Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport
and Digital Infrastructure

Investigation Report 07/14

Serious Marine Casualty

Collision between the installation vessel PACIFIC ORCA and the fishing vessel JURIE VAN DEN BERG north of TSS Terschelling-German Bight on 17 January 2014

22 July 2015

The investigation was conducted in conformity with the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Act – SUG) of 16 June 2002, amended most recently by Article 1 of 22 November 2011, BGBl. (Federal Law Gazette) I p. 2279.

According to said Law, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims (Article 9(2) SUG).

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.

The German text shall prevail in the interpretation of this investigation report.

Issued by:
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1 Summary

At about 0224 CET[1] on 17 January 2014, the Cyprus-flagged wind farm installation vessel PACIFIC ORCA collided with the German-flagged fishing vessel JURIE VAN DEN BERG north of the Terschelling-German Bight traffic separation scheme. The PACIFIC ORCA was sailing from Eemshaven in the Netherlands to the Borkum Riffgrund 1 wind farm laden with the foundations for wind turbines. She departed from Eemshaven on the prior evening. The fishing vessel was sailing back to Eemshaven after a six-day fishing voyage in the North Sea.

After crossing the Terschelling-German Bight traffic separation scheme at right angles, the PACIFIC ORCA altered her course from 350° to 048° to starboard in the direction of the wind farm about eight and a half minutes before the collision. After having completed the navigational course alteration the PACIFIC ORCA was on a collision course with the JURIE VAN DEN BERG, which was proceeding on a southerly course. The evasion manoeuvres initiated on both vessels later on did not succeed in preventing the collision. Both vessels sustained material damage. There were neither personal injuries nor environmental pollution. After the collision, both vessels could return to Eemshaven unassisted.

[1] All times shown in this report are local = Central European Time

2 FACTUAL INFORMATION

2.1 PACIFIC ORCA

2.1.1 Photo of ship

Figure 1: Photo of ship

2.1.2 Ship particulars

Name of ship:	PACIFIC ORCA
Type of ship:	Wind farm installation vessel
Nationality/Flag:	Cyprus
Port of registry:	Limassol
IMO number:	9601326
Call sign:	5BRE3
Owner:	Swire Pacific Offshore, Cyprus
Operator:	Swire Blue Ocean A/S, Denmark
Year built:	2012
Shipyard:	Samsung Heavy Industries
Classification society:	Germanischer Lloyd
Length overall:	161.30 m
Breadth overall:	49.03 m
Gross tonnage:	24,586
Draught (max.):	6.00 m
Engine rating:	4 x 3,400 kW on 4 rudder propellers
Main engine:	8 x MAN Doosan 9L27/38
(Service) Speed:	13.0 kts
Hull material:	Steel
Minimum safe manning:	14

2.1.3 Voyage particulars

Port of departure:	Eemshaven, Netherlands
Port of call:	Borkum Riffgrund 1 wind farm
Type of voyage:	Merchant shipping, international
Cargo information:	Foundations for WT[2]
Manning:	40
Other people working on board:	46
Draught at time of accident:	5.30 m
Pilot on board:	No
Number of passengers:	None

[2] Wind turbine

2.2 JURIE VAN DEN BERG

2.2.1 Photo of ship

Figure 2: Photo of ship

2.2.2 Ship particulars

Name of ship:	JURIE VAN DEN BERG
Type of ship:	Fishing vessel
Nationality/Flag:	Germany
Port of registry:	Ditzum/Ems
IMO number:	7904803
Call sign:	DCDW
Fisheries code:	NG1
Owner:	Seefischereibetrieb Gebr. v. d. Berg
Year built:	1979
Shipyard:	Hoogezand, Gorter
Classification society:	None
Length overall:	36.28 m
Breadth overall:	8.20 m
Tonnage:	269 GT (247 GRT)
Draught (max.):	4.40 m
Engine rating:	993 kW
Main engine:	Deutz SBV 8M 628
(Service) Speed:	10.2 kts
Hull material:	Steel
Minimum safe manning:	6

2.2.3 Voyage particulars

Port of departure:	Eemshaven
Port of call:	Eemshaven
Type of voyage:	Fishing National/International
Cargo information:	16 t of fish
Draught at time of accident:	4.40 m
Manning:	6
Pilot on board:	No
Number of passengers:	None

2.3 Marine casualty or incident information

Type of marine casualty/incident:	Serious marine casualty, collision
Date, time:	17/01/2014, 0224
Location:	German Bight
Latitude/Longitude:	φ 53°53.0' N λ006°23.4'E
Ship operation and voyage segment:	Open sea
Human factors:	Yes, human error Yes, violation
Consequences (for people, ship, cargo, environment, and other):	Material damage to both vessels; no personal injuries or environmental pollution

2.3.1 Nautical chart

Excerpt from Nautical Chart 1001, BSH

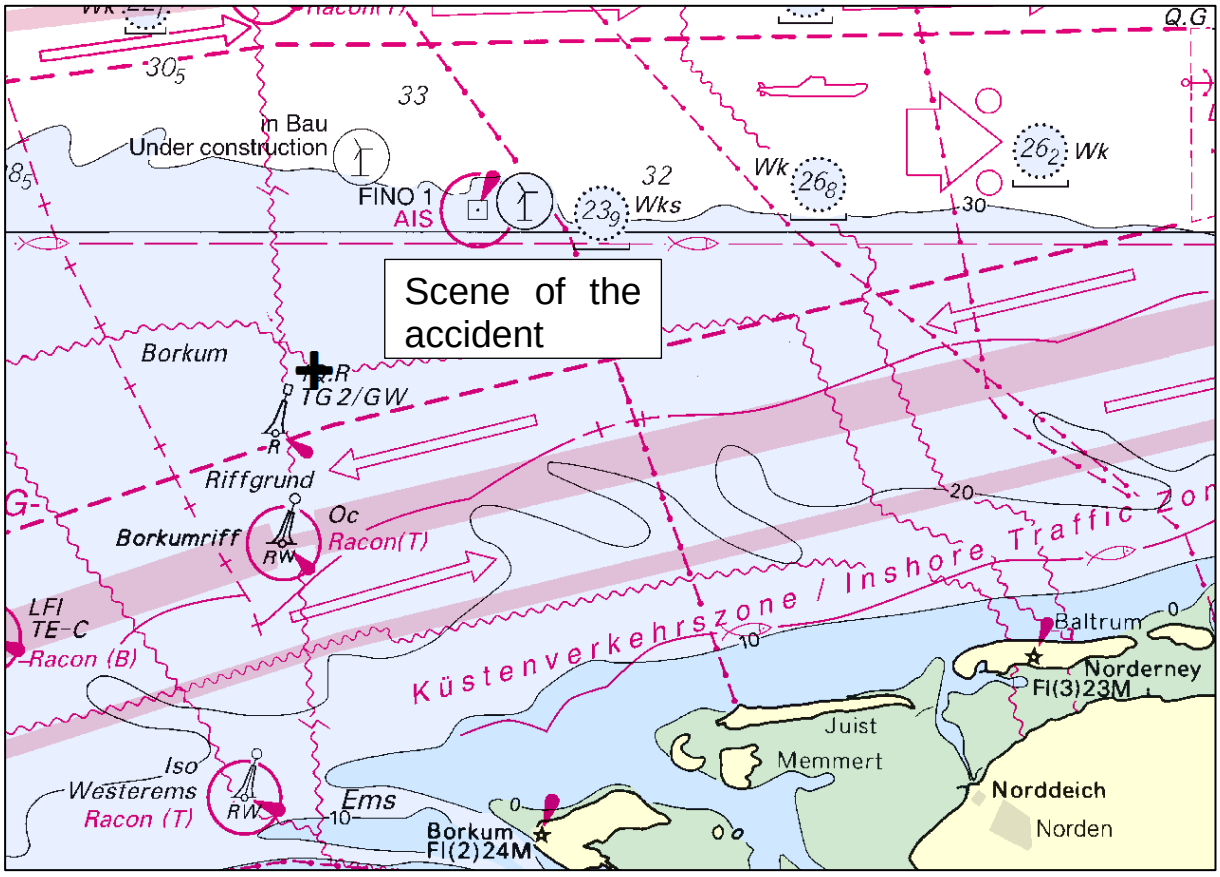

Figure 3: Nautical chart showing the scene of the accident

2.4 Shore authority involvement and emergency response

Agencies involved:	VTS Wilhelmshaven, Federal Police Sea
Resources used:	Federal Police Vessel BP 24
Actions taken:	Scene investigated
Results achieved:	Neither vessel took on water; both were able to reach Eemshaven without assistance

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

3.1.1 PACIFIC ORCA

The Cyprus-flagged wind farm installation vessel PACIFIC ORCA sailed out of Eemshaven in the Netherlands on 16 January 2014. She was laden with foundations for wind turbines. Her destination was the Borkum Riffgrund 1 wind farm. The master handed over the watch to the second officer after the pilot left the ship shortly after midnight. The master then finished some paperwork on the aft steering position, which is about 20 m away from the main steering position. Besides the second officer, a chief officer and a lookout manned the bridge.

After crossing the Terschelling-German Bight traffic separation scheme at right angles, the second officer switched to manual control of the ship's steering at 0215 and altered the course from 350° to 048°. The chief officer was carrying out work in the chartroom, which was separated from the main steering position by a blackout curtain. The heading control system was switched on again at 0217 and a desired track of 050° set. The lookout reported a vessel on the port side at 0220. At this point, the second officer was making logbook entries in the chartroom. The second officer verified the report and estimated that the distance to the other vessel was about half a mile. He then checked the radar image. No AIS data were displayed apart from a dotted AIS symbol, however. Therefore, he determined the risk of collision by means of a visual bearing at a window frame. Since the bearing did not change sufficiently, the second officer switched to manual control at 0222 and initiated a course alteration to starboard. When the lookout – at the request of the second officer – was unable to detect any course alteration by the other vessel, five short blasts of the whistle were sounded at 0223. The master then hurried forward to the port side of the bridge and identified a fishing vessel at a range of 100-150 m. The collision occurred immediately afterwards at 0224. The fishing vessel struck the port side of the fore section. The master assumed command and ordered a course alteration to port in order to part from the fishing vessel.

Immediately after the collision, the PACIFIC ORCA contacted the JURIE VAN DEN BERG using VHF radiotelephony (channel 16). The PACIFIC ORCA remained at the scene of the accident after the collision to make a detailed investigation of the damage. The return voyage to Eemshaven started at 1020 after preliminary investigations on board by the Federal Police Sea.

3.1.2 JURIE VAN DEN BERG

The German-flagged fishing vessel JURIE VAN DEN BERG sailed out of Eemshaven in the Netherlands early in the morning of 13 January 2014 for a fishing voyage in the North Sea. Fishing was discontinued on the afternoon of 16 January and the vessel prepared for the return voyage to Eemshaven.

The return voyage started at about 1830. The skipper took charge of the watch at 2345; there was no lookout deployed.

