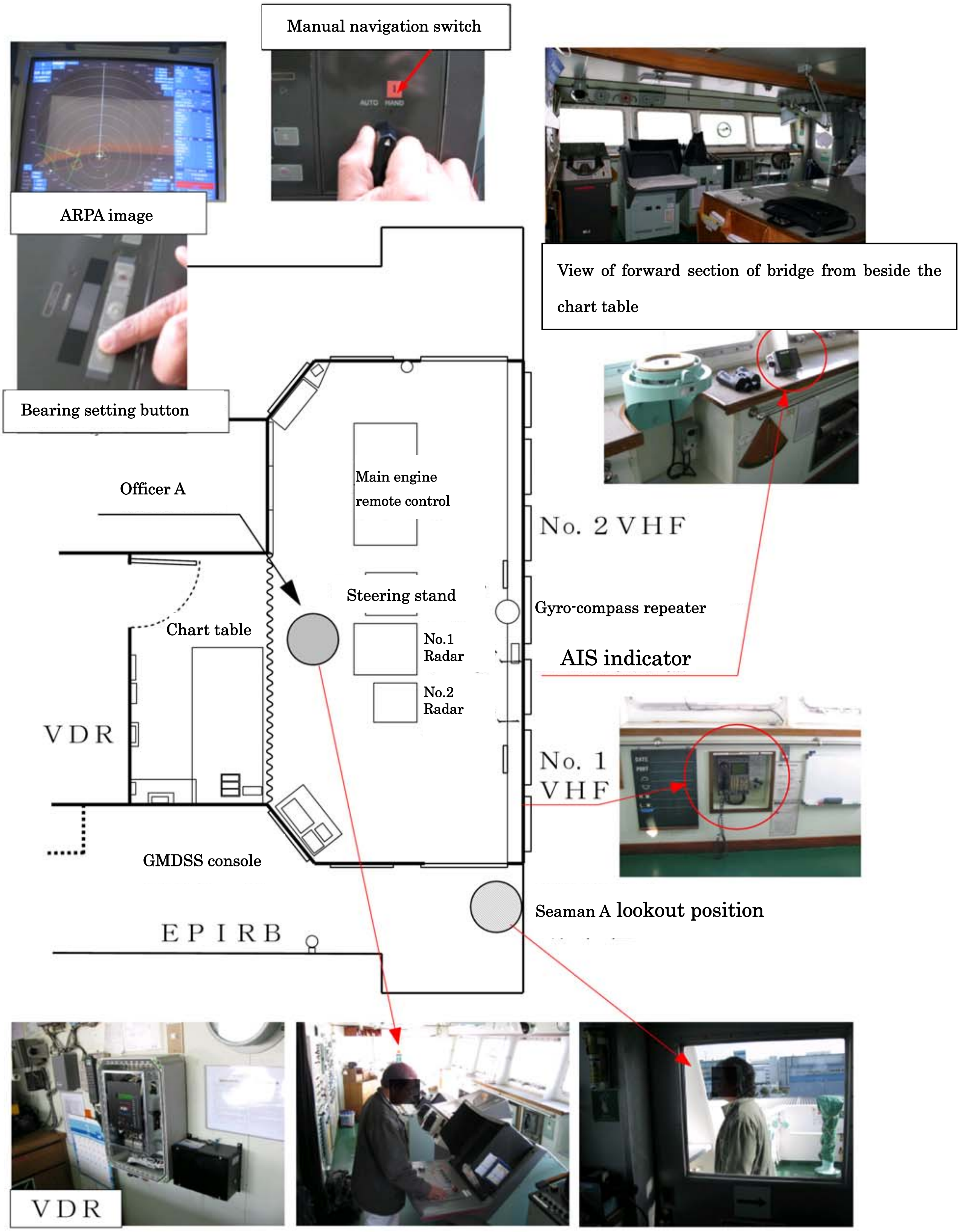


Figure 11: Equipment layout of vessel B

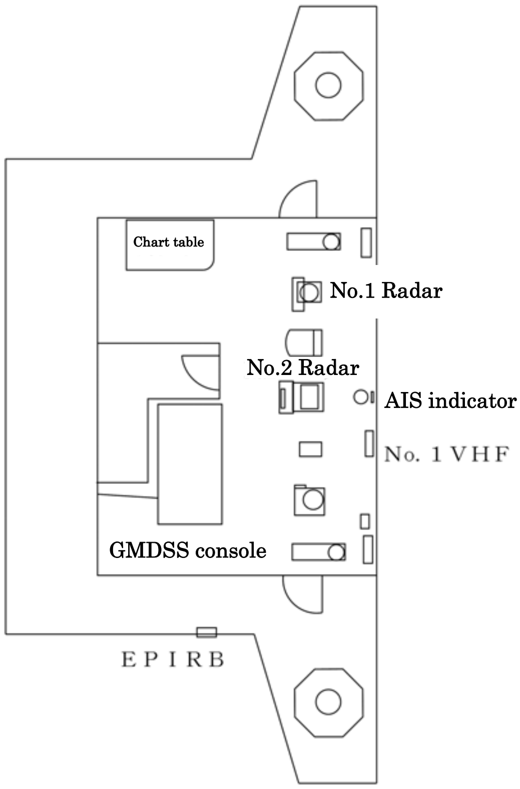


Figure 12: Deck layout of vessel B

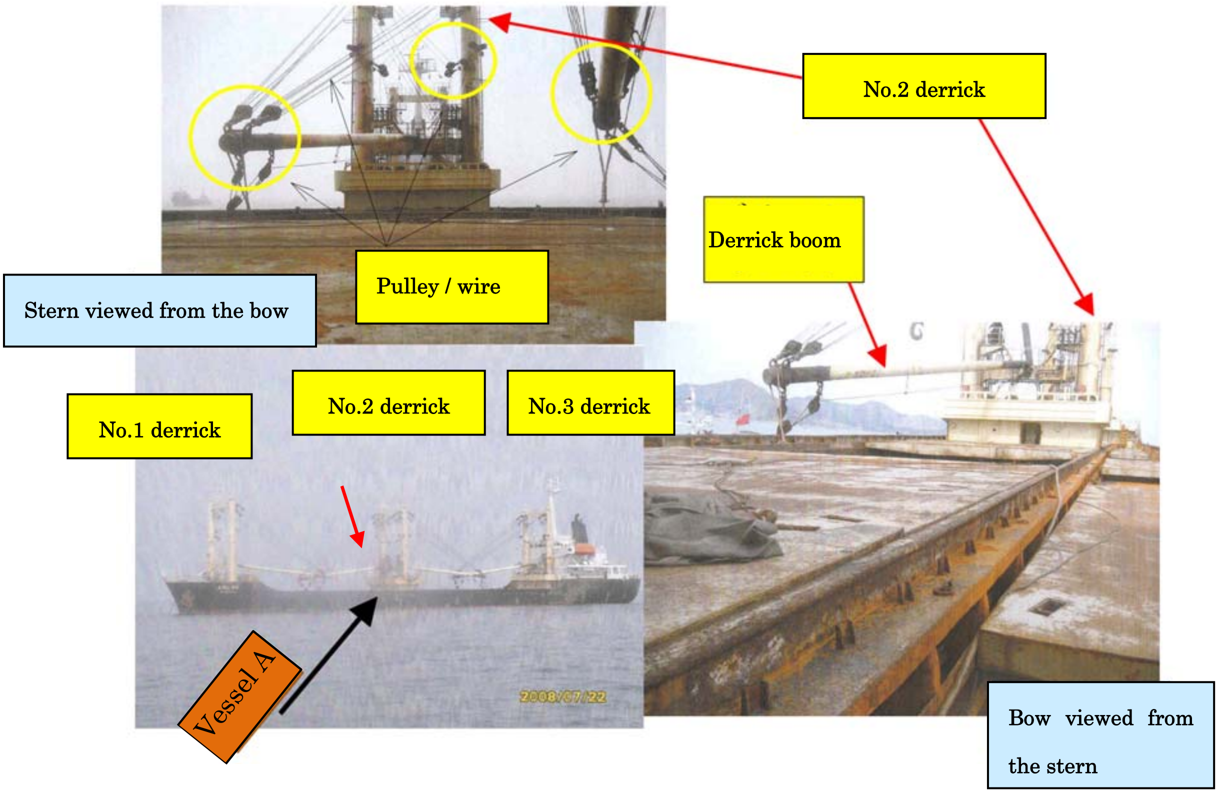


Figure 13: Summary of derrick on board vessel B

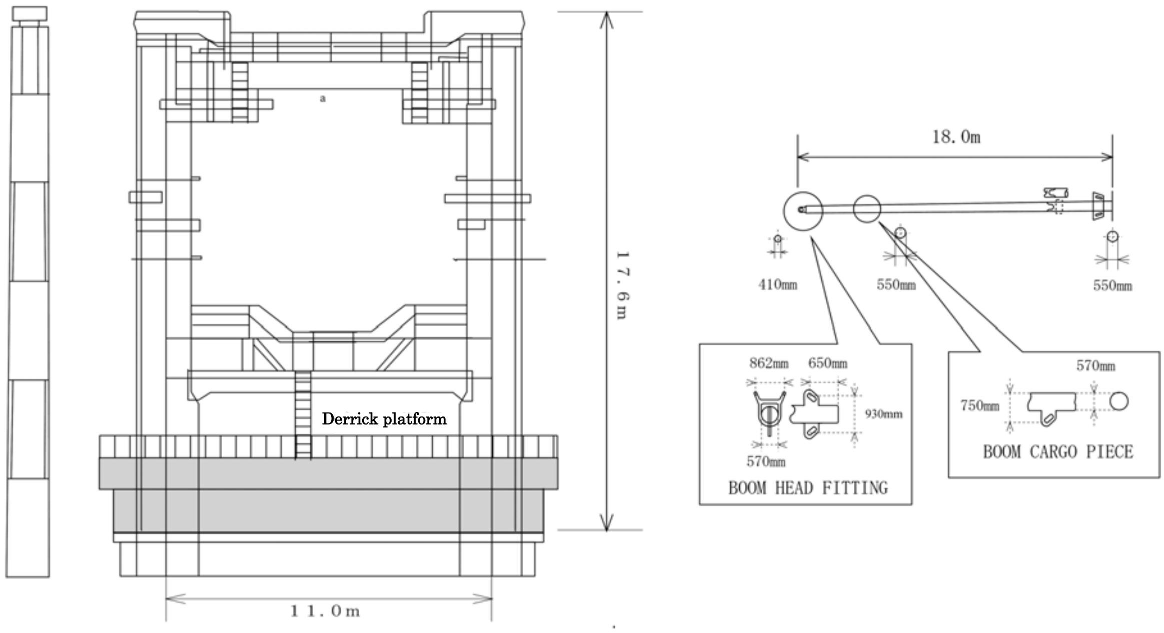


Figure 14: Relative positions of the both vessels upon coordination of the waterline

