Marine Board of Hamburg
Germany

Investigation report

B 5/2000 M

MV JANRA, capsizing in Northern Baltic 23.12.2000

This investigation report was written to improve safety and prevent new accidents. The report does not address the possible responsibility or liability caused by the accident. The investigation report should not be used for purposes other than the improvement of safety.

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SUMMARY

The German container vessel mv JANRA was on route from Rauma to the Kiel Canal when she collided on December 23, 2000 at about 03.07 hrs ships time (02:07 UTC) with the 20 metre high edge mark "Tröskeln Västra" in the Finnish territorial waters in the Northern Baltic.

The 2nd mate was alone on the bridge at the time of the collision. When colliding with the edge mark the vessel hit with her starboard side of the forecastle into the edge mark column and the ice deflector cone. As a consequence of the collision the edge mark fell down.

As a result of the damages water entered into wing tank No. 1 and cargo hold No. 1. The vessel developed a list of about 15 degrees. The master gave the order to prepare for abandoning the ship. The crew left the ship by using the free-fall lifeboat when the list quickly increased to about 25 degrees. The master and the 2nd mate remained onboard for some time. The flooding continued and finally led to capsizing some hours later.

Similar collisions on Deep Water Route Edge Marks had occurred four times previously. These accidents happened in fair weather and early morning hours. JANRA's collision must be viewed partly as a fatigue problem on this sea area.

The investigators have given safety recommendations on the safeguard against fatigue to ship owners. Safety recommendations on the requirements for survival suits, on small cargo ship damaged stability regulations and on the design criteria for edge marks have been given to maritime administrations.

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Figure 1. JANRA turned upright on February 17, 2001.

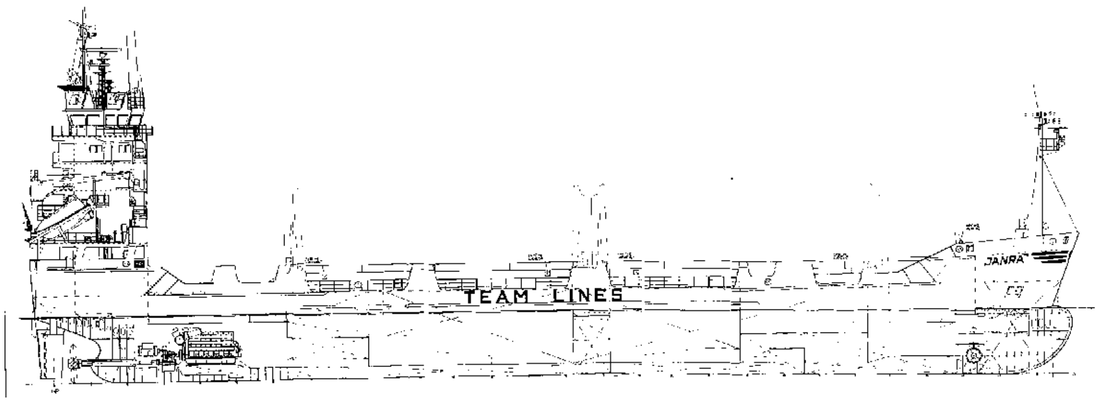


Figure 2. General arrangement drawing of JANRA.

INTRODUCTION

The German container vessel mv JANRA sailed from Rauma in Finland to Germany on December 22. She collided in the Northern Baltic with an edge mark on December 23. The vessel was damaged by the collision so severely that she capsized.

JANRA was towed into sheltered waters south of Aland. There she was turned upright.

Accident investigation

Finnish investigation. The Accident Investigation Board of Finland received in the morning of December 23 news about the capsizing of the JANRA. During the Christmas time the tow and the preparations for the salvage operation were followed.

The Accident Investigation Board nominated the commission to investigate the JANRA accident on December 27, 2000. Director Kari **Lehtola**, from Accident Investigation Board was appointed as the chairman of the commission. The other commission members were chief accident investigator, naval architect Martti **Heikkilä**, and maritime accident investigator, captain Risto **Repo** from Accident Investigation Board as well as Board's experts master mariner Kari **Larjo** and major (ret'd) Pertti **Siivonen**.