The fishing vessel proceeded on a course of 176° at about 10 kts. The skipper claimed that he initially identified the PACIFIC ORCA on the radar at a range of 10-11 nm and later visually at a range of 3 nm. Using the radar system and the electronic nautical chart, he found that the PACIFIC ORCA was sailing on a reciprocal course at approximately the same speed and that the closest point of approach stood at 0.8 nm if the vessels passed starboard to starboard. When the skipper recognised the PACIFIC ORCA's course alteration to starboard and the risk of collision, the distance to the PACIFIC ORCA was, according to his statement, 0.5 to 1 nm. A course alteration to port was initiated and an order issued to set the engine to astern. The collision was unavoidable, however. First, the fishing gear's starboard boom struck the PACIFIC ORCA. As events unfolded, the fishing vessel scraped along the entire port side of the PACIFIC ORCA. All the crew members woke up because of the collision and went to the bridge. The fishing vessel was then inspected for leakage. Water ingress was not found. The voyage to Eemshaven was continued after communicating with the PACIFIC ORCA on VHF.

Excerpt from Nautical Chart 50, BSH

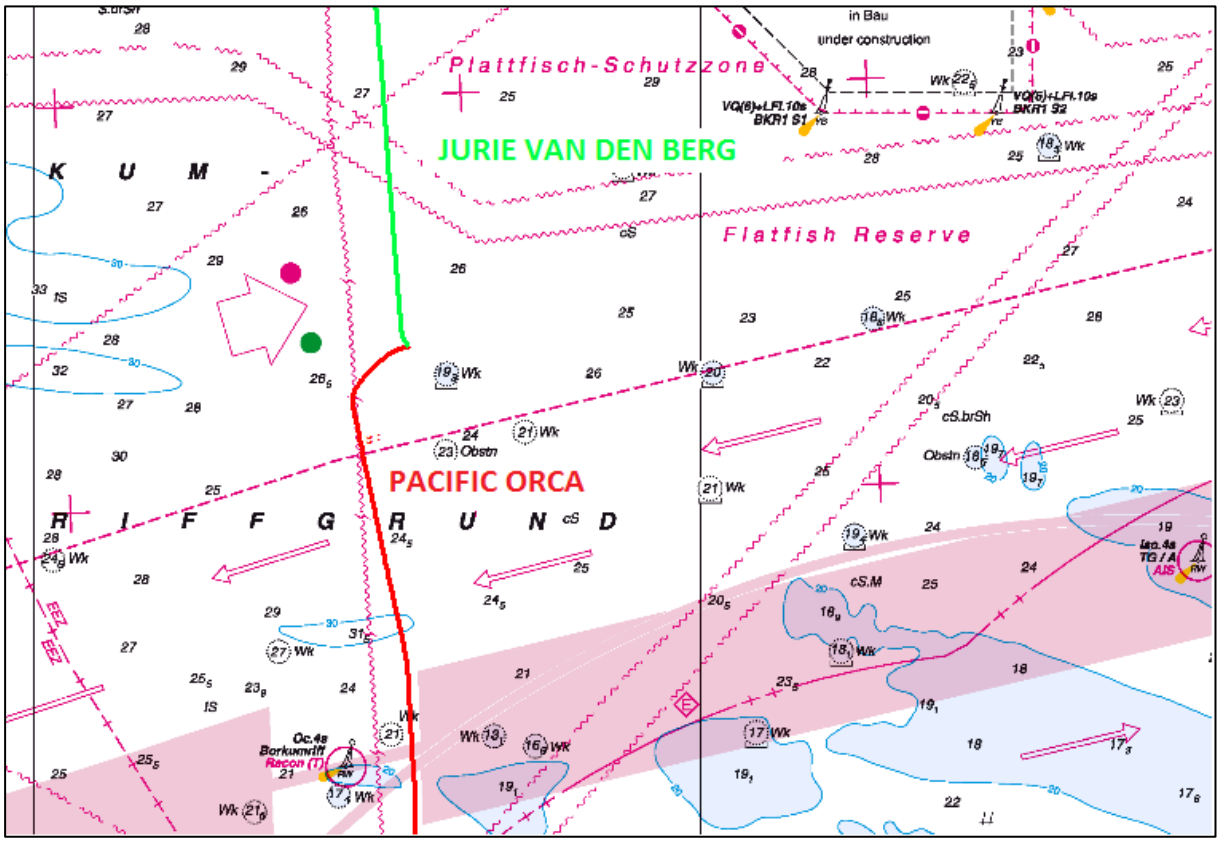

Figure 4: Track of each vessel

3.1.3 Consequences of the accident

Collision damage on board the PACIFIC ORCA was only minor. Next to a puncture in the shell plating in the forward section of the ship, only minor damage (dents, paint abrasions and deformations on a carrier platform) was found.

Figure 5: Apparent collision damage

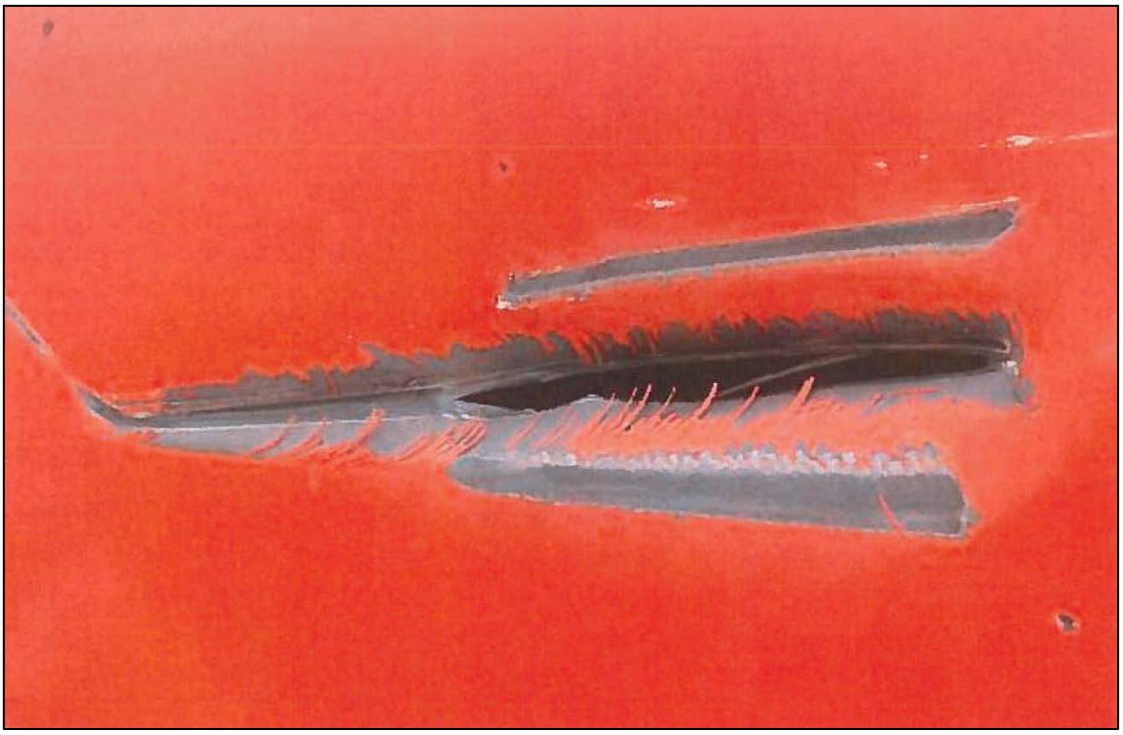

Figure 6: Punctured shell plating

The damage to the JURIE VAN DEN BERG was much greater. There was extensive damage to the entire starboard side, the fishing gear, as well as the forward and aft mast. Part of the damage was caused by the PACIFIC ORCA's deck cargo, which towered over the hull wall.

Figure 7: Damage to the starboard side and fishing gear

Figure 8: Buckled aft mast

The marine casualty did not cause any personal injuries. Since no fuel or lubricant tanks were damaged during the collision, there was no impact on the environment, either.

3.2 Investigation

The Federal Bureau of Maritime Casualty Investigation was informed about this serious marine casualty by the Federal Police immediately on the day it occurred and started the investigation. This investigation report was co-ordinated with the investigating authority of the Republic of Cyprus (Marine Accident Investigation Service).

The analysis of the PACIFIC ORCA's voyage data recorder (VDR) was of fundamental importance to reconstructing the accident. Using these data and the AIS recordings made by the locally competent vessel traffic service it was possible to reconstruct the track of the two vessels involved in the subsequent collision with absolute certainty. Further conclusions as to the collision were drawn from the analysis of recorded communication on the bridge of the PACFIC ORCA.

Furthermore, statements of the parties involved, as well as the investigation reports of the Federal Police Sea and the Dutch police were available for the investigation. Staff of the BSU surveyed the PACIFIC ORCA.

3.2.1 PACIFIC ORCA

The PACIFIC ORCA is a wind farm installation vessel that entered service in 2012. The ship was carrying valid certificates for a special purpose ship at the time of the accident. The bridge is enclosed and spans the entire breadth of the ship's forward section (49 m). Visibility forward of the bow is slightly obstructed at the main steering position, which is positioned amidships, by the foundations of the helicopter deck. The controls for the four rudder propellers (azipods), the two radar systems, the ECDIS[3], and the heading control system (autopilot) are located at the main steering position.

Figure 9: Obstructed visibility at the main steering position

[3] Electronic chart display and information system

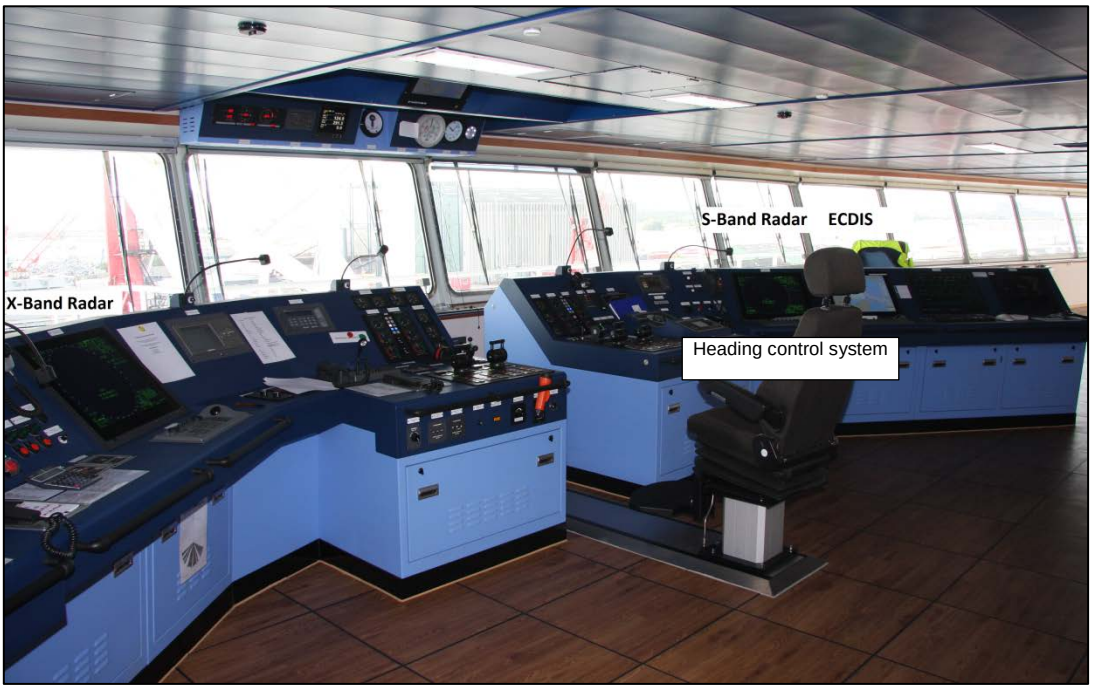

Figure 10: Main steering position

3.2.1.1 Manning

The minimum safe manning certificate stipulates a minimum crew of 14 people for the PACIFIC ORCA. 40 seamen were on board on the day of the accident. Alongside the master were an additional master, two chief officers, and two second officers in service. The Canadian master had 34 years of professional experience, including 13 years as a pilot and eight years as a master. He assumed command of the PACIFIC ORCA for the first time in October 2013. The master, a chief officer, a second officer, and a lookout were on the bridge at the time of the accident. All were British apart from the master. The chief officer had 23 years of professional experience, including seven years as a chief officer. The second officer had 12.5 years of professional experience, including 9.5 years as a watchkeeping officer. The lookout had 2.5 years of professional experience, including 15 months on the PACIFIC ORCA. He met the requirement needed to be issued a certificate of competency for forming part of the navigational watch. It was not possible to demonstrate one had been issued, however.