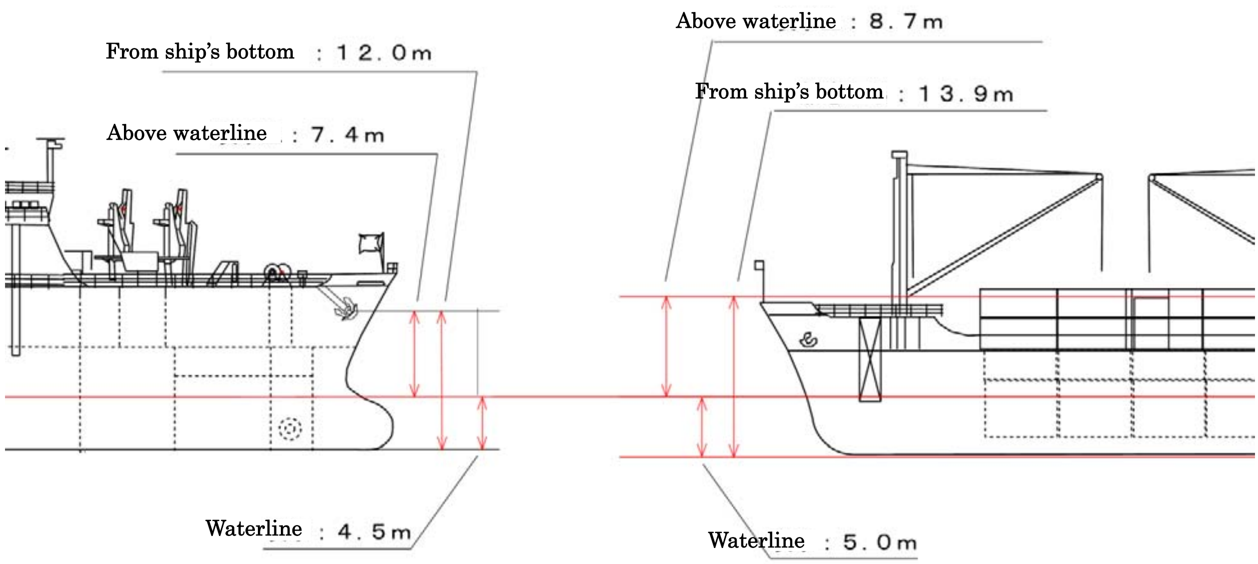


Figure 15: Relative positioning of vessels according to the statement of Officer A