After the accident, an internal breathalyser test was conducted on everyone involved using an Alcoscan AL7000 testing device. According to the ship's command, all the results were negative.

3.2.1.2 Performance of the navigational watch

A two-watch system is in place for the navigational watch on the PACIFIC ORCA. The watches are divided into 12-hour periods with the change of watch taking place at 0600 and 1800.

According to the masters standing orders, one chief officer, one second officer, and three deckhands are assigned to each watch. Both officers must be present on the bridge at all times. Generally, only one officer is responsible for the ship's conning,

whereas the other officer carries out other work. One of the three deckhands must be present on the bridge and they usually relieve each other every two hours. The owner provided excerpts of the manual defined by the ISM Code[4] that were relevant to the accident and the master's standing orders. Although the ship is equipped with two ECDISs on standby, paper charts were primarily used for navigation.

3.2.1.3 Analysis of the voyage data recorder

The ship was equipped with a type SVDR 3000 voyage data recorder manufactured by Samsung. The data were backed up by the crew after the accident and given to the BSU by the owner. The manufacturer provided the playback software.

The voyage data recorder recorded the radar images of the X-band radar (located on the port side of the steering position). The following settings were used for this radar (type FAR 2817 manufactured by Furuno): centred north-up display, 6 nm range, no range markers, relative motion; tuning: automatic; anticlutter sea[5]: manual 42%; anticlutter rain: 14%.

At 0142, the AIS symbol of an oncoming vessel was selected on the radar in order to display the AIS data. After that, no further operation of the radar system was visible until 0233.

The other vessel involved in the subsequent collision, the JURIE VAN DEN BERG, first became visible on the radar (see Figure 11) as a radar echo and AIS symbol in the form of a dotted triangle at 020500. Section 3.2.1.5 addresses this particular rendering of an AIS symbol in detail. The range was 6 nm and the relative bearing 010° to starboard. Furthermore, the planned track of the PACIFIC ORCA is shown on the radar image.

As things progressed, the JURIE VAN DEN BERG was visible on the radar images clearly and continuously as a radar echo and AIS symbol. When the PACIFIC ORCA started her navigational course alteration at 021530 (Figure 12), the distance to the JURIE VAN DEN BERG was 2.4 nm and the relative bearing 024° to starboard. By only 021615 (Figure 13), the JURIE VAN DEN BERG was almost right ahead at a range of 2.2 nm. The course alteration was completed at 021800 (Figure 14). The distance to the JURIE VAN DEN BERG was now 1.6 nm with a relative bearing of 037° to port.

The display range of the radar system was not reduced subsequently. Consequently, later radar images do not deliver any findings as to the further events surrounding the accident. The rendering of the JURIE VAN DEN BERG was distorted and merged with the PACIFIC ORCA's own echo.

[4] ISM Code: International Safety Management Code
[5] Anticlutter: alleviation of clutter caused by swell, precipitation, cloud formation, etc.

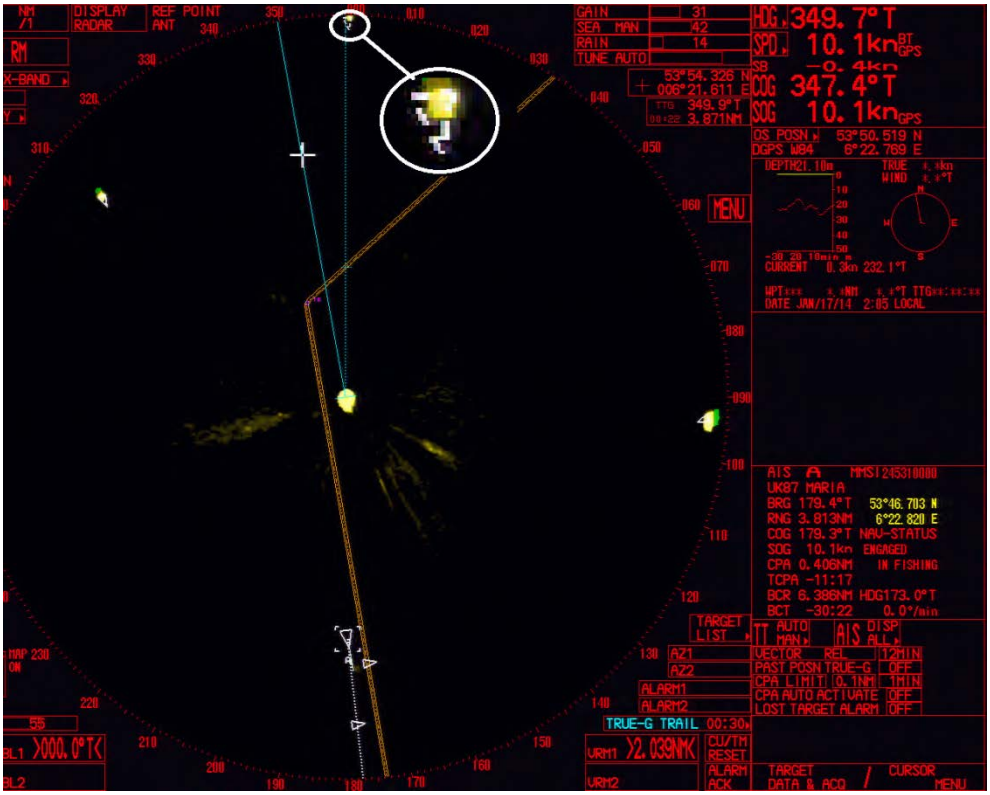

Figure 11: Radar image at 0205 (AIS target magnified)

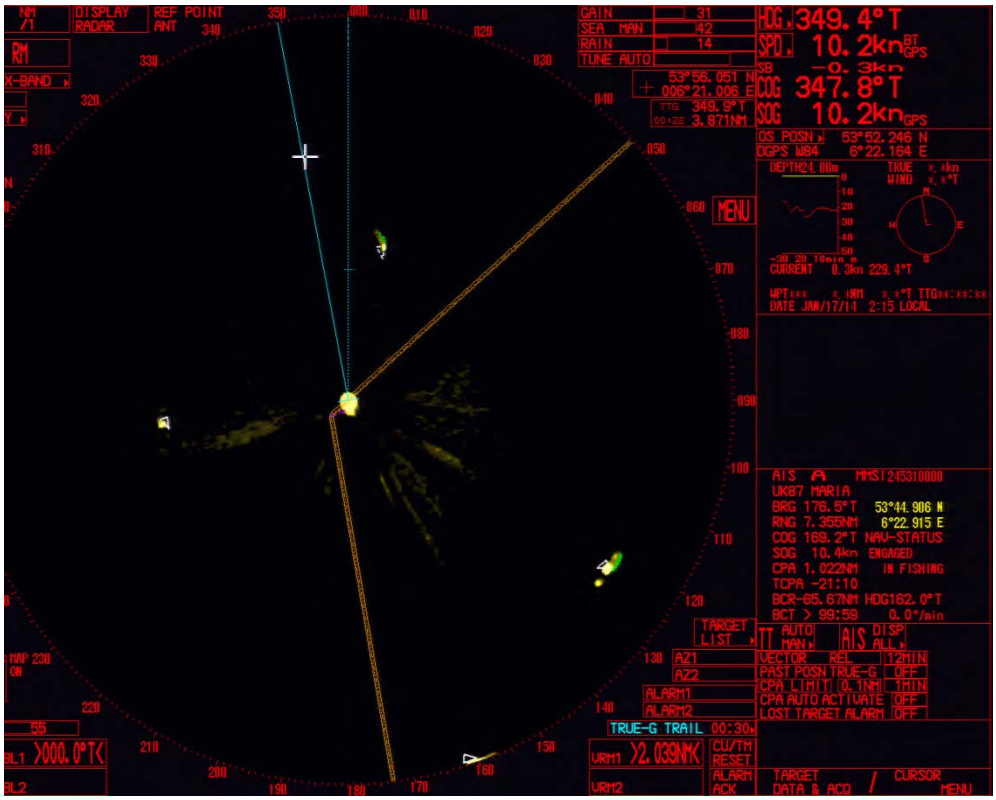

Figure 12: Radar image at 021530

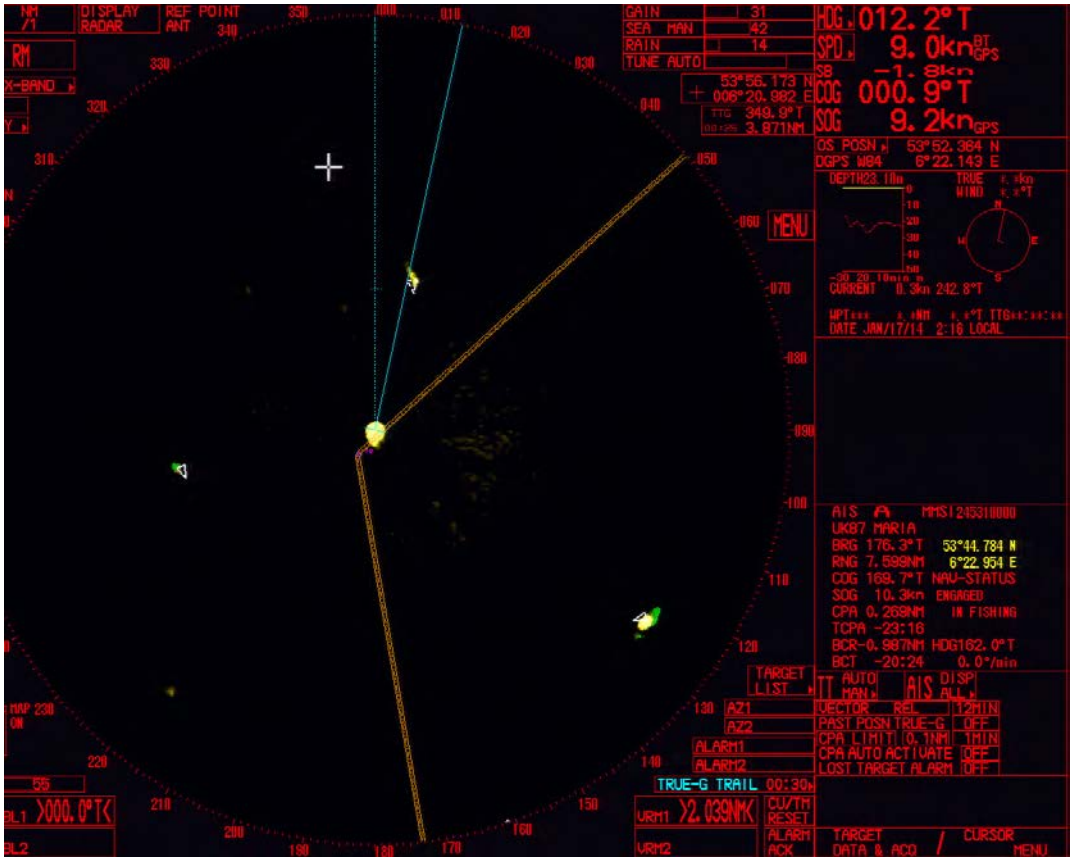

Figure 13: Radar image at 021615

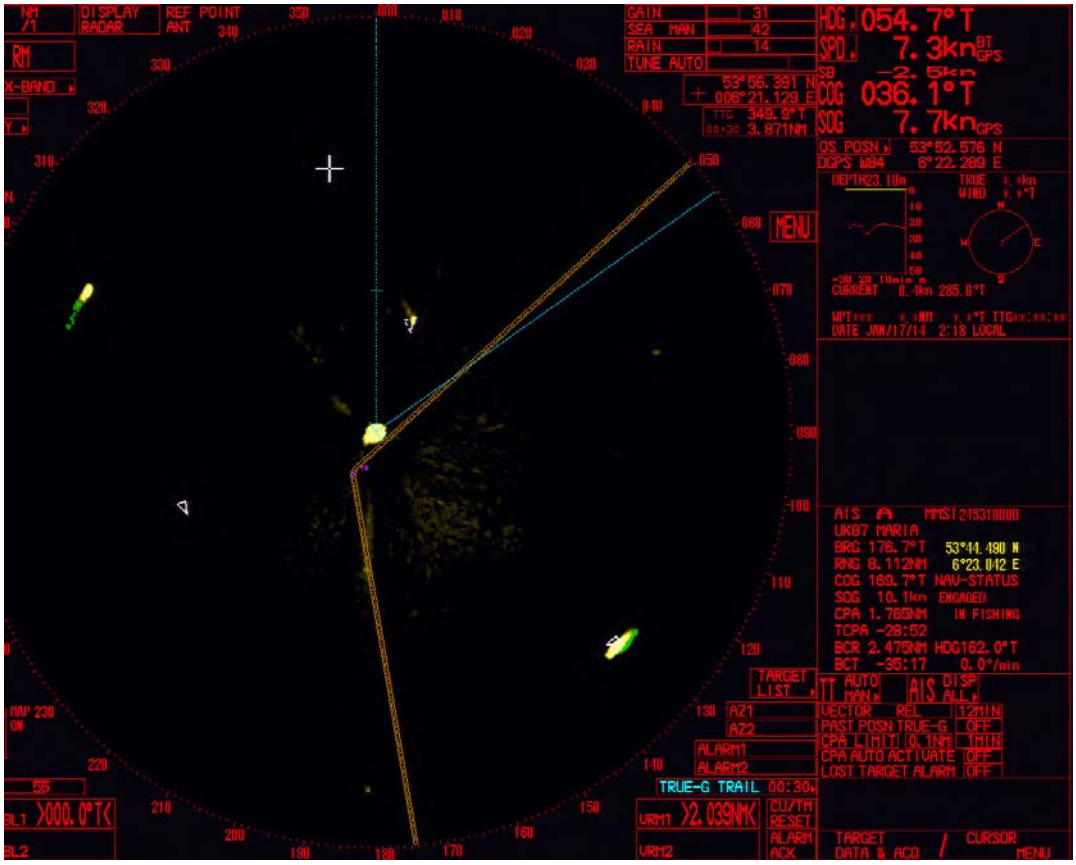

Figure 14: Radar image at 021800

The voyage data recorder recorded both the internal communication on the bridge and the VHF radio traffic continuously. While the quality of the recordings of the bridge microphones was only moderate, the recording of the VHF radio traffic transmitted and received is largely clear and easy to understand.

To begin with, the analysis of the internal communication is indicative of the normal course of a watch. There was a lively exchange between the officer on watch and lookout, which is how the navigational course alteration before the collision was also explained. Step noises are often heard, indicating that the people involved regularly changed their position on the bridge. As far as clearly audible, the communication relevant to the course of events leading up to and during the accident is shown below.

Time (approx.)	Audible activity relevant to events leading up to and during the accident
022003-022014	The lookout calls the second officer and informs him that a vessel is on the port side.
022120	The second officer tells the lookout that he is moving to starboard.
022230-022237	The second officer asks what type of vessel it is. The lookout replies that it is a fishing vessel in very close proximity.
022247-022305	The second officer asks twice whether the fishing vessel is altering her course. The lookout says no.
022306	Five short blasts of the whistle are sounded.
022319	The chief officer arrives and asks what is going on. The second officer responds.
022328	The master arrives and asks what has happened. The lookout refers to the fishing vessel.
022333	The chief officer orders 'hard to starboard'. This is confirmed by the second officer.
022357	Collision noises.
022405	The master orders 'hard to port'.

The analysis of the audio recording after the collision demonstrates – given the circumstances – appropriately calm and well-organised crisis management by the ship's command. At 022643, the PACIFIC ORCA called the JURIE VAN DEN BERG on VHF channel 16. Communication proved difficult because some questions were not answered, the answers were inaudible and often suddenly interrupted.

3.2.1.4 Installation of the radar systems

An exceptionally high number of false echoes and shadow sectors were noticed during the analysis of the radar images. These are caused by the PACIFIC ORCA's six legs. The performance standards[6] for radar equipment states the following in respect of installation of the radar antenna:

[6] MSC.192(79) of 6 December 2004

7.5.1 Antenna

Blind sectors should be kept to a minimum, and should not be placed in an arc of the horizon from the right ahead direction to 22.5° abaft the beam and especially should avoid the right ahead direction (relative bearing 000°). The installation of the antenna should be in such a manner that the performance of the radar system is not substantially degraded. The antenna should be mounted clear of any structure that may cause signal reflections, including other antenna and deck structure or cargo. In addition, the height of the antenna should take account of target detection performance relating to range of first detection and target visibility in sea clutter.

Figure 15 is indicative of the false echoes of an entire wind farm due to reflections. At the same time, two vessels (AIS targets to the left of the image) are in a shadow sector, meaning a radar echo is not displayed for them.

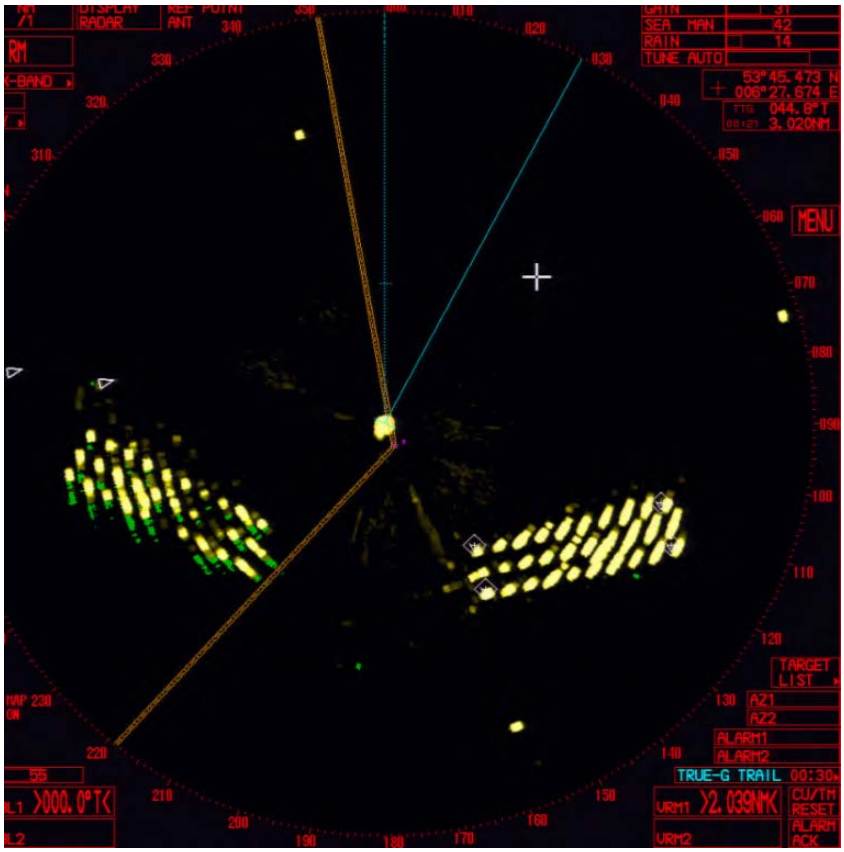

Figure 15: Radar image with reflections

Figure 16 shows the photo of a drawing of the shadow sectors of the X-band radar system. The display is attached below the radar system (see Figure 10).

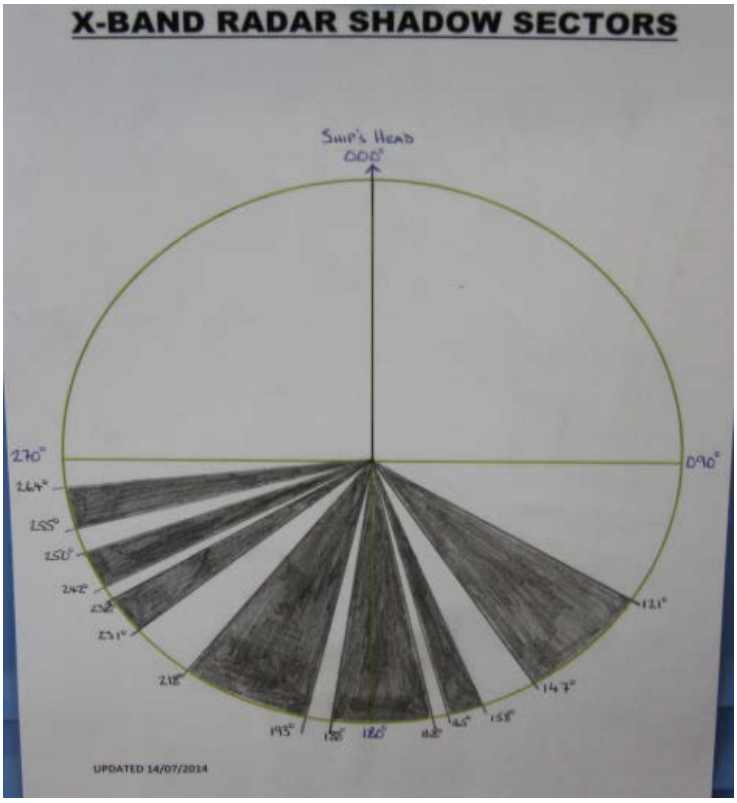

Figure 16: Shadow sectors

3.2.1.5 Rendering of the AIS symbol of the JURIE VAN DEN BERG

The AIS symbol of the JURIE VAN DEN BERG was rendered on the radar screen as a triangle with a broken line.