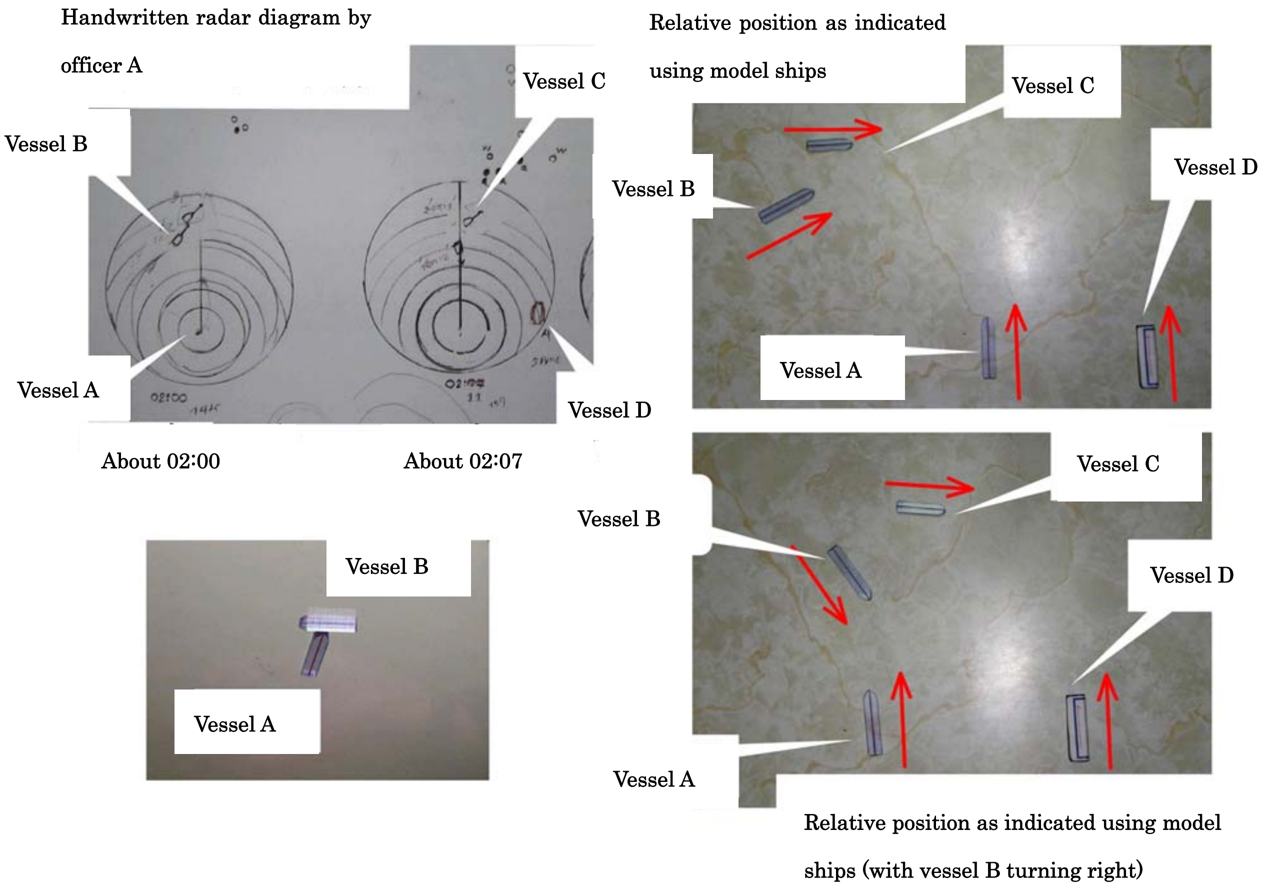


Figure 16: Marine traffic in the vicinity according to AIS logs

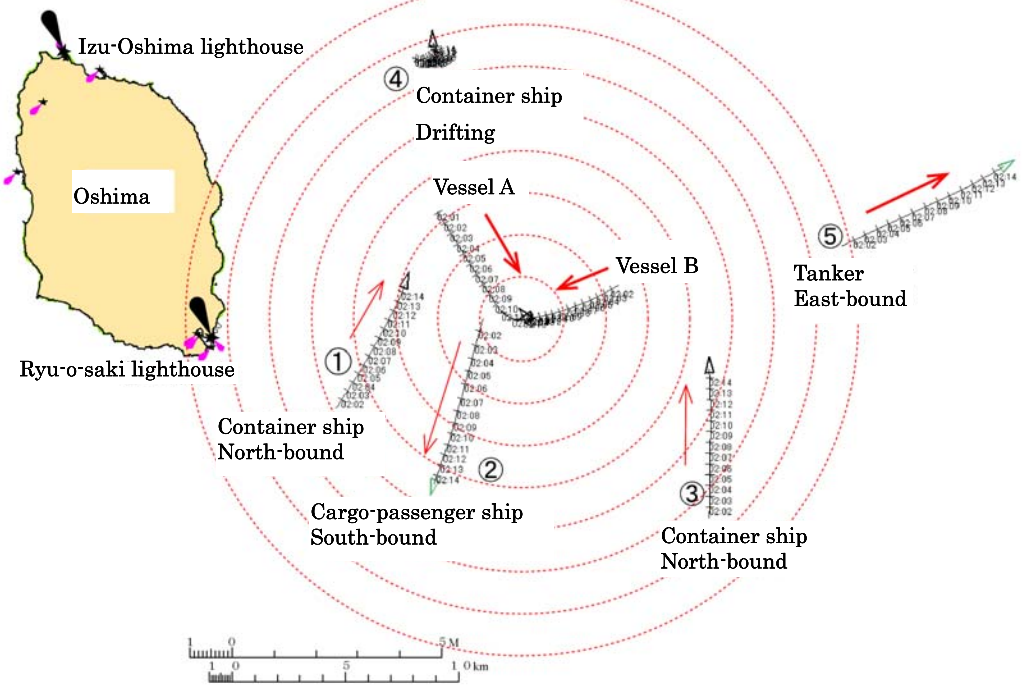


Figure 17: Summary of weather and sea conditions

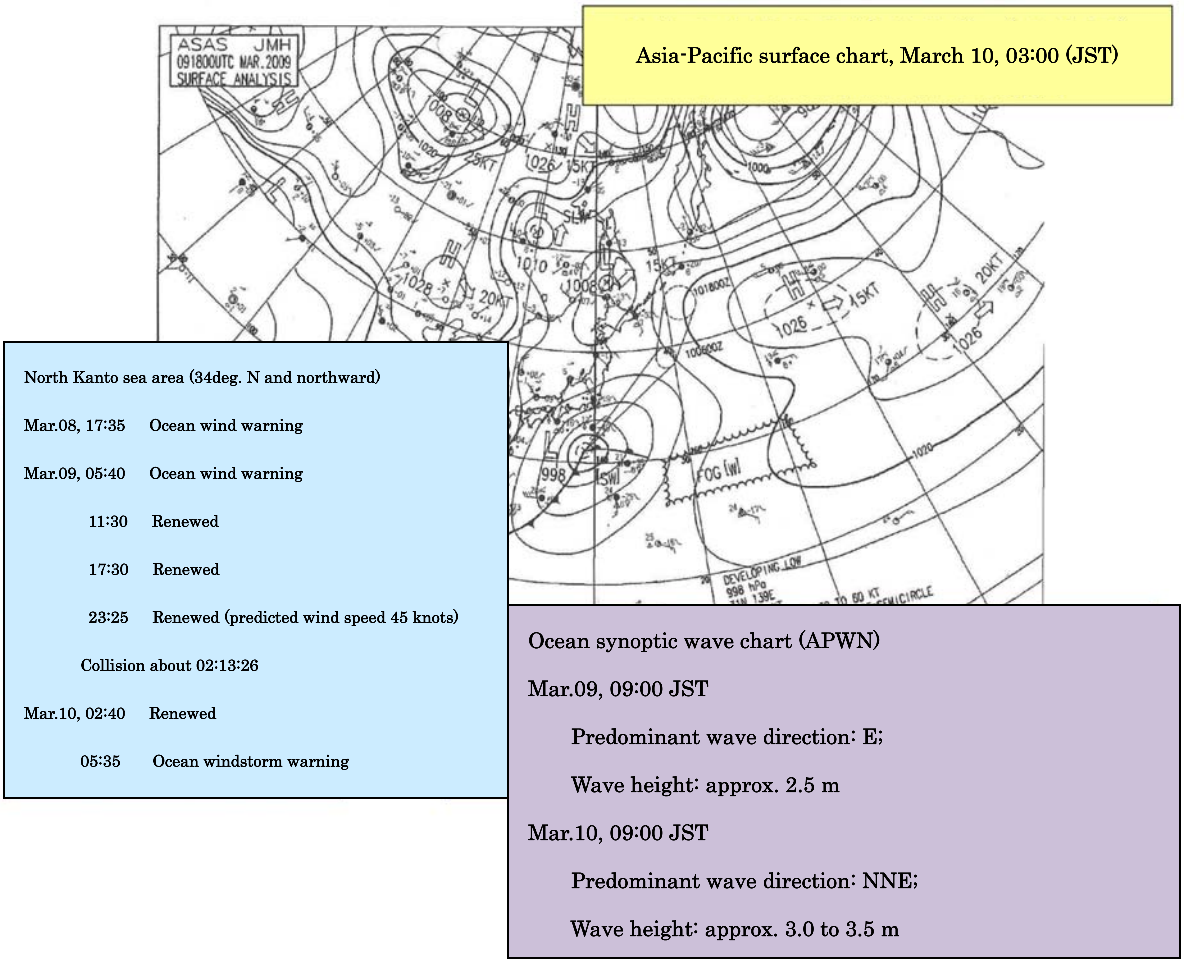
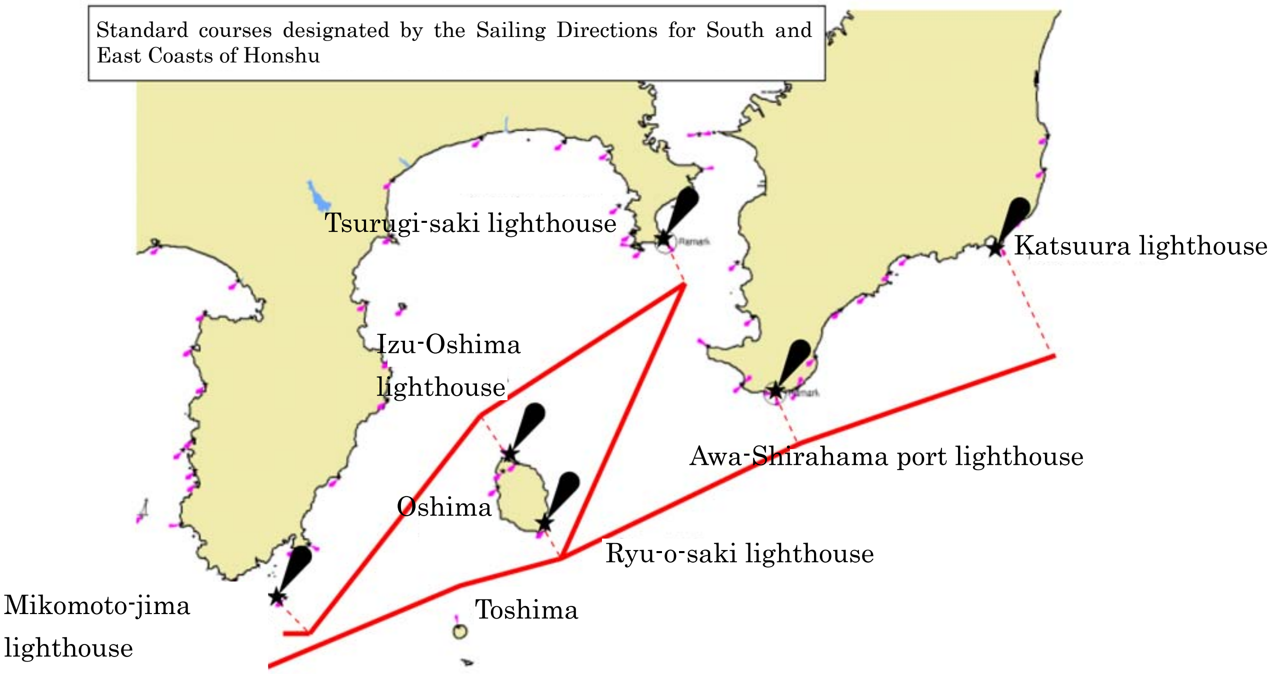


Figure 18: Marine traffic in the vicinity of Oshima (1)



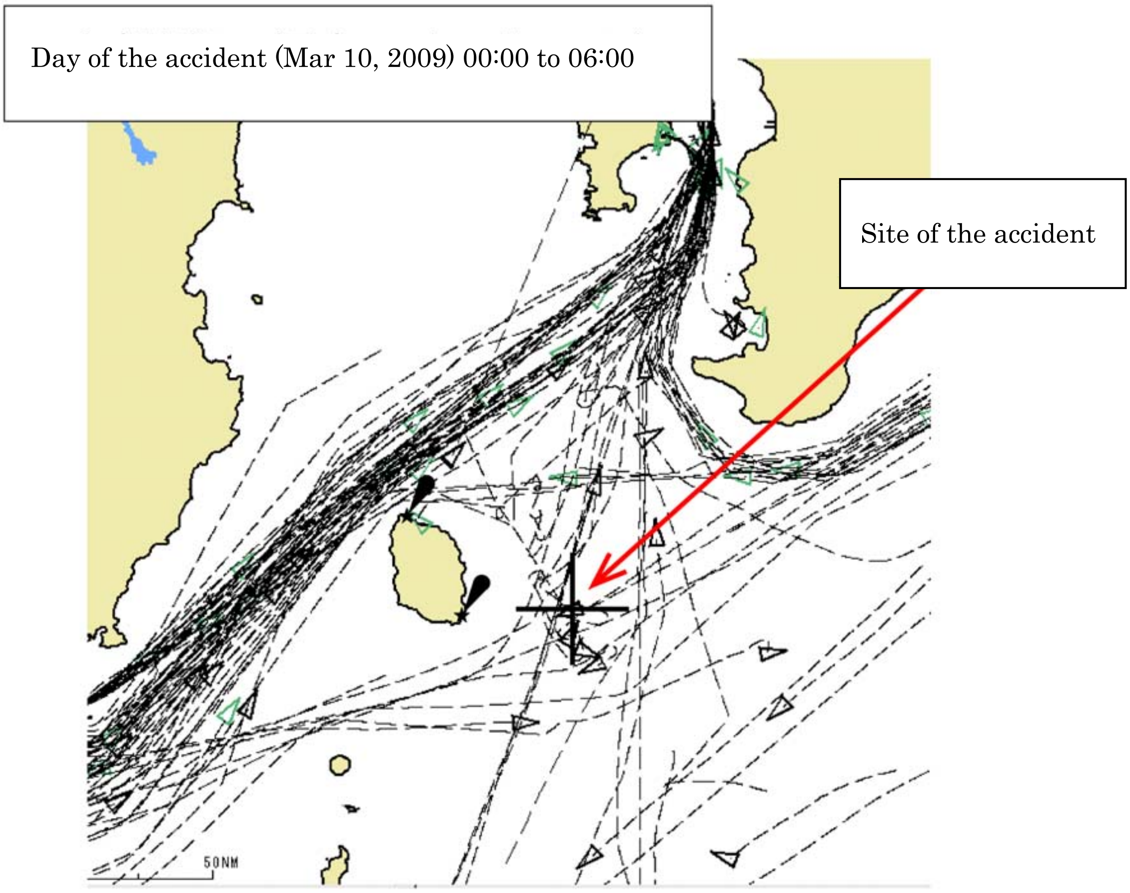


Figure 19: Marine traffic in the vicinity of Oshima (2)

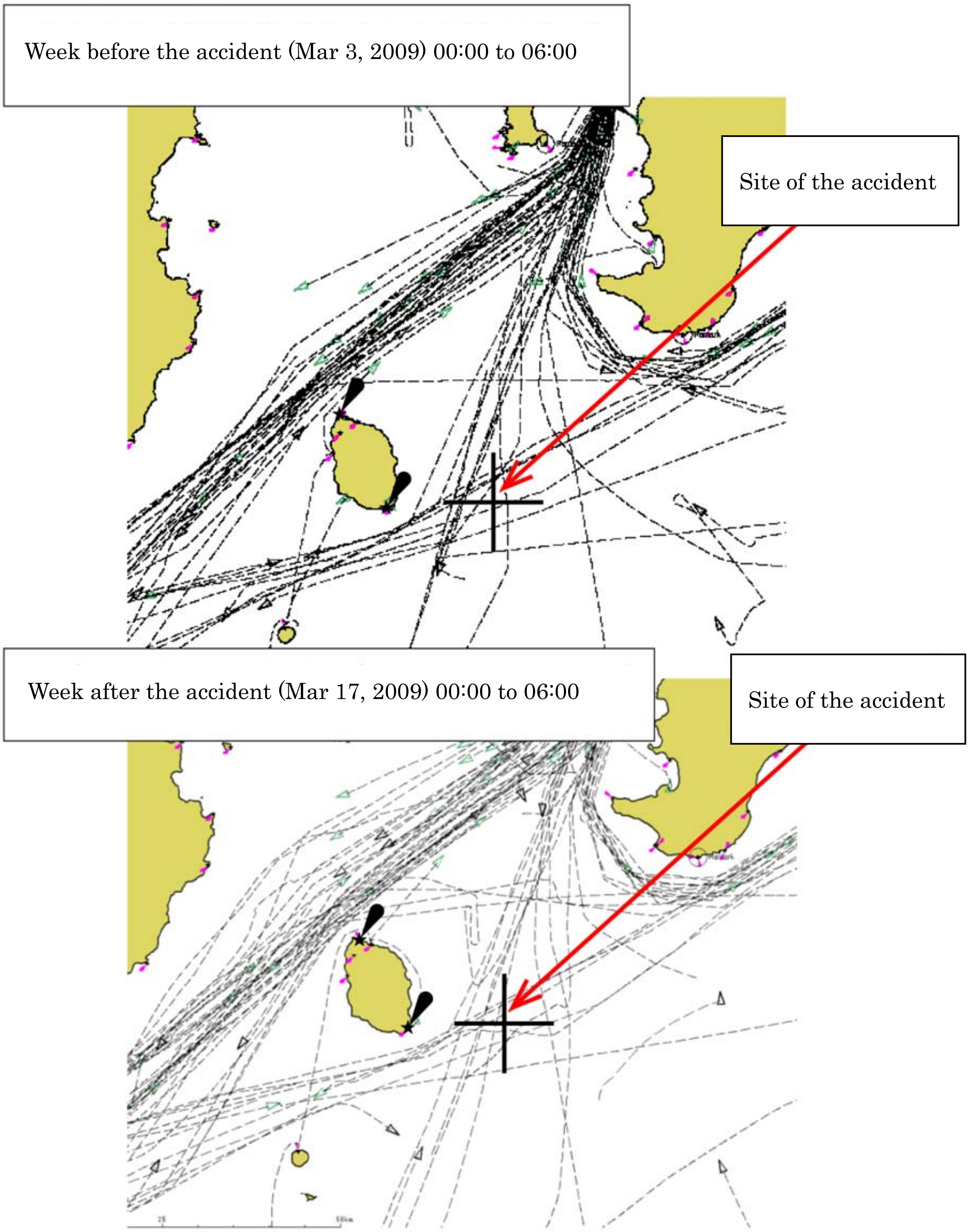
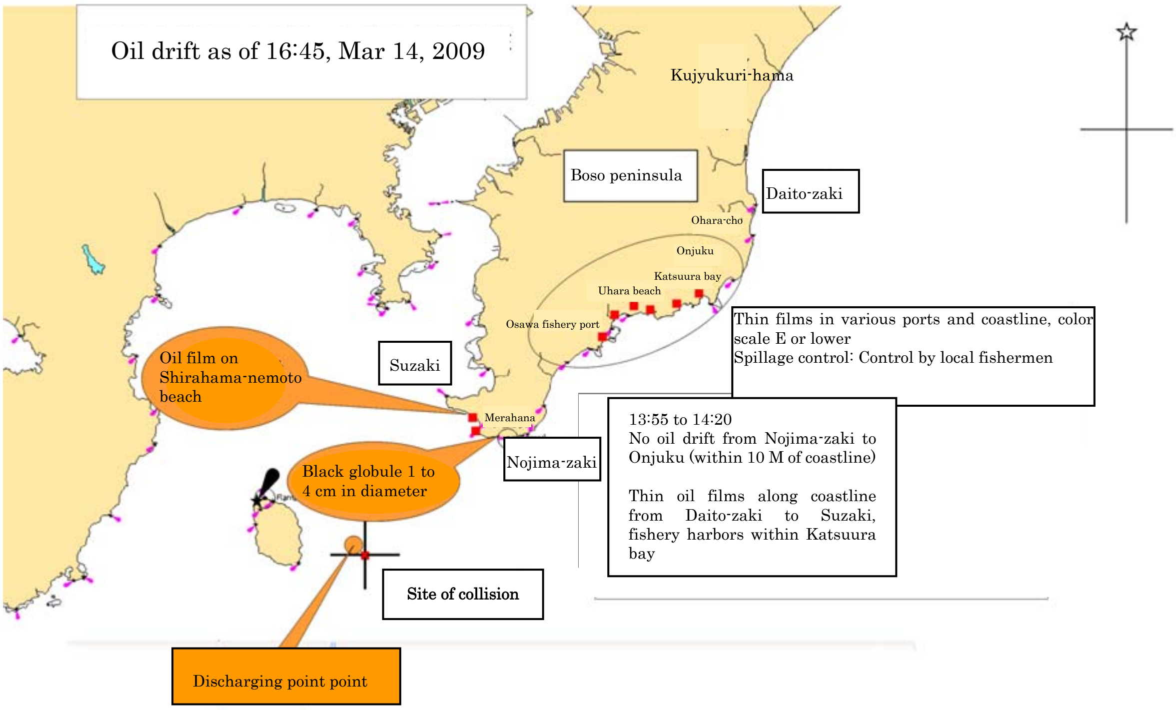
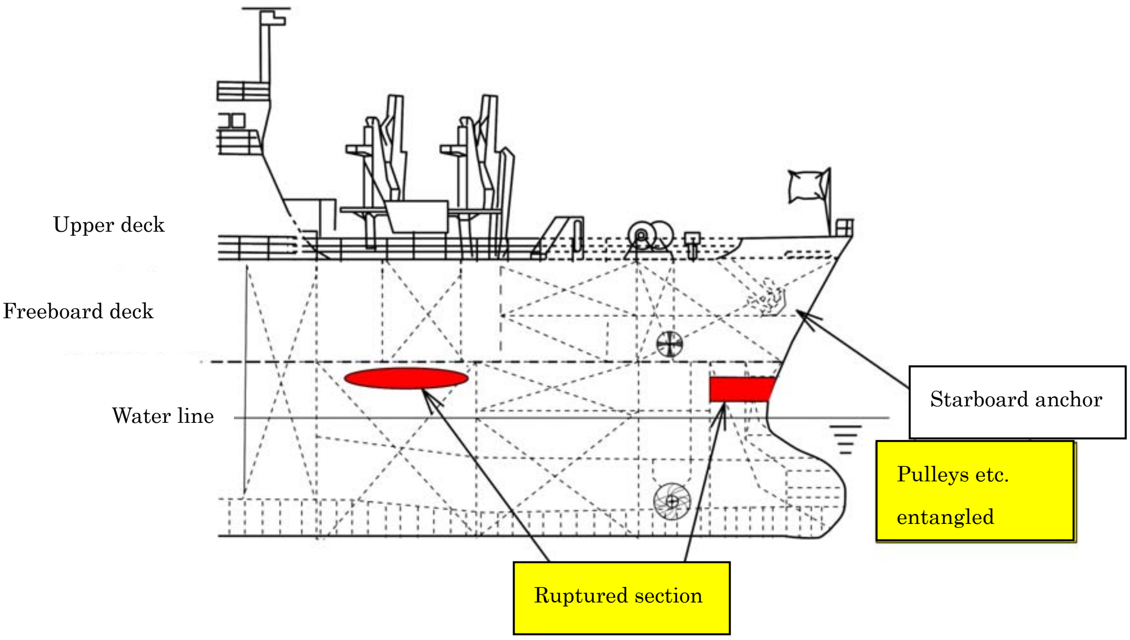