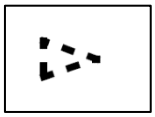

Figure 17: AIS symbol

The second officer was not aware of the exact meaning and found it unusable. This symbol is not included in the IMO's guidelines for the presentation of navigation-related symbols, terms and abbreviations[7]. Similarly, this display mode is not mentioned in the IMO's guidelines[8] for using an AIS.

A request to the manufacturer of the radar equipment revealed that this symbol was not included in the operating instructions, either, as shown in the following excerpt.

[7] SN/Circ.243 of 15 December 2004
[8] Resolution A.917(22): Guidelines for the Onboard Operational Use of Shipborne Automatic Identification Systems (AIS)

When the AIS is turned on, AIS targets are marked with appropriate AIS symbol as below.

SYMBOL	STATUS	REMARKS
	Activated target	All AIS symbols shown with thick line. Color is selectable from menu.
	ROT higher than preset ROT	Displayed for turning ship.
	Dangerous target	Displayed when CPA/TCPA is within CPA/TCPA LIMIT. Red in color. Flashing until acknowledged.
	Lost target	"X" overlaid on a lost target. Red in color. Erased after acknowledged.
	Target selected for data display	Broken square is overlaid on target selected to display its data. A, B or C shown to indicate data box location (at the right side of the screen).

Figure 18: Excerpt of the radar equipment operating instructions

The symbol and its meaning are only included in a standard[9] of the International Electrotechnical Commission (IEC). Users of radar equipment are not normally familiar with this standard. This symbol should be used for AIS targets for which collision avoidance computation (CPA/TCPA)[10] is not possible.

3.2.2 JURIE VAN DEN BERG

The fishing vessel JURIE VAN DEN BERG was built as a side trawler in 1979 and initially operated under the Dutch flag. She has flown the German flag since 1988. She held a valid International Fishing Vessel Safety Certificate at the time of the accident, which was issued by the Ship Safety Division (BG Verkehr). The vessel's equipment included two X-band radar systems, a heading control system, and two electronic chart systems (ECS). Also present was a Protec-W Inland Waterways AIS made by L-3 Aviation Recorders, which was connected with an ECS.

Proper functioning of the AIS was confirmed during the annual survey[11] of the AIS by the classification society Germanischer Lloyd on 2 September 2013.

[9] IEC 62288 – Maritime navigation and radiocommunication equipment and systems – Presentation of navigation-related information on shipborne navigational displays
[10] CPA: Closest point of approach. TCPA: Time to CPA
[11] In accordance with SOLAS Chapter V Regulation 18

However, the analysis of the AIS data on the day of the accident showed that the dynamic data were not complete: the speed over ground (SOG) and the course over ground (COG) were not transmitted. This occurs when the connected external GPS receiver is improperly configured. Only data for the position (not for the SOG and COG) are sent to the AIS. Basically, the same sensor data as that used on the vessel for navigation should be transmitted by the AIS. It is for that reason that the technical specifications[12] for the AIS provide that the data of the external GPS receiver is primarily used for the transmissions. This means that – as in the present case – the SOG and COG data are not transmitted even when they are available through the internal GPS.

Obstructed visibility forward of the bridge caused by the fishing gear.

Figure 19: Obstructed visibility

3.2.2.1 Manning

The crew of the JURIE VAN DEN BERG consisted of six people and thus corresponded to the minimum safe manning certificate, which next to the skipper stipulated a chief officer, a chief engineer officer, and three deckhands. Besides the skipper, three other crew members actually held a navigating certificate. The skipper and the three people who held a navigating certificate carried out the navigational watch alternately. The skipper was alone on the bridge at the time of the accident. A detailed plan of the work and rest periods of crew members was not submitted to the investigators in spite of several requests.

3.2.3 Analysis of the AIS

The Waterways and Shipping Directorate recorded and made available to the BSU the AIS transmissions of the two vessels. In conjunction with the PACIFIC ORCA's VDR data, it is possible to trace the track, distances, and course alterations of each vessel.

[12] IEC 61993-2, ITU-R M.1371-4

The track of the PACIFIC ORCA is shown in red and that of the JURIE VAN DEN BERG in green in the below figure. The location of the GPS antenna of each vessel is shown.

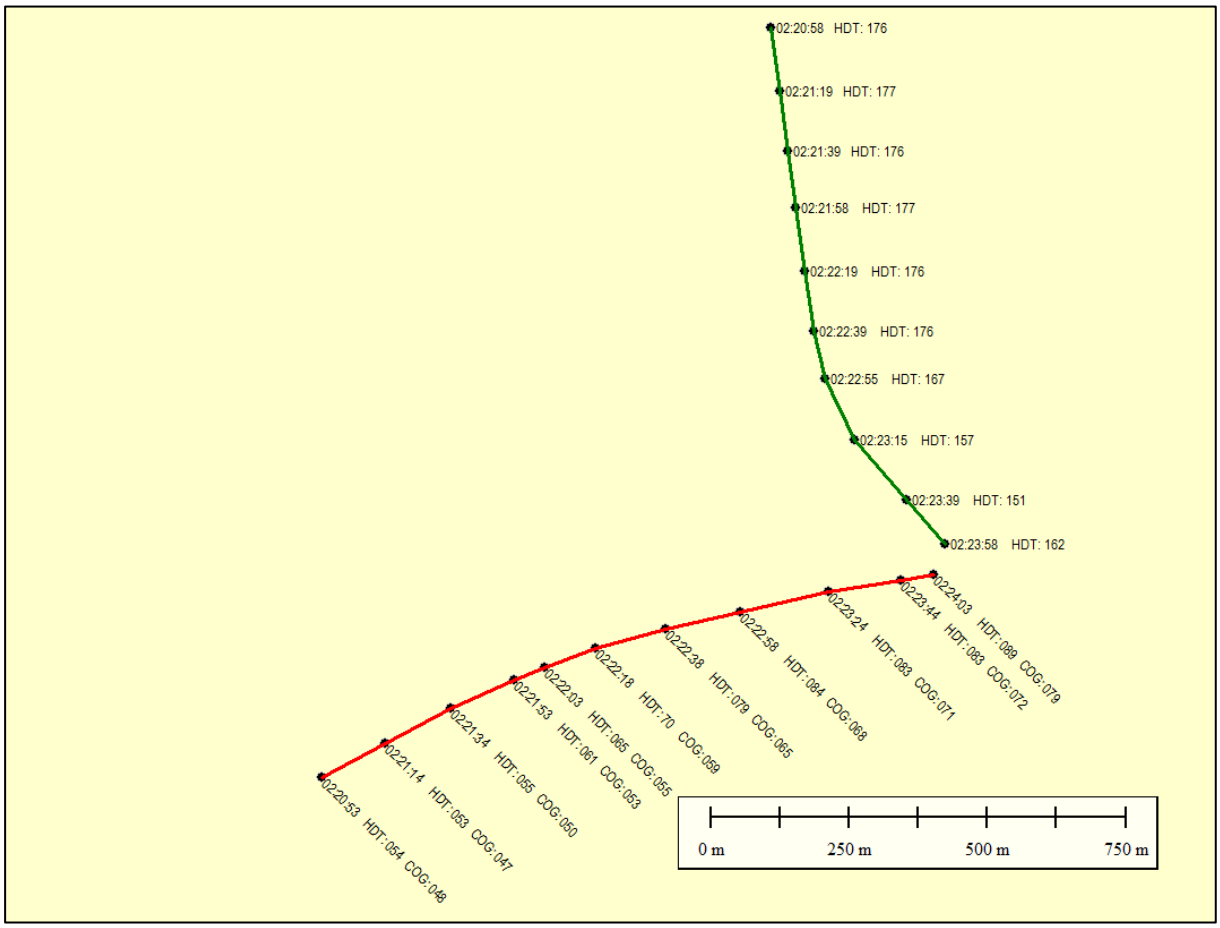

Figure 20: AIS display

The range stood at 1.0 nm when the lookout on the PACIFIC ORCA identified the JURIE VAN DEN BERG at 022003. The distance between the vessels decreased to 0.62 nm up until 022126 on a steady bearing. An alteration of course to starboard from 054° to 084° (TH) was then carried out on the PACIFIC ORCA. This course alteration was completed about one minute before the collision. The PACIFIC ORCA only began to turn to starboard again immediately before the collision.

The JURIE VAN DEN BERG initiated an alteration of course to port at between 022239 and 022255. The distance between the vessels at 022255 stood at about 330 m. The course changed from 176° to 151° (TH) at 022339 and then the course changed to starboard to up to 162° (TH). Due to the collision, the JURIE VAN DEN BERG was turned back to port.

3.2.4 Weather and visibility

The Federal Bureau of Maritime Casualty Investigation requested an official report on the weather and, in particular, visibility in the area of the accident from the Maritime Consulting department of Germany's National Meteorological Service. The weather situation is set out as follows in the report (editorially abridged):

A vast low pressure complex with multiple centres between Iceland and Scotland marked the weather on 17 January 2014. A southerly force 4-5 Bft wind prevailed at the time of the accident. There were scattered clouds and no precipitation. Visibility in the area is specified at 5-10 km. There was no fog.

The information in the weather report largely agrees with the observations made on the two vessels.

3.2.5 Navigation lights and other lighting

At the time of the accident, the PACIFIC ORCA bore the lights of a power-driven vessel underway, consisting of two masthead lights, sidelights, and a sternlight. Due to the specific design of the ship, the minimum horizontal distance of the two masthead lights of half a ship length is not met. Masking occurs within the emission range of the forward masthead light, mainly in the area abaft the beam. In addition, extensive deck lighting was turned on.

The JURIE VAN DEN BERG also bore the lights of a power-driven vessel consisting of a masthead light, sidelights, and a sternlight. Depending on their position, the fishing gear booms may mask the sidelights. The sidelights were not masked at the time of the accident, since the booms were in an upright position.

4 ANALYSIS

4.1 General physiological conditions

The accident occurred at 0224 in the morning. Due to the so-called circadian rhythm (physiological clock), practically all the functions of a person change systematically in the course of a day and night. Circadian rhythms influence the sleeping and waking state, the body temperature and hormonal changes, thus also the performance of a person. Performance reaches its absolute low at about three in the morning.