Figure 20: Conditions of oil spillage



(Note) Based on the "Drifting and floating oil situation by the Japan Coast Guard

Figure 21: Damages to the bow section of Vessel A



Reference Figure: Tracks assuming the two vessels proceeded without veering

(from about 15 minutes prior to the collision to the time of the collision)

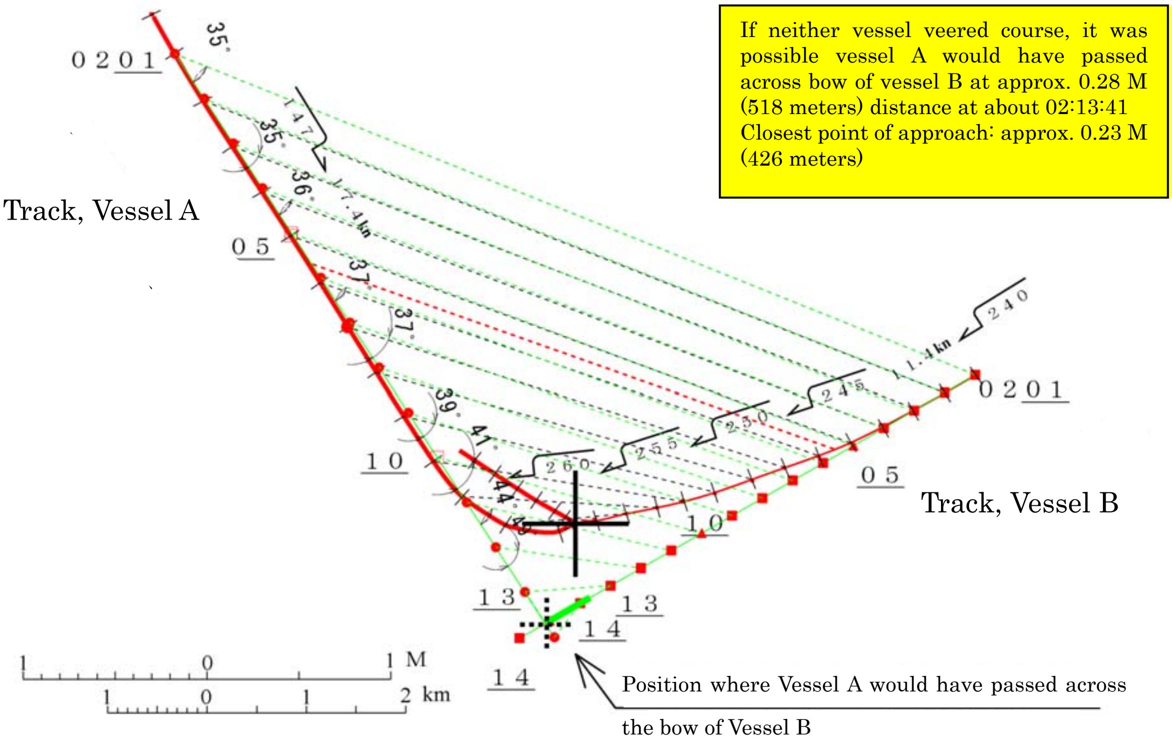


Table 1: AIS logs, Vessel A

Time stamp corresponds to Japan Standard Time (JST) -2 seconds

Time	Latitude North (deg)	Longitude East (deg)	COG	Heading	SOG (kn)
01:42:04	34-48-41.9	139-29-28.3	146	146	16.9
01:42:10	34-48-40.8	139-29-29.3	145	146	16.9
01:42:17	34-48-39.2	139-29-30.7	145	145	17.0
(abbreviated)					
01:45:59	34-47-47.9	139-30-16.6	143	145	17.3
01:46:04	34-47-46.1	139-30-18.3	143	146	17.3
01:46:11	34-47-44.6	139-30-19.5	144	146	17.3
(abbreviated)					
01:59:59	34-44-23.5	139-32-56.8	147	148	17.4
02:00:05	34-44-21.5	139-32-58.3	147	148	17.3
02:00:11	34-44-20.0	139-32-59.4	147	148	17.3
(abbreviated)					
02:02:53	034-43-40.1	139-33-29.6	148	148	17.5
02:02:59	034-43-38.6	139-33-30.8	148	148	17.5
02:03:04	034-43-37.1	139-33-31.9	148	148	17.4
(abbreviated)					
02:04:59	34-43-09.2	139-33-53.3	147	148	17.2
02:05:04	34-43-07.7	139-33-54.4	147	148	17.2
02:05:10	34-43-06.5	139-33-55.3	147	148	17.2
(abbreviated)					
02:05:17	34-43-05.0	139-33-56.5	148	148	17.2
02:05:22	34-43-03.5	139-33-57.6	147	148	17.1
02:05:29	34-43-02.0	139-33-58.7	147	148	17.1
02:05:34	34-43-00.6	139-33-59.8	148	148	17.1
02:05:41	34-42-58.9	139-34-01.1	147	148	17.1
02:07:53	034-42-26.9	139-34-25.4	147	147	17.2
02:07:58	034-42-25.4	139-34-26.5	147	148	17.3
02:08:05	034-42-23.5	139-34-28.1	146	147	17.2
(abbreviated)					
02:09:17	34-42-06.7	139-34-41.5	146	148	17.2
02:09:22	34-42-05.2	139-34-42.6	147	148	17.2
02:09:29	34-42-03.8	139-34-43.8	146	148	17.2
02:09:34	34-42-02.3	139-34-44.9	147	148	17.2
02:09:41	34-42-00.7	139-34-46.3	147	148	17.2
02:09:47	34-41-59.2	139-34-47.4	146	148	17.2
02:09:53	34-41-58.0	139-34-48.3	147	149	17.2
02:09:58	34-41-56.5	139-34-49.4	147	147	17.2
02:10:05	34-41-54.6	139-34-51.0	147	146	17.3
02:10:11	34-41-53.4	139-34-52.0	146	144	17.3
02:10:17	34-41-52.0	139-34-53.2	145	143	17.3
02:10:22	34-41-50.8	139-34-54.2	144	142	17.2
(abbreviated)					
02:10:59	34-41-43.1	139-35-02.8	134	128	16.7
02:11:00	34-41-43.1	139-35-02.8	134	128	16.7
02:11:02	34-41-42.5	139-35-03.5	132	127	16.6
(abbreviated)					
02:11:59	34-41-34.3	139-35-19.9	116	108	16.0
02:12:00	34-41-34.3	139-35-19.9	115	107	15.9
02:12:02	34-41-34.0	139-35-20.7	114	106	15.8
02:12:05	34-41-33.7	139-35-21.6	113	105	15.8
02:12:08	34-41-33.5	139-35-22.5	112	104	15.7
02:12:11	34-41-33.2	139-35-23.4	111	104	15.7
02:12:13	34-41-33.1	139-35-24.0	110	103	15.6
02:12:15	34-41-33.0	139-35-24.3	109	102	15.6
02:12:18	34-41-32.8	139-35-24.9	109	101	15.6
02:12:20	34-41-32.5	139-35-26.1	109	099	15.5
02:12:22	34-41-32.5	139-35-26.1	108	099	15.5
02:12:24	34-41-32.2	139-35-27.7	106	097	15.5
02:12:28	34-41-32.1	139-35-28.6	105	095	15.4
02:12:33	34-41-31.9	139-35-30.1	103	091	15.3
02:12:36	34-41-31.8	139-35-31.0	101	088	15.3
02:12:38	34-41-31.8	139-35-31.0	101	086	15.3
02:12:41	34-41-31.7	139-35-32.2	098	084	15.1
02:12:45	34-41-31.7	139-35-33.4	096	081	15.0
02:12:48	34-41-31.7	139-35-34.0	094	079	14.9
02:12:53	34-41-31.8	139-35-35.8	091	075	14.6
02:12:59	34-41-32.0	139-35-37.5	086	071	14.4
02:13:07	34-41-32.5	139-35-39.7	080	063	14.0
02:13:10	34-41-32.6	139-35-40.5	079	061	13.9
02:13:12	34-41-32.9	139-35-41.3	076	059	13.8
02:13:14	34-41-32.9	139-35-41.5	074	058	13.7
02:13:16	34-41-33.1	139-35-42.0	072	057	13.6
02:13:18	34-41-33.4	139-35-42.8	071	055	13.6
02:13:20	34-41-33.6	139-35-43.3	070	052	13.5
02:13:22	34-41-33.7	139-35-43.5	068	051	13.4
02:13:24	34-41-34.0	139-35-43.9	067	049	13.3
02:13:25	34-41-34.0	139-35-43.9	067	048	13.3
02:13:26	34-41-34.3	139-35-44.6	064	046	13.1
02:13:27	34-41-34.4	139-35-44.8	063	045	13.0
02:13:29	34-41-34.4	139-35-44.8	063	044	13.0
02:13:30	34-41-34.6	139-35-45.2	062	042	13.0
02:13:33	34-41-35.2	139-35-45.9	053	025	11.6
02:13:36	34-41-35.5	139-35-46.0	048	020	9.9
02:13:38	34-41-35.6	139-35-45.8	045	016	8.9
02:13:41	34-41-35.6	139-35-45.8	040	012	5.6
02:13:45	34-41-35.7	139-35-45.7	034	009	4.1
02:13:48	34-41-35.8	139-35-45.6	027	006	2.9
02:13:51	34-41-35.7	139-35-45.6	030	004	2.2
02:13:55	34-41-35.7	139-35-45.6	023	001	1.6
02:13:57	34-41-35.8	139-35-45.5	354	000	1.2
02:14:01	34-41-35.7	139-35-45.5	038	359	0.6
02:14:08	34-41-35.7	139-35-45.4	309	356	0.5
02:14:12	34-41-35.7	139-35-45.5	308	354	0.0
02:14:15	34-41-35.7	139-35-45.5	294	351	0.4
02:14:17	34-41-35.7	139-35-45.4	277	350	0.6
02:14:20	34-41-35.7	139-35-45.4	282	347	0.4

(Note) Ship position indicates position of GPS antenna

Table 2: AIS logs, Vessel B

Time stamp corresponds to Japan Standard Time (JST) -2 seconds

Time	Latitude North (deg)	Longitude East (deg)	COG	Heading	SOG (kn)
1:46:53 AM	34-43-43.0	139-41-19.2	242	238	11.6
1:47:03 AM	34-43-42.0	139-41-17.1	241	240	11.7
1:47:14 AM	34-43-40.9	139-41-14.7	240	240	11.7
(abbreviated)					
1:59:55 AM	034-42-28.9	139-38-38.2	237	241	11.2
2:00:04 AM	034-42-28.1	139-38-36.3	239	239	12.1
2:00:13 AM	034-42-27.2	139-38-34.2	241	239	11.6
(abbreviated)					
2:02:42 AM	34-42-12.9	139-38-03.6	239	240	11.4
2:03:03 AM	34-42-11.0	139-37-59.6	240	240	11.2
2:03:12 AM	34-42-10.1	139-37-57.5	239	238	11.4
2:03:22 AM	34-42-09.2	139-37-55.5	242	239	11.5
2:03:34 AM	34-42-08.0	139-37-53.3	238	240	11.6
2:03:42 AM	34-42-07.2	139-37-51.4	243	241	11.5
2:03:53 AM	34-42-06.2	139-37-49.3	240	242	11.4
2:04:03 AM	34-42-05.4	139-37-47.3	241	243	11.5
2:04:13 AM	34-42-04.6	139-37-45.2	245	244	11.7
2:04:22 AM	34-42-03.8	139-37-43.2	250	244	11.3
2:04:34 AM	34-42-02.9	139-37-40.9	242	245	10.9
2:04:42 AM	34-42-02.1	139-37-39.0	245	246	11.5
2:04:53 AM	34-42-01.3	139-37-36.9	242	247	11.6
2:05:03 AM	34-42-00.6	139-37-34.8	248	247	11.8
2:05:14 AM	34-41-59.8	139-37-32.4	251	246	11.6
2:05:24 AM	34-41-59.1	139-37-30.3	250	248	10.9
2:05:34 AM	34-41-58.4	139-37-28.2	249	248	11.2
2:05:42 AM	34-41-57.8	139-37-26.3	246	247	11.4
2:05:53 AM	34-41-57.0	139-37-24.0	254	247	11.4
2:06:03 AM	34-41-56.4	139-37-22.0	246	248	11.1
2:06:14 AM	34-41-55.7	139-37-19.6	247	248	11.4
2:06:24 AM	34-41-55.0	139-37-17.5	250	249	11.3
2:06:34 AM	34-41-54.3	139-37-15.3	252	249	11.2
2:06:42 AM	34-41-53.7	139-37-13.4	252	250	11.4
2:06:53 AM	34-41-53.0	139-37-11.0	256	249	11.3
2:07:03 AM	34-41-52.5	139-37-09.1	252	250	10.7
2:07:14 AM	34-41-51.8	139-37-06.7	250	250	10.6
2:07:24 AM	34-41-51.2	139-37-04.5	247	248	11.8
2:07:34 AM	34-41-50.6	139-37-02.4	254	248	11.0
2:07:53 AM	34-41-49.3	139-36-58.2	248	247	11.1
2:08:03 AM	34-41-48.7	139-36-56.3	248	247	11.4
2:08:14 AM	34-41-47.9	139-36-53.9	248	247	11.2
2:08:24 AM	34-41-47.3	139-36-51.9	250	248	11.1
2:08:33 AM	34-41-46.7	139-36-49.8	248	248	10.7
2:08:43 AM	34-41-46.1	139-36-47.8	250	249	11.2
2:08:53 AM	34-41-45.4	139-36-45.6	249	250	11.4
2:09:14 AM	34-41-44.2	139-36-41.4	254	253	10.8

Time	Latitude North (deg)	Longitude East (deg)	COG	Heading	SOG (kn)
2:09:33 AM	34-41-43.2	139-36-37.1	256	252	10.9
2:09:43 AM	34-41-42.7	139-36-35.3	253	251	10.6
2:10:14 AM	34-41-41.1	139-36-28.8	255	256	10.4
2:10:34 AM	34-41-40.4	139-36-24.6	256	257	10.7
2:10:42 AM	34-41-40.0	139-36-22.8	259	257	10.3
2:10:53 AM	34-41-39.7	139-36-20.7	260	258	10.0
2:11:03 AM	34-41-39.3	139-36-18.6	254	257	10.6
2:11:14 AM	34-41-39.0	139-36-16.4	259	257	10.4
2:11:22 AM	34-41-38.7	139-36-14.5	258	258	10.4
2:11:33 AM	34-41-38.3	139-36-12.3	254	258	10.5
2:11:42 AM	34-41-37.9	139-36-10.5	269	258	10.2
2:11:53 AM	34-41-37.6	139-36-08.4	256	259	9.9
2:12:03 AM	34-41-37.3	139-36-06.4	253	259	10.3
2:12:14 AM	34-41-37.0	139-36-04.1	262	261	10.3
2:12:23 AM	34-41-36.7	139-36-02.2	256	261	10.2
2:12:34 AM	34-41-36.4	139-36-00.0	255	262	9.9
2:12:39 AM	34-41-36.3	139-35-59.0	260	263	10.5
2:12:41 AM	34-41-36.3	139-35-58.6	257	264	10.1
2:12:42 AM	34-41-36.2	139-35-58.2	262	264	10.3
2:12:53 AM	34-41-36.1	139-35-56.2	265	266	10.1
2:13:03 AM	34-41-35.9	139-35-54.2	264	268	10.0
2:13:06 AM	34-41-35.9	139-35-53.5	264	269	9.9
2:13:08 AM	34-41-35.8	139-35-53.2	268	269	9.7
2:13:08 AM	34-41-35.8	139-35-53.0	270	269	9.9
2:13:09 AM	34-41-35.8	139-35-52.8	270	269	10.1
2:13:11 AM	34-41-35.8	139-35-52.6	268	269	10.3
2:13:14 AM	34-41-35.8	139-35-51.9	267	270	9.9
2:13:20 AM	34-41-35.7	139-35-50.5	272	270	9.7
2:13:21 AM	34-41-35.7	139-35-50.3	273	270	9.8
2:13:23 AM	34-41-35.8	139-35-50.1	273	270	9.9
2:13:23 AM	34-41-35.8	139-35-50.1	273	270	9.9
2:13:24 AM	34-41-35.8	139-35-49.9	271	270	9.9
2:13:32 AM	34-41-35.8	139-35-48.3	281	270	5.4
2:13:34 AM	34-41-35.8	139-35-48.2	302	272	4.5
2:13:35 AM	34-41-35.9	139-35-48.1	291	273	3.7
2:13:38 AM	34-41-36.0	139-35-47.9	325	272	3.5
2:13:38 AM	34-41-36.0	139-35-47.9	329	271	3.5
2:13:39 AM	34-41-36.1	139-35-47.9	335	270	3.8
2:13:41 AM	34-41-36.2	139-35-47.8	340	268	3.9
2:13:42 AM	34-41-36.2	139-35-47.8	337	267	3.5
2:13:42 AM	34-41-36.2	139-35-47.8	337	267	3.5
2:13:44 AM	34-41-36.4	139-35-47.7	342	264	4.1
2:14:04 AM	34-41-36.9	139-35-46.9	295	249	4.6
2:14:05 AM	34-41-36.9	139-35-46.8	288	248	5.7
AIS signal terminated					

(Note) Ship position indicates position of GPS antenna

Table 3: Changes in bearings/distances to Vessel B as seen from Vessel A based on VDR Data

Time indication corresponds to the VDR time stamps +9 hours, and signifies Japan Standard Time (JST) +2 seconds