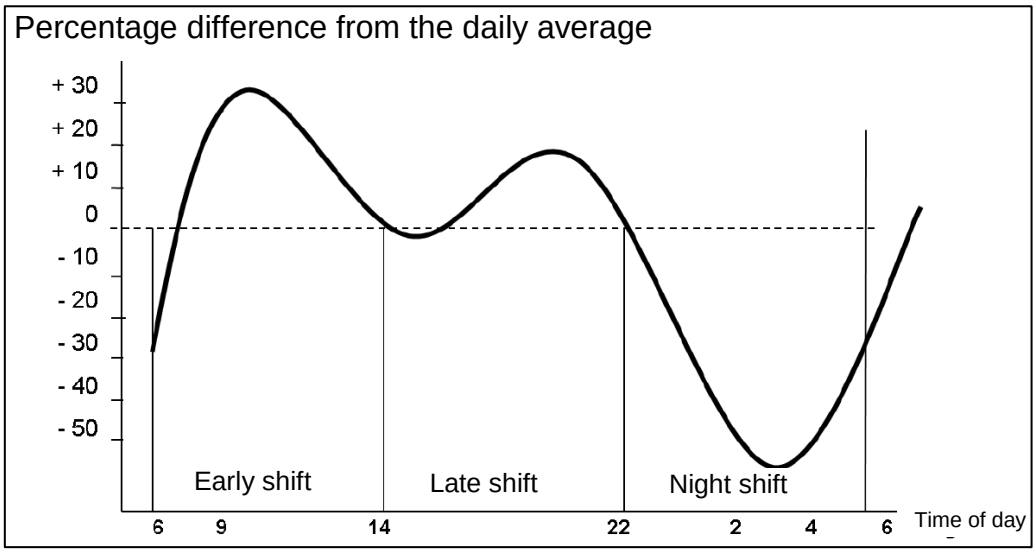

Figure 21: Performance curve of a person[13]

The impairment of the performance of a person causes a slowing of physical and mental reflexes and/or the ability to judge. With regard to error frequency, fluctuations can be identified according to the time of day. Accordingly, error frequency does not depend only on the motivation of a person. Figure 22 shows how error frequency increases at night, in particular.

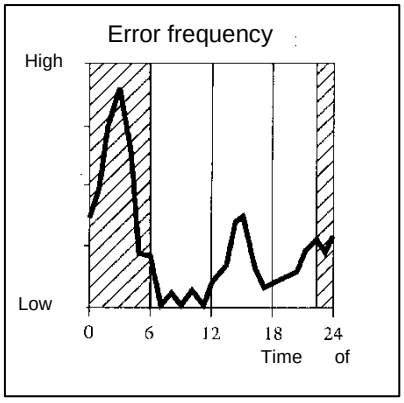

Figure 22: Error frequency at different times of the day[14]

[13] Source: Graf, O., Physiologische Leistungsbereitschaft und nervöse Belastung (physiological motivation and nervous stress), Dortmund, 1954

[14] Source: Zulley J, Knab B: Wach und fit (awake and fit), 2009

The circadian rhythm is controlled by daylight and cannot be influenced by a person. In particular, habituation cannot increase performance at night.

4.2 Hours of work and rest

With regard to hours of work and rest, the PACIFIC ORCA is subject to the provisions of the STCW Code[15] of 1995 and the Maritime Labour Convention of 2006.

The Maritime Labour Convention states that the normal working hours' standard for seafarers, like that for other workers, shall be based on an eight-hour day with one day of rest per week and rest on public holidays. In determining the hours of work, consideration should be given to the danger posed by the fatigue of seafarers, especially those whose duties involve navigational safety and the safe and secure operation of the ship.

The limits on hours of work or rest shall be as follows:

(a) maximum hours of work shall not exceed:

(i) 14 hours in any 24-hour period; and

(ii) 72 hours in any seven-day period;

or

(b) minimum hours of rest shall not be less than:

(i) 10 hours in any 24-hour period; and

(ii) 77 hours in any seven-day period.

Hours of rest may be divided into no more than two periods, one of which shall be at least six hours in length, and the interval between consecutive periods of rest shall not exceed 14 hours.

In contrast to the Maritime Labour Convention, the STCW Code only contains identical provisions on the minimum hours of rest.

Hours of work and rest were adhered to on the PACIFIC ORCA. The relatively short period of service of only one month on board and the uninterrupted rest p

eriods of 12 hours are certainly suitable for preventing long-term signs of fatigue. The long continuous watchkeeping periods of 12 hours, especially for the duration of an entire night, should be viewed critically, however. At the time of the accident, the officers on watch had already been engaged in watchkeeping for more than eight hours without a break. In contrast to the Seearbeitsgesetz (Germany's law on maritime labour), the international regulations do not contain provisions for hours of rest during the maximum hours of work each day.

The schedule of service was displayed on the bridge in accordance with the provisions. However, for sea operation it provided for a traditional three-watch system with one chief officer and two officers on watch.

[15] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

By way of derogation, a two-watch system with two chief officers and two officers on watch was actually organised for sea operation.

Neither the STCW Code nor the Maritime Labour Convention applies to fishing vessels. Flying the flag of Germany, the JURIE VAN DEN BERG is therefore subject to Germany's law on maritime labour. Maximum hours of work and minimum hours of rest are consistent with the provisions of the aforementioned Maritime Labour Convention. On fishing vessels, the minimum hours of rest may be reduced with the approval of the Ship Safety Division (BG Verkehr). No exemption was granted for the JURIE VAN DEN BERG.

Timesheets were only submitted for the JURIE VAN DEN BERG with the opinion on this report in spite of several requests. According to the timesheets, the skipper only had five rest periods, each with hone hour, during a time period of 24 hours in the two days before the accident. The skipper had a rest period of thirteen and a half hour, divided into four sections between one hour and four and a half hour in the 24 hours before the accident. The skipper stated that he slept twice for two hours and once for four hours during these rest periods. In the 48 hours before the accident, the rest periods of the skipper fell below the minimum rest period. Moreover, the rest periods were divided into several short periods. A minimum period of 6 consecutive hours was reached lately 42 hours before the accident occurred.

A Fishing Labour Certificate had not been issued for the JURIE VAN DEN BERG, meaning she was not entitled to undertake this fishing voyage. An inspection of the hours of work and rest by the flag State, as provided for by Germany's law on maritime labour, was not made.

4.3 Manning and organisation on the bridge

At the time of the accident, the second officer was responsible for navigation on the PACIFIC ORCA. Besides the second officer, a lookout was on the bridge. Therefore, the bridge was sufficiently manned according to the requirements of the STCW Code. The chief officer was occupied with other tasks in the chartroom, which was separated from the bridge by curtains (marked red in Figure 23), and the master was at a computer workstation (marked in green in Figure 23) at the bridge's aft steering position.

The obligation to man the bridge with two officers at all times during sea operation did not comply with the ISM Manual but exclusively with the masters standing orders. However, co-operation and distribution of tasks among officers during watchkeeping are not defined in the standing orders. This means that there are no provisions for the circumstances under which the ship's command (dual watch) must be exercised with the involvement of others or when it can be done alone. The master justified this instruction with the high administrative effort during the short voyages. It is reportedly usual practice that the conning is only effected by one officer whereas the other officer is preoccupied with administrative work. The two officers relieve each other of the ship's conning at otherwise undefined intervals.

The second officer dispensed with the support of the chief officer when he recognised the risk of collision, even though the chief officer was in the immediate vicinity. Moreover, the second officer's position at the helm was not ideal for monitoring the success of the evasion manoeuvre because of the obstructed visibility and constraints vis-à-vis taking a bearing.

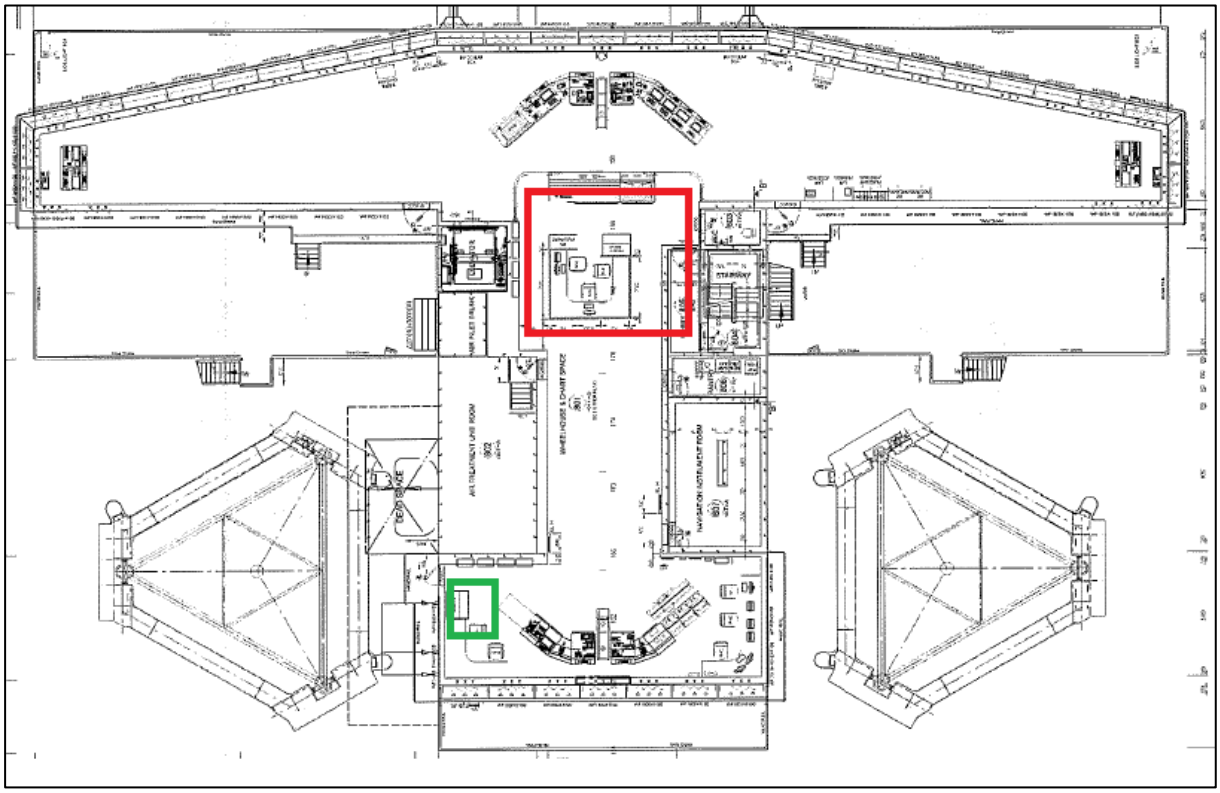

Figure 23: Plan of the PACIFIC ORCA's bridge

According to the requirements of both the standing orders and the STCW Code, the second officer should have informed the master. The chief officer and the master were only made aware of the situation by the sounding of the whistle signal, however.

The skipper of the JURIE VAN DEN BERG was alone on the bridge. A lookout was not posted, even though this was required according to the Schiffssicherheitsverordnung (Germany's ordinance for the safety of seagoing ships). *(Article 13(3) – Rules of Conduct – The officer in charge of the navigational watch on a ship flying the flag of Germany is [...] 2. responsible for manning the lookout with a suitable person in pilotage waters and in the period from sunset to sunrise).*

4.4 Traffic regulations

The accident occurred in the German Exclusive Economic Zone (EEZ) seaward of the scope of the German Traffic Regulations for Navigable Waterways, meaning only the International Regulations for Preventing Collisions at Sea, 1972, referred to hereinafter as COLREGs, applied.

The two vessels first approached on reciprocal or almost reciprocal courses. Regulation 14 – Head-on situation – of the COLREGs does not apply, however, because there was no risk of collision. The closest point of approach of 0.8 nm calculated can be regarded as safe. Moreover, the relative bearing at the beginning of the PACIFIC ORCA's course alteration was already 024° to the starboard side.