	Vessel B viewed from Vessel A		Vessel B		Vessel A	Relative	
Time	Bearing (deg)	Distance (M)	Heading (deg)	Speed (kn)	Heading (deg)	bearing from vessel A (deg)	
02:00:01	112	5.0	239	12.1	148	Port	36
02:01:02	112	4.7	238	11.2	148	Port	36
02:02:01	112	4.3	239	11.7	148	Port	36
02:03:02	111	3.9	240	11.2	148	Port	37
02:04:03	111	3.6	241	11.5	148	Port	37
02:05:02	110	3.2	248	11.8	148	Port	38
02:05:35	110	3.0	249	11.2	148	Port	38
02:06:01	109	2.9	246	11.1	148	Port	39
02:07:02	108	2.5	252	10.7	148	Port	40
02:08:00	107	2.2	248	11.1	147	Port	41
02:09:02	104	1.8	249	11.4	148	Port	44
02:09:24	103	1.7	254	10.8	148	Port	45
02:10:03	101	1.5	253	10.6	146	Port	45
02:10:22	098	1.3	255	10.4	140	Port	42
02:11:02	093	1.0	254	10.6	126	Port	33
02:11:27	091	0.9	258	10.4	118	Port	28
02:12:01	085	0.6	253	10.3	105	Port	20
02:12:31	082	0.5	256	10.2	090	Port	08
02:13:00	076	0.3	265	10.1	067	Starboard	09
02:13:16	072	0.2	267	9.9	054	Starboard	18
02:13:32	071	0.1	273	9.9	025	—	
02:13:46	071	0.0	337	3.5	006	—	
02:14:03	071	0.0	337	3.5	357	—	
02:14:17	071	0.0	337	3.5	347	—	
02:14:30	071	0.0	337	3.5	335	—	
02:14:47	071	0.0	337	3.5	324	—	
02:15:02	071	0.0	337	3.5	319	—	
02:15:15	071	0.0	337	3.5	318	—	
02:15:23	071	0.0	337	3.5	318	—	
02:15:30	071	0.0	337	3.5	318	—	
02:15:40	071	0.0	337	3.5	318	—	

Termination of bearing/distance indication for vessel B at this point

Table 4: Search and rescue activities

* Time indication in Japan Standard Time (JST)

Date/time	Japan Coast Guard	JMSDF	Police	Civilian vessel
As of 14:30, Mar/10 (TUE)	03:30 Countermeasures HQ (3rd Regional HQ) 03:30 Local HQ (Shimoda Coast Guard Office) 06:00 Major disaster HQ (3rd Regional HQ) Patrol boat x6; Aircraft x5; Special rescue x6 ppl; National strike team x2 ppl	Defense ship x3; aircraft x2	Patrol ship x1; aircraft x1	3 vessels (one of which is vessel A, about 03:00 to 12:30) (1) Container ship x1 (2) Cargo ship x1
As of 20:00, Mar/10 (TUE)	Patrol boat x4; Aircraft x1; Special rescue x2 ppl; National strike team x2 ppl	Defense ship x3	—	—
As of 09:00, Mar/11 (WED)	Patrol boat x5; Aircraft x5; Survey vessel x1; Special rescue x2 ppl; National strike team x5 ppl	Defense ship x3; aircraft x3	Aircraft x1	Spillage control vessel x3
As of 19:00, Mar/11 (WED)	Patrol boat x3; Survey vessel x1; National strike team x5 ppl	—	—	—
As of 09:45, Mar/12 (THR)	Patrol boat x3; Aircraft x2; Survey vessel x1; National strike team x3 ppl	Aircraft x2	—	Spillage control vessel x3
As of 19:00, Mar/13 (FRI)	Patrol boat x6; Aircraft x2; National strike team x4 ppl	—	—	Spillage control vessel x3
As of 09:00, Mar/14 (SAT)	Patrol boat x2; Aircraft x2; National strike team x4 ppl	—	—	Spillage control vessel x3 (no spillage control due to weather)
As of 09:00, Mar/15 (SUN)	Patrol boat x3; Aircraft x2; National strike team x4 ppl	—	—	Spillage control vessel x 3
As of 09:00, Mar/16 (MON)	Patrol boat x3; Aircraft x2; National strike team x4 ppl	—	—	Spillage control vessel x3 (23 people engaged in spillage control)
As of sundown (about 17:46, Mar/16 (MON)	Dedicated search terminated (search continued as part of nornal patrol activity)	—	—	Spillage control vessel x2

Table 5: VDR Data, audio records

Time stamp corresponds to Japan Standard Time (JST) +2 seconds.	
Recorded audio is in English.	
02:03 to 02:04	02:03:22 Continued low-toned "peep" noise
02:04 to 02:05	Continued low-toned "peep" noise
02:05 to 02:06	Continued low-toned "peep" noise
	02:05:24 Hail from vessel B "CYGNUS ACE, THIS IS ORCHID PIA, COME IN PLEASE"
	02:05:35 Second hail from vessel B
02:06 to 02:07	Continued low-toned "peep" noise
02:07 to 02:08	Continued low-toned "peep" noise
02:08 to 02:09	02:08:10 continued stopped
	02:08:32 Dual-toned "pee-poo" alarm
	02:08:42 Alarm stops with confirmation "peep"
02:09 to 02:10	02:09:10 Confirmation "peep"
	02:09:50 Dual-toned "pee-poo" alarm
	02:09:55 Alarm stops with confirmation "peep"
02:10 to 02:11	02:10:10 Continued low-toned "peep" noise
	02:10:46 Confirmation "peep"
02:11 to 02:12	02:11:30 Confirmation "peep"; Continued low-toned "peep" noise
02:12 to 02:13	Continued low-toned "peep" noise
	02:12:13 Alarm "peep-peep-peep" begins
02:13 to 02:14	Continued alarm tone "peep-peep-peep"
	02:13:21 Officer A mumbles "HEY" in a small voice
	02:13:24 Noise "rattle! rattle! rattle! (bang! bang! bang!) boom!"
	02:13:49 Master A arrives on bridge asks "WHAT HAPPENED?" in relatively small voice. Officer A responds with phrase "THIS ONE IS ・・・COURSE・・・"
	02:13:55 Master A, "OH!" sounds surprised
	02:13:57 Extremely large crashing noise "BAANG!!"
02:14 to 02:15	Continued alarm tone "peep-peep-peep"
	02:14:00 Extremely large scraping noise of vessel hulls moving against each other (- 10 seconds)
	02:14:13 Master A shouts loudly "WHAT HAPPENED, 2/O"
	02:14:21 Master A shouts loudly "WHAT ARE YOU DOING"
	02:14:28 Master A shouts loudly "COLLISION"
	02:14:37 Call tone "beep"
	02:14:40 Incoming VHF call from Tokyo MARTIS "CYGNUS ACE, CYGNUS ACE"
	02:14:55 Master A says "WHAT HAPPENED, 2/O"
02:15 to 02:16	Continued alarm tone "peep-peep-peep"
	02:15:00 VHF call from Tokyo MARTIS "ORCHID PIA, ORCHID PIA" (1st call)
	02:15:26 Another VHF call from Tokyo MARTIS "ORCHID PIA, ORCHID PIA" (2nd call)
	02:15:35 Voice of master A instructing the crew to confirm the condition of each tank
	02:15:47 Master A asks "WHAT HAPPENED?"
	02:15:50 Officer A starts to respond with the phrase "THIS ONE IS ・・・COURSE・・・" and falls silent
02:16 to 02:17	Continued alarm tone "peep-peep-peep"
	02:16:03 Incoming VHF call from Yokohama Port Radio
	02:16:06 Master A responds to call (Yokohama Port Radio instructs to switch to 12 ch)
	02:16:10 Dual-toned "pee-poo" alarm stops after short time
	02:16:27 Alarm tone "peep-peep-peep" stops
	02:16:47 3rd regional HQ "DID YOU COLLIDE?" Master A "WE COLLIDED. CURRENTLY CHECKING DAMAGE"
02:17 to 02:18	02:17:40 3rd regional HQ "ARE YOU ALL RIGHT?" Master A "NOW UNDER WAY, CHECKING MY DAMAGE."
02:18 to 02:19	02:18:00 Master A reports to 3rd regional HQ "NOW UNDER WAY, CHECKING MY DAMAGE. DETAILS UNKNOWN"
	02:18:30 Tokyo MARTIS calls to vessel B (call sign) on the VHF (3rd attempt)
	Master A instructs crew to confirm location of collision
	02:18:50 Tokyo MARTIS calls to vessel B (call sign) on the VHF (4th attempt)
02:19 to 02:20	02:19:04 Master A reports to 3rd regional HQ "NOW UNDER WAY, CHECKING MY DAMAGE."
	02:19:55 Call tone "beep"
02:20 to 02:21	02:20:04 Call tone buzzer "beep" stops
02:21 to 02:22	02:21:30 Master A "WHAT IS THE NAME OF THE OTHER SHIP? WHAT KIND? WHAT KIND OF SHIP DID WE CRASH INTO?; Officer A "I DON'T KNOW."; Master A "FISHING BOAT… CARGO…"
02:22 to 02:23	02:22:02 Master A "WHAT KIND OF CARGO SHIP"
	02:22:30 3rd regional HQ calls to vessel A on the VHF
	02:22:45 Master A responds
02:23 to 02:24	02:23:01 3rd regional HQ "CAN YOU SEE THE OTHER SHIP ON RADAR?"
	02:23:10 Master A "WE CAN'T SEE THE OTHER SHIP ON RADAR"
	02:23:30 3rd regional HQ "WE ARE SENDING HELP. REQUEST YOUR ASSISTANCE AT THE SITE IF POSSIBLE"
	02:23:50 Master A "ACKNOWLEDGED"
02:24 to 02:25	02:24:00 3rd regional HQ "CAN YOU MOVE?"
	02:24:10 Master A "NOW CHECKING DAMAGE.WILL REPORT LATER"
02:25 to 02:26	02:25:02 Call tone "beep" stops soon

Table 6: Result of analysis by NMRI (summary)

1. Estimated circumstances of the collision

As a prerequisite for the estimation of the circumstances of the collision, the weather and sea conditions prevailing at the time of the accident were evaluated based on the estimated wave condition data and general weather/sea condition forecast and observation charts. The central values of the ocean wave conditions were calculated as indicated in Table 1-1 below.

Table 1-1 Weather/Sea conditions at the time of the accident

Visibility	3-5 nautical miles
Wind direction	NE (45 deg.)
Wind speed	23.3kn (12m/s)
Wave direction	ESE (113 deg.)
Wave height	2.24 m
Wave cycle	8 sec.

Actual sea conditions are subjected to the influence of diverse wave components, and the wave phase changes with the positions. It is therefore impossible to exactly reproduce the actual situation under which the accident occurred. Accordingly, ship motions for the two vessels involved in the collision were estimated using the significant wave height and mean cycle computed from the primary components of the wave.

The pitch and roll angles and heights of vertical motions, which are required for the estimation of the ship motion, were provisionally estimated from charts compiling the calculation data for the series 60 hull form. (Reference material: *Kinematics of hull form and marine structures*; Chapter II, section 3; *Estimation of ship motion under the influence of ocean waves* – Seizo MOTORA, Publisher; Seizando-Shoten Co., Ltd.; 1992)

As indicated in Table 1-1, the prerequisite sea conditions were estimated as: Wave direction (θ) 113 deg., Significant wave height (H) 2.24 m, Wave cycle (T) 8 sec. Based on these estimates, the coefficients required for the estimation are as follows: Wave length ($\lambda = \frac{g}{2\pi}T^2$) approximately 100.m, wave count ($K = \frac{2\pi}{\lambda}$) 0.063, wave oscillation ($\xi = \frac{H}{2}$) 1.12 m. The estimated pitch/roll angles and heights of vertical motions obtained from the compiled charts based on these coefficients and the angles of wave encounter (χ) for the vessels are as indicated in Table 1-2 below.