The PACIFIC ORCA brought about a risk of collision due to the navigational course alteration. The COLREGs contain no specific rules for the conditions under which a risk of collision may be brought about. A 'long range' of 8 nm (Long Range Rule) was discussed at the London Conference on the COLREGs. However, this was not laid down due to the multitude of possible situations.[16] Due to this regulatory gap, Rule 2(a) COLREGs is applicable.

Rule 2 – Responsibility –
(a) Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Having regard to the following circumstances:

- distance between the vessels at the start of the course alteration 2.4 nm, after completion of the course alteration 1.6 nm;
- time until the closest point of approach or collision at the start of the course alteration about 6.5 minutes, after completion of the course alteration about 5 minutes;
- open sea room, no restriction caused by shallows, navigation marks or the like, and
- no restriction caused by other traffic,

bringing about a risk of collision contradicts good seamanship.

The owners of the PACIFIC ORCA arranged for the preparation of an expert opinion on the facts of this case. The opinion concludes that no relationship within the meaning of the COLREGs existed between the two vessels at the beginning of the course alteration, and therefore, the course alteration reportedly does not merit any criticism.
Referring to the comments of BSH Nautical Chart 2910 (Mariner's Routeing Guide German Bight), the opinion states that in this area of high traffic density a large number of vessels cross the Terschelling-German Bight traffic separation scheme and, similar to the PACIFIC ORCA, many vessels alter their course in the direction of the wind farm after crossing. The investigators believe that due consideration should also be given to the actual traffic situation, however. Traffic density was low at the time of the course alteration. The manoeuvres of neither vessel were restricted by other vessels. Nautical Chart 2910 (see excerpt in Figure 24) gives no indication that a large number of vessels sail in an easterly direction towards the wind farms after crossing the traffic separation scheme. As the track (marked in red in Figure 24)

[16] Source: Weber, Hanno, Seeverkehrsrecht in Handbuch Nautik (maritime traffic legislation in navigation manual), 2010

shows, the PACIFIC ORCA's clear tendency after passing the BORKUMRIFF buoy was westward, meaning a course alteration eastward after crossing the traffic separation scheme seemed rather unlikely.

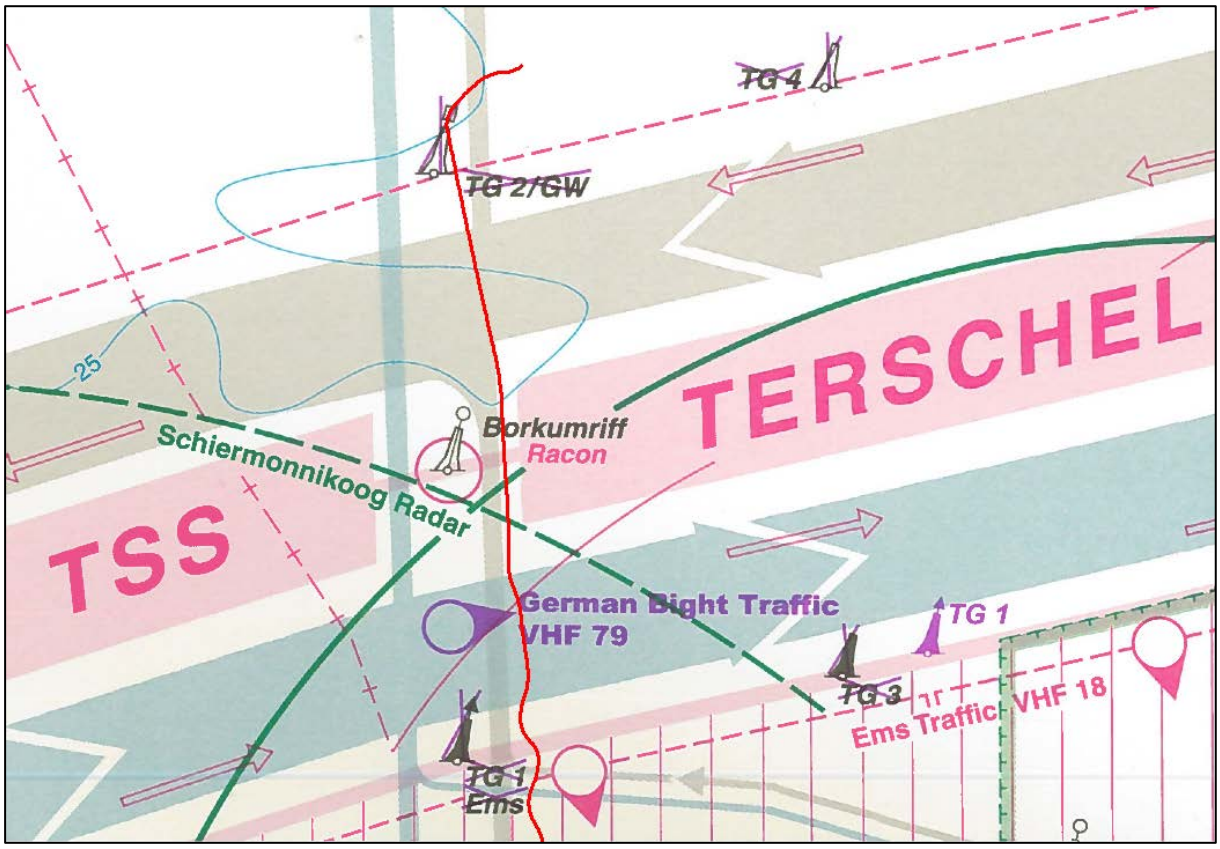

Figure 24: Excerpt from Nautical Chart 2910 (BSH)

The opinion goes on to state that the two vessels were proceeding at moderate speed. Due to the course alteration, the PACIFIC ORCA's speed dropped by about 3 kts. Due to the course alteration, the two vessels no longer approached each other on a direct reciprocal course. Accordingly, the speed at which the two vessels approached each other dropped further. This extended the time the fishing vessel had to recognise the risk of collision and initiate an evasion manoeuvre. However, the investigators believe it is important to consider that the risk of collision could only be determined reliably after the course alteration was completed. At this point, the distance between the two vessels had reduced to 1.6 nm and the time until the collision to 5 minutes.

Moreover, the extreme loss of speed was caused by the course alteration carried out with an extraordinary high rate of turn. After having altered the course the PACIFIC ORCA did not maintain her speed, but instead increased her speed rapidly again.

As a main argument, the opinion states that the two vessels are extremely manoeuvrable. A turning circle of less than one cable is specified for the JURIE VAN DEN BERG. A transfer of 0.15-0.45 nm and an advance of 0.51-0.65 nm are given for the PACIFIC ORCA's turning circle. The fishing vessel's crash stopping distance was also considered low. This argument does not convince the investigators, either.

During daytime it would have been difficult to assess the manoeuvrability of the other vessel. However, during the night, as in the present case, it is simply impossible. Rather than manoeuvrability, one could have relied on the range of the navigation lights instead. The range of a masthead light is 6 nm on the PACIFIC ORCA and 5 nm on the JURIE VAN DEN BERG.

In the prevailing visibility, the two vessels were in sight of each other before the course alteration.

The uncertainties in the COLREGs can give rise to different interpretations of the same. However, it must be noted that in the present case not all the facts had been considered before the course alteration on the PACIFIC ORCA. Rather, the JURIE VAN DEN BERG went unnoticed before the course alteration although she was easy to identify especially by means of radar and AIS.

Rules 5 and 7 COLREGs were not sufficiently observed by either vessel.

Rule 5 – Lookout –
Every vessel must use sight, sound and any other available means appropriate for the given circumstances and conditions to maintain a proper lookout at all times. This must provide a detailed overview of the situation and potential risk of collision.

Rule 7 – Risk of collision –
(a) Every vessel must use all available means appropriate to the prevailing circumstances and conditions to determine whether the potential risk of a collision exists. If there is any doubt such risk shall be deemed to exist.
(b) Proper use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision [...]

On the PACIFIC ORCA, the JURIE VAN DEN BERG was neither identified using radar nor with the help of the AIS, even though she was clearly visible on the radar as radar echo and AIS target as early as 15 minutes before the course alteration. The JURIE VAN DEN BERG was first identified only visually at a range of 1 nm. According to the lookout, the visual identification of the JURIE VAN DEN BERG was hampered by a large number of lights in the background (other vessels, platforms, wind farms under construction, etc.). This fact and the inadequate installation of the radar antennas should have led to more intense monitoring of the radar. Moreover, the use of both radars at a range of 6 nm must be viewed critically. The fishing vessel would have been visible earlier had the range been greater.

On the JURIE VAN DEN BERG, the PACIFIC ORCA was first seen on the radar and later also visually. However, the investigators assume that the PACIFIC ORCA's course alteration was not observed. This is because the statements given by the skipper cannot be reconciled with the VDR/AIS data and it is otherwise impossible to explain the other actions. The skipper claimed that he saw both top lights of the PACIFIC ORCA in one line and both of her side lights at the same time, when she altered her course. This time, about 7.5 minutes before the collision, is depicted in figure 13. At that time the distance between the vessels stood at 2.2 nm. However, a course alteration of the JURIE VAN DEN BERG is only identifiable approx. one

minute before the collision. Even though the calculated passing distance to the PACIFIC ORCA can be considered safe, observation of her should have been continued until it was clear that she was finally passed. Since the PACIFIC ORCA's navigational course alteration was executed at a high rate of turn, she could have been identified on the JURIE VAN DEN BERG both visually and on the radar/AIS at an early stage.

4.5 Evasion manoeuvre

The range was 1.0 nm when the JURIE VAN DEN BERG was identified on the PACIFIC ORCA. After determining the steady bearing and the associated risk of collision, the distance between the vessels had dropped to 0.62 nm. The second officer estimated the distance to be 0.5 nm or less. An alteration of course to starboard from 054° to 084° (TH) was then carried out on the PACIFIC ORCA. The investigators believe that execution of the course alteration was too moderate for this short range. Firstly, the course was only altered by about 30°; secondly, the maximum rate of turn reached was only 28°/min. By contrast (see figure 25), the previous navigational course alteration was executed at a maximum rate of turn of 48°/min. Moreover, a maximum rate of turn of 86°/min. was reached during the 'hard to starboard' course alteration initiated immediately before the collision. This first evasion manoeuvre was completed about one minute before the collision. The risk of collision still existed, however. Apart from sounding five short blasts of the whistle, no further action was taken. Therefore, the course and speed of the PACIFIC ORCA was virtually unchanged in the final minute before the collision. The PACIFIC ORCA only began to turn to starboard again immediately before the collision. At this point, it was no longer possible to prevent the collision.