Table 1-2 Estimated perturbation at the time of the accident

	Pitch angle (deg.)	Roll angle (deg.)	Vertical displacement (m)
Vessel A	0.8	5.6	0.2
Vessel B	1.6	2.8	0.45

The vertical motion of the bow section of vessels is determined by the pitch and vertical motion of the hull.

Judging from the AIS logs and available information, the collision apparently occurred with the bow section of vessel A running onto the middle section of vessel B on the port side. In order for the bow to run upon the hull, the bottom of vessel A's hull needs to be positioned higher than the freeboard deck of vessel B. At the time of the accident, the forward draft of vessel A was 4.50 *m* and the freeboard of vessel B was 3.20 m.

Upheaval at the bow section of vessel A is considered to be the combined result of the vertical motion and pitch components. There exists an approximately 90. deg. phase deviation between vertical motion and pitch, with the pitch diminishing to almost zero at the peaks of vertical motion. Diagram 1-1 indicates the upheaval of the bow when the cycle of wave encounter is assessed as 8 sec with the oscillation of pitch angle and vertical motion respectively calculated as 0.1 deg. and 0.20m. According to this diagram, the upheaval of the bottom of the hull reaches 1.20m at 0.24 sec.

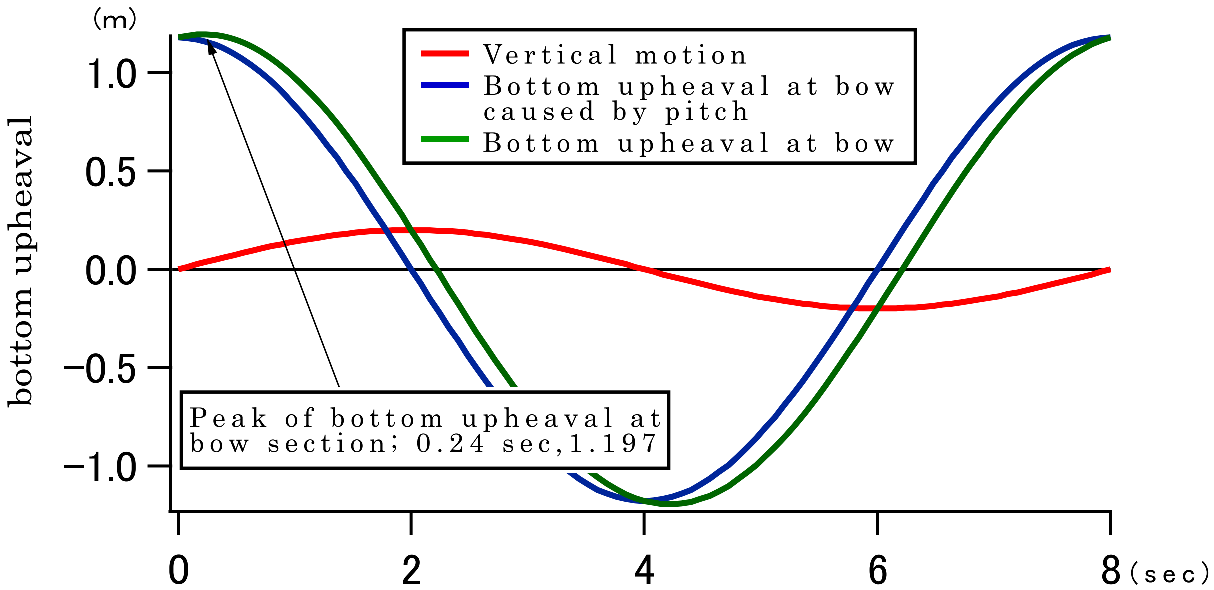


Diagram 1-1 Relationship between vertical motion and pitch

As vessel B got run upon at the middle section of the hull, she was not subjected to the effects of pitch so much, with the wave-based subsidence basically caused by the vertical motion components. The amount of subsidence was estimated at 0.45 m. As vessel B was proceeding at 270. deg. with the wave direction at 113. deg., the vessel was basically navigating in following-waves, but the effects of roll are presumed to be relatively small at approximately 3. deg.

Assuming the wave-based subsidence for vessel B was 0.45 m, the difference of height between the bottom sections of the two vessels would be $1.20m + 0.45m \fallingdotseq$ 1.7m at the bow of vessel A. In order for the bow section of vessel A to run on vessel B, a height difference of 7.70 m is necessary. The height difference estimated above signifies the average for the weather conditions indicated above, and may easily reach a double value considering the occurrence of irregular waves. In such case, maximum possible difference in the height of the bottom of the vessels may amount to approximately 3.4 m. Based on this estimate, it is considered probable that the bottom section of vessel A bow collided with the side of vessel B at the position 4.3 m below the upper deck, rolling vessel B over to the right with the kinetic momentum gained from the ship's speed of 13. kn, concurrently breaking the shell plating of vessel B. Vessel A ended up riding on the upper deck of vessel B. The relationship between the two vessels during this process is indicated in Diagram 1-2.

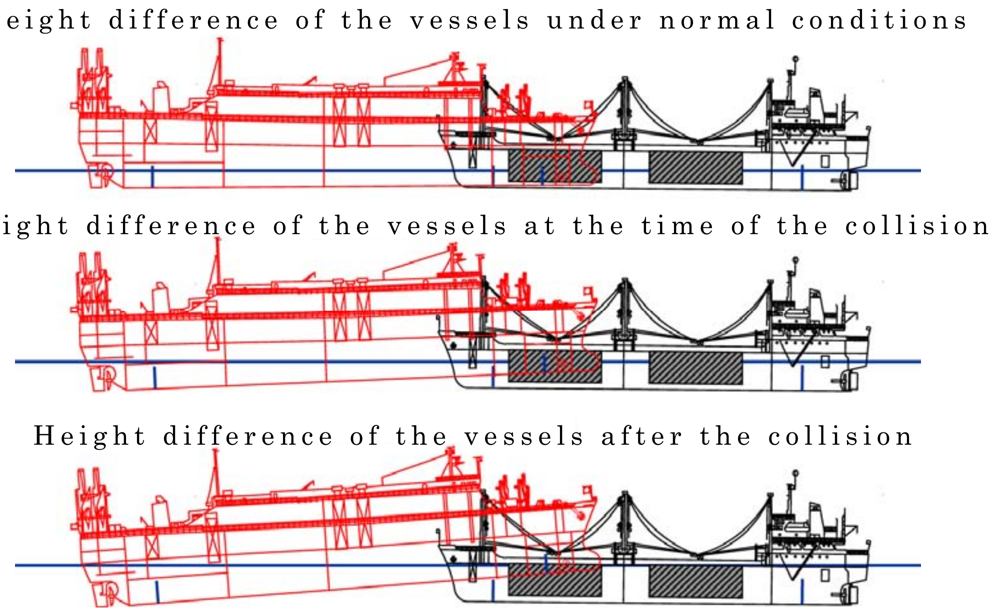


Diagram 1-2 The relationship between the two vessels at the time of the collision

2. Estimated Sinking Processes of Vessel B

2.1 Estimated Conditions of Vessel B

After the collision, the bow section of vessel A ran onto vessel B from port to starboard. In these circumstances, the forces applied to vessel B are categorized into two primary components, namely, the static load of vessel A running onto vessel B, and the combined lateral forces of the inertia force and the propulsion force of vessel A. According to the analysis of the VDR logs, two impact noises were confirmed at about 02:13:26 and 02:13:58.. As the ruptures and scratches of vessel A are concentrated in the bow section with the rear section remaining almost intact, it is presumed that vessel A rode onto vessel B in the initial stage of the collision, causing the hull of vessel B to break in at the middle section under the combined forces of the weight of and propulsion force of vessel A. As a result, vessel B is presumed to have sunk within a matter of minutes after the collision.

Accordingly, the conditions of the hull after the collision and the forces applied to vessel B are estimated as follows.

2.2 Estimated Static Subsidence and Downward Forces Applied to Vessel B When Vessel A Straddled upon Vessel B

To determine the conditions of the two vessels after vessel A ran upon vessel B, the extent of static subsidence of vessel B was estimated on the following assumptions:

(1) Vessel A ran onto vessel B in the vicinity of the center of buoyancy. Accordingly the trim of vessel B was not so great.

(2) Based on the presence of scratches of approximately 20.0m in length on the bottom of vessel A's hull, the point of application of vessel A was at 10.0m from the bow.

Coefficients used in the estimation are as indicated in Table 2-1. Based on the particulars of the subject vessels, coefficients of water plane for vessel B – Cw, secondary moment coefficient – j, and trim moment per centimeter were approximated by referring to the first volume of *Theoretical Vessel Engineering* (author: Masanobu OHGUSHI, Kaibun-do Publishing Co., Ltd., 1971). The trim moment per centimeter parameter can only effectively be used for minute trim fluctuations, the same parameter was employed for the sake of estimate calculations.

Table 2-1 Particulars of respective vessels

Name	Vessel A	Vessel B
LOA (m)	134.86	111.60
LPP (m)	126.00	103.98
B (m)	20.00	16.40
Depth (m)	14.09	8.70
Design Draft (m)	6.10	6.70
Average waterline without load (m)	-	2.832
Cb Block Coef.	0.59	0.70
Cp Prismatic Coef.	0.62	0.72
Cw Water plane area Coef.	0.82	0.81
Displacement (t) (Vessel B unloaded; vessel A fully loaded)	9257	3485
Water plane area (m^2)	2053.	1381.
Displacement tonnage per centimeter (t) (sea water)	21.1	14.2
Secondary moment coefficient j	0.0484	0.0476
Trim moment per centimeter (approximated)	153.7	84.5

2.2.1 Calculations of the Static Subsidence of Vessel B, and the Weights of Vessel A applied onto Vessel B

Assuming the subsidence of vessel B caused by vessel A running onto vessel B is X cm, the buoyancy generated by the subsidence as derived from the displacement tonnage per centimeter parameter for vessel B is $14.2X$ t.

On the other hand, the $14.2X$ t of uplifting force working on a point 10.0 m from the foremost point of vessel A's bow will result in a decrease of draft at her center of gravity, as well as in a head-lifting trim for vessel A.

From the displacement tonnage per centimeter parameter for vessel A, the decrease of draft at the center of gravity point is calculated as:

$$14.2X / 21.1 = 0.673X \text{ cm}$$

On the other hand, the head-lifting moment is:

$$14.2X \left(126.00/2. - 10.0\right) = 752.6X \quad t\text{-}m$$

Based on the displacement tonnage per centimeter parameter for vessel A, the trim is shifted by the head-lifting moment as follows:

$$T = {752.6\,X}/{153.7} = 4.90\,X \ \text{cm}$$

Disregarding the shift in the center of buoyancy, the uplift occurring at the point 10.00 *m* from the bow is estimated as:

$$d = 0.673\,X + \frac{4.90\,X}{2.}\left(\frac{{126.00}/{2.} - 10.0}{{126.00}/{2.}}\right)$$

$$= 2.73\,X \ \text{cm}$$

With the distance from the mean draft of vessel B to her upper deck being 3.20 m and the forward draft of vessel A being 4.50 m, the following equations are set up to obtain the amount of subsidence of Vessel B (206 cm), since the upper deck of vessel B would be positioned at a roughly equivalent height with the ship's bottom of vessel A if vessel A should run onto vessel B:

$$320. - X = d - 450.$$

$$320. - X = 2.73\,X - 450.$$

$$X = 206 \ \text{cm}$$

Additionally, the weight applied to vessel B is calculated as follows:

$$G = 14.2 \times 206.$$

$$= 2{,}925 \ \text{t}$$

2.2.2 Estimated Forces Applied to Vessel B by Vessel A's Thrust Forces

According to the various statements and other information available, vessel A did not stop her engines upon collision with vessel B although she slightly reduced the engine output. In other words, vessel A continued navigating with some sort of thrust forces maintained. The situation after the collision of the two vessels is comparable to a situation where vessel A pushes an integrated mass of the two vessels laterally. Under such circumstances, the thrust is equivalent to the resistance that would be met in pushing vessel B in a lateral direction.