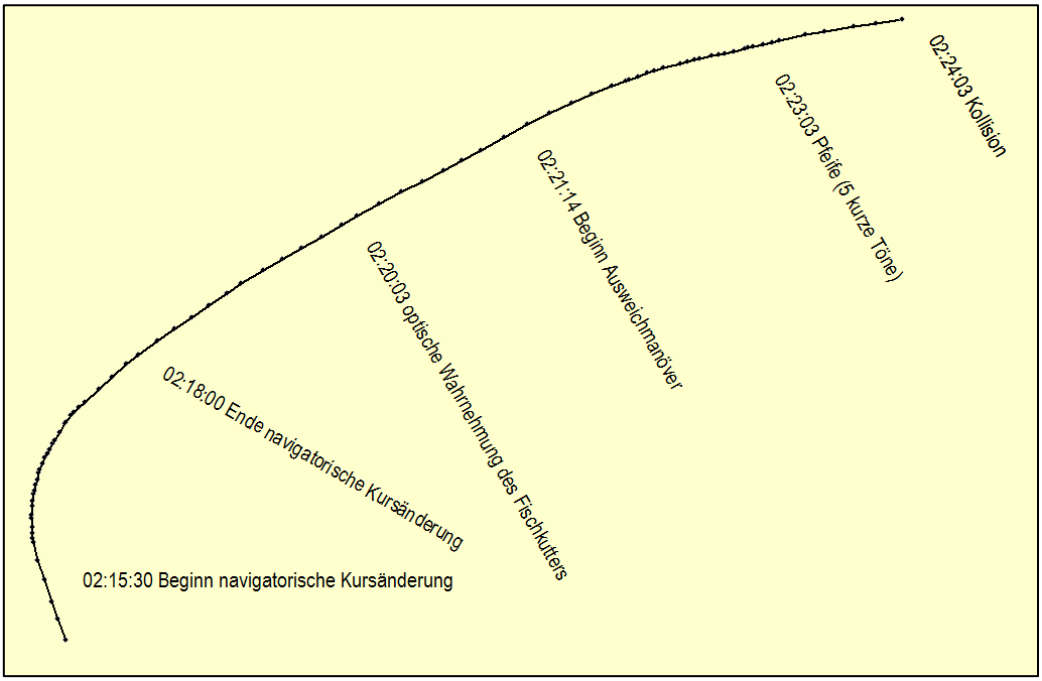

Figure 25: Track of PACIFIC ORCA

The evasion manoeuvre of the JURIE VAN DEN BERG can be traced using the headings in the transmitted AIS data. All the AIS transmissions of the final two minutes before the collision are shown in the table below. Viewed in conjunction with

Figure 20, it is evident that a course alteration to port is initiated on the JURIE VAN DEN BERG between 022239 and 022255. Here, the distance to the track of the PACIFIC ORCA stood at 9-11 ship lengths. The investigators assume that a port manoeuvre was initiated on the JURIE VAN DEN BERG because they had not observed the course alteration of the PACIFIC ORCA, initially went for a starboard-to-starboard pass and thus wanted to give the PACIFIC ORCA more room. The whistle signals of the PACIFIC ORCA may have led to the error being noticed. After realising this error, a starboard course alteration was initiated. The distance was too low to avoid the collision, however. The vessel only turned significantly a few seconds before the collision. As a result, the two vessels collided almost at right angles (see Figure 26). A change in speed is not visible on the JURIE VAN DEN BERG.

Time	Heading (HDT)		Time	Heading (HDT)
022158	176		022319	157
022219	176		022322	156
022228	176		022328	156
022239	176		022339	151
022255	167		022355	161
022256	167		022358	162
022258	166		Collision	
022302	167		022402	142
022315	157		022416	100

Table: Headings on the JURIE VAN DEN BERG

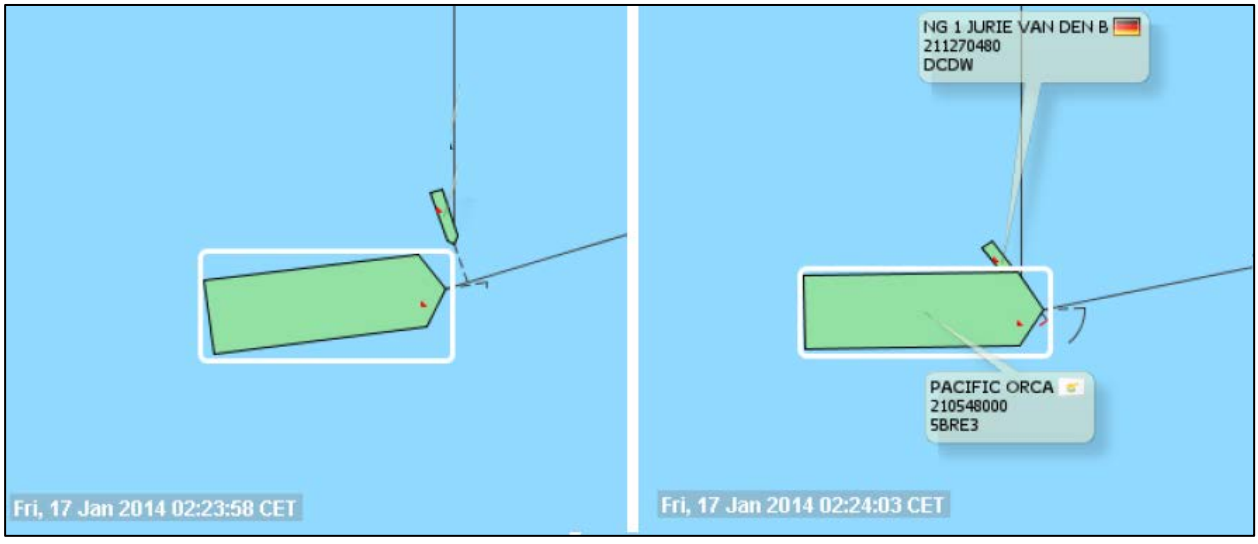

Figure 26: Collision (AIS display)

4.6 AIS

The erroneous installation of the AIS on the JURIE VAN DEN BERG resulted in the incomplete transmission of dynamic data. Consequently, it is reasonable to assume that the error already existed when the voyage started. This illustrates the importance of the periodical surveys of a vessel's own AIS transmissions set out in the IMO's guidelines for using an AIS.

Due to the JURIE VAN DEN BERG's incomplete dynamic AIS data, the PACIFIC ORCA's AIS was unable to calculate a CPA/TCPA for this vessel. The AIS symbol used (dashed triangle) was described neither in the device manuals nor in the relevant IMO publications. Moreover, the meaning is not self-explanatory but rather open to an incorrect interpretation. It was regarded as unusable on the PACIFIC ORCA, which is why they did not bother to view the AIS data. The valid data for range and bearing may have been useful. At this point, it must be added that the JURIE VAN DEN BERG's data could have been determined easily with the radar's target tracking function because of the clear traffic situation, however.

4.7 Environmental conditions

Environmental conditions had no significant impact on the course of events leading up to and during the accident. They corresponded to the conditions expected for the sea area and time of year. Consistent information given by all the parties indicated that good visibility prevailed. However, this accident also shows that visual recognition, of small vessels in particular, can be difficult in the area of wind farms and construction sites.

5 CONCLUSIONS

This accident confirms, yet again, the crucial importance of an effective lookout and careful observation of the radar in the interest of collision prevention. Presumably, the PACIFIC ORCA would have abstained from crossing the bow of JURIE VAN DEN BERG during her navigational course alteration had she identified the fishing vessel beforehand. This course alteration was undoubtedly easy to recognise on the JURIE VAN DEN BERG, however. Moreover, there was sufficient time available to establish a safe passing distance with an evasion manoeuvre. The risk of collision was only recognised very late on both vessels. In spite of that, both vessels could still have prevented the collision due to the extraordinarily good manoeuvrability. However, the evasion manoeuvres were not executed with rigour and resolve, and their effectiveness was insufficiently checked.

The manning of the PACIFIC ORCA's bridge with two officers and a lookout was carried out in accordance with the master's standing orders on the basis of the particular circumstances of the ship. These resources were only employed inadequately, however. There were no specific instructions for co-operation between the two officers. The second officer evidently underestimated the risk of collision, the chief officer was not informed, and his assistance was not requested. Because of the watch system practiced, consisting of 12-hour-watches, an impairment of the performance of the officers on watch cannot be ruled out – at night, in particular.

The absence of a lookout means that the bridge of the JURIE VAN DEN BERG was not manned properly. This contributed to the fact that the risk of collision was not recognised in a timely manner. It is possible that the skipper was fatigued because the minimum hours of rest were not met.

The safety benefit of the AIS is reduced by erroneous installation. The use of unknown symbols, which may be interpreted incorrectly, for the rendering of AIS targets could cause confusion and misjudgement among users.

The investigation and determination of the cause of the accident was largely made possible by the available VDR data from the PACIFIC ORCA. Once more, the particular value of a functioning voyage data recorder has been confirmed with respect to a reliable marine casualty investigation.

6 ACTIONS TAKEN

6.1 Owner of the PACIFIC ORCA

The owner of the PACIFIC ORCA reviewed the accident internally. The following changes are planned:

- voyage planning: detailed description of the traffic densities and flows expected during the voyage;
- master's standing orders: acknowledgement by the master on entry into service. Redraft when operating area changes or for other necessary reasons;
- the lookout should move around frequently on the bridge to avoid blind spots caused by the helicopter deck;
- background lighting caused by overhanging structural elements should be reviewed. Screening arrangements should be made where necessary;
- improve handover procedure between the lookout and the two officers keeping the watch.

The changes are to be examined during the next internal audit.

6.2 Manufacturer of the radar systems (FURUNO)

The manufacturer of the radar systems has updated the list of AIS targets in the radar system manuals to include and explain the 'No CPA/TCPA' AIS target (see Figure 17).

7 SAFETY RECOMMENDATIONS

The following safety recommendations do not constitute a presumption of blame or liability in respect of type, number or sequence.

7.1 Federal Ministry of Transport and Digital Infrastructure

The Federal Bureau of Maritime Casualty Investigation recommends that the Federal Ministry of Transport and Digital Infrastructure encourage the appropriate committees of the International Maritime Organization (IMO) to include and explain the 'Collision avoidance computation not possible' AIS symbol in the guidelines pertaining to AISs.

7.2 Owner of the PACIFIC ORCA

The Federal Bureau of Maritime Casualty Investigation recommends that the owner of the PACIFIC ORCA train the master and the officers on watch on effective bridge team management, the employment of two officers on watch, in particular.

7.3 Owner of the PACIFIC ORCA

The Federal Bureau of Maritime Casualty Investigation recommends that the owner of the PACIFIC ORCA organise the hours of work for officers on watch in a way that minimises impairments of performance.

7.4 Owner of the JURIE VAN DEN BERG

The Federal Bureau of Maritime Casualty Investigation recommends that, having regard to the duration of the voyage, the owner of the JURIE VAN DEN BERG man the vessel with sufficient resources to ensure that prescribed hours of work and rest, as well as bridge manning can be maintained.

8 SOURCES

- Investigations of the Federal Police
- Investigations of the Dutch police
- Written statements
  - Ship's commands
  - Owners
- Witness accounts
- Nautical charts and ship particulars, Federal Maritime and Hydrographic Agency (BSH)
- Official weather report by the Germany's National Meteorological Service (DWD)
- AIS recordings of Vessel Traffic Service German Bight
- Documentation, Ship Safety Division (BG Verkehr)
  - Ship file of the JURIE VAN DEN BERG
- Figure 1: Hasenpusch. Figures relating to the JURIE VAN DEN BERG: Dutch police. All others: BSU