Generally, the resistance working on a rectangular solid moving at a constant speed V is obtained from the following equation:

$$R = 0.5\,Cd\,\rho\,L\,d\,V^2$$

Upon reference to the ship speed immediately after the collision as contained within the AIS data, vessel A decelerated from 13 kn at the time of the collision to a speed of 1 kn in 15 seconds. When objects collide with each other, their speeds are rapidly dropped upon collision, and then gradually decelerated. Although it is difficult to make a general statement about speed drops owing to insufficient data in the AIS, it is considered probable that vessel A initially decelerated her speed from 13 kn to about 10 kn, and then turned to gradual deceleration.

Assuming the hull as a rectangular solid and the resistance coefficient Cd as 1, it is considered highly probable that the following lateral forces were exerted on vessel B at speeds of 10 kn and 1 kn respectively:

$$R = 0.5 \times 1. \times 104.34 \times 111.60 \times 5.50 \times \left(10.0 \times {}^{1852.}\!\!/_{3600.}\right)^2 / 1000.$$

$$R = 847.5 \ \text{t}$$

and

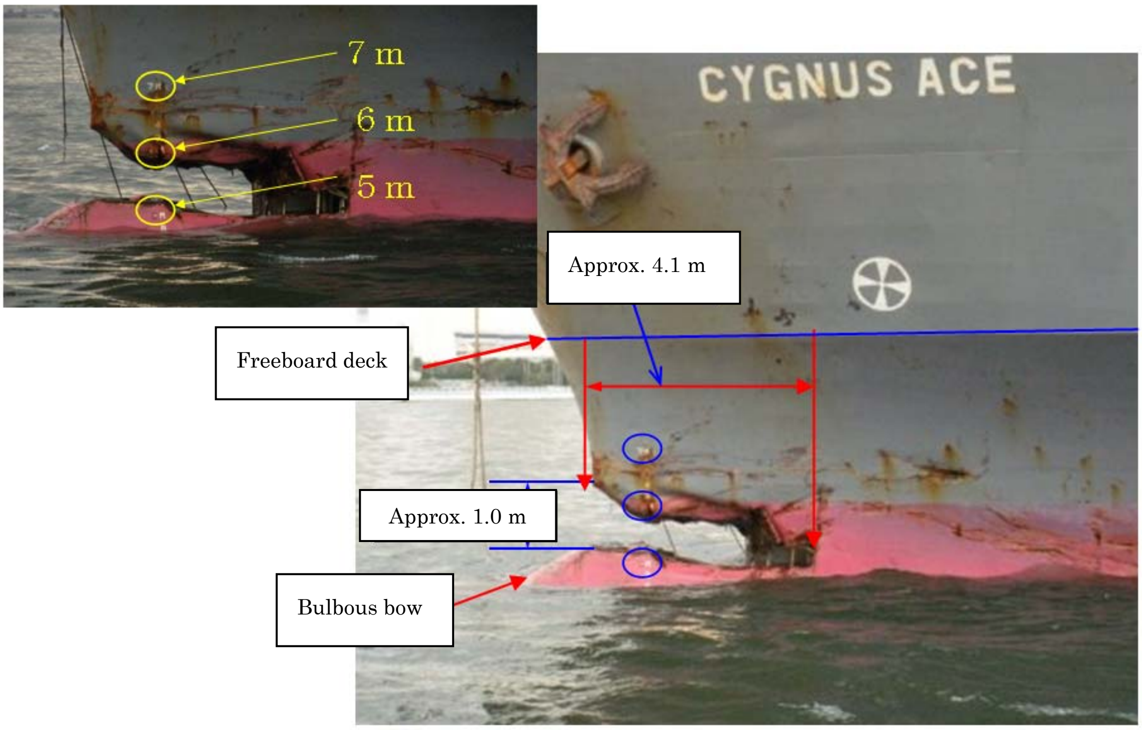
$$R = 0.5 \times 1. \times 104.34 \times 111.60 \times 5.50 \times \left(1.0 \times {}^{1852.}\!\!/_{3600.}\right)^2 / 1000.$$

$$R = 8.5 \ \text{t}$$

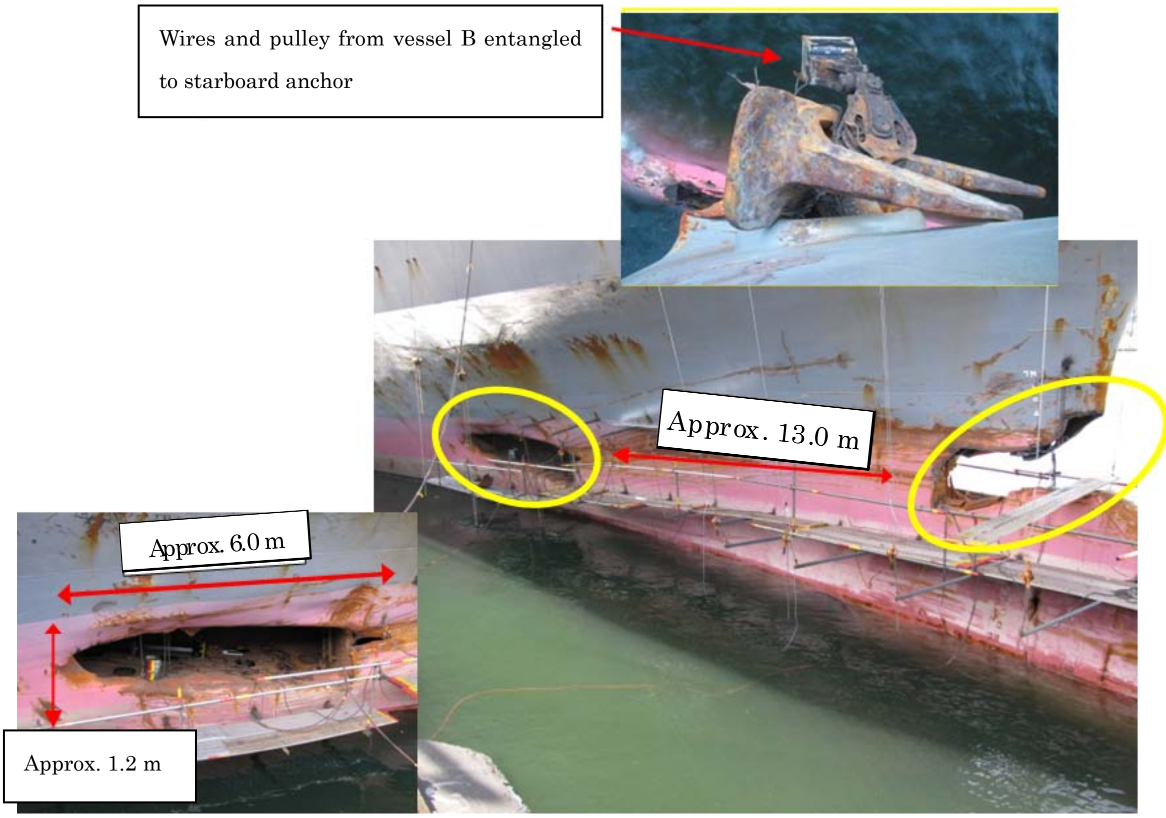
2.3 Conclusion

Based on the damage conditions and other available information, it is considered probable that vessel A ran onto vessel B, resulting in the breaking of vessel B. Vessel A running onto vessel B caused vessel B to subside by approximately 2 meters, and at the same time applied onto the middle section of vessel B’s hull a combined load of approximately 3,000 tonnes consisting of the static load of vessel A and lateral thrust forces of vessel A. Furthermore, vessel B was almost fully loaded with 5,050 tonnes of heavy cargos, and it is therefore reasonably assumed that vessel B was broken down by vessel A running onto vessel B.

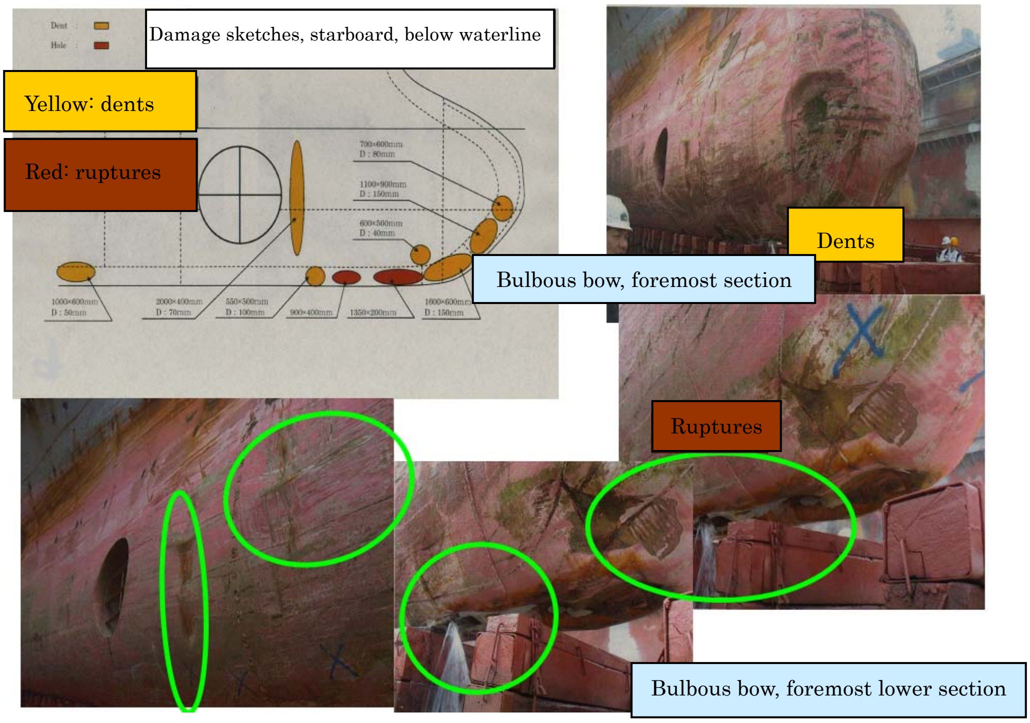
Photograph 1: Damages above the waterline of Vessel A (1)



Photograph 2: Damages above the waterline of Vessel A (2)



Photograph 3: Damages below the waterline of Vessel A (starboard)



Photograph 4: Damages below the waterline of Vessel A (port)