German investigation. The Marine Investigation Board of Hamburg (Seeamt Hamburg) received the message about the capsizing of the JANRA on December 27, 2000 and hold close contact with the Accident Investigation Board of Finland (AIB). The chairman of the Seeamt Hamburg, Jochen Hinz appointed a commission consisting of lawyer Jochen **Hinz**, master mariner Uwe **Kummerfeldt**, mechanical engineer Hark-Ocke **Diederichs**, master mariner and pilot Michael **Nicolaysen**, and master mariner and shipping company owner Jürgen **Stahmer**.

Joint investigation commission. In a meeting between the Finnish and German investigators in Helsinki early January 2001 a joint investigation commission for JANRA accident was formed. This joint Finnish–German investigation commission was agreed to consist of investigators appointed for the case in both countries.

It was also agreed, that the joint investigation would be carried out according to the IMO-Resolution A.849 (20) (Code for the Investigation of Marine Casualties and Incidents), and that Finland would take the role of lead investigating state according to article 6.2 of the Resolution. The objectives of the commission would be close co-operation in the investigation and a joint investigation report with related safety recommendations.

The investigations on the vessel after it had been turned upright were made jointly on February 17, 2001. Special interest was focused on salvage of the data of the electronic chart computer, which had been more than two months under water. The costs for retrieval of this data, which was successful, were shared between Germany and Finland.

Public Hearing in Hamburg. In a public hearing in Hamburg on June 14, 2001 the involved ship officers, the ship owner and some witnesses were interviewed by the German commission. The watch keeping officer was not available and his written report was presented by his lawyer. The Finnish members of the joint commission presented the analysed facts of the electronic sea-charts, the VTS-data and recovered documents in the hearing. The Provincial government of Aland was also represented.

Comments on the report. The final draft of this report was sent for comments according to the Finnish Accident Investigation Act to the maritime authorities in Finland and in Germany as well as to the ship owner and the master.

Comments on the report were received from the Finnish South Western Sea District, from the Finnish Hydrographer's office and the representative of the ship owner. Comments have been taken into account where the investigation commission has considered them relevant and some text changes have been made accordingly. The comments are included as appendices of this report.

1 OVERVIEW OF THE ACCIDENT AND THE INVESTIGATION

1.1 Vessel

1.1.1 General data

Ship's name	MV JANRA
Company	Reederei Jürgen Ohle KG
Home port	Hamburg
Place of Registry	Hamburg
Register No	17620
IMO Number	9113733
Call Sign	DGPJ
Type	Container vessel
Manning	10 persons and 1 passenger
Classification	Germanischer Lloyd
Class	100 A5 E3 Containership + MC E3 AU
Ice Class	E3 = 1 A
Year of Building	1995
Construction Yard	J.J.Sietas KG Schiffswerft GmbH &Co
Length o.a.	101.09 m
Length bp	96.13 m
Breadth	18.20 m
Draft	6.56 m
Block coefficient, Cb	0.64
Gross tonnage	3999
Dead weight	5210 tons
Propulsion power	3825 kW
Main engine	Deutz MWM Motorenwerke Mannheim type TBD 645 L9
Speed	15.5 knots

The vessel was equipped with a left-turning controllable pitch propeller, a flap rudder and a bow thruster of 400 kW output.

Two auxiliary diesel engines of 340 kW each, two generators of 390 kVA each and a shaft generator of 680 kW were installed.

Pumping capacity comprised of two ballast pumps of 210 m^3/hr each. The port side pump could be used alternately as emergency cooling water pump or as freshwater generator booster pump. Two fire fighting pumps of 150 m^3/hr each, one of which could be remotely controlled from the bridge.

The vessel had three hatches and two holds. The hatch covers were hydraulically operated folding panels (MARCOR).

1.1.2 Vessel Documents

Certificate of class for the hull	**Date of issue**
GMDSS Installation for the Area A3	03. May 2000
International Load Line Certificate	09. May 2000
Sailing Permit	22. May 2000
Cargo ship safety construction certificate	22. May 2000
Cargo ship safety radio certificate	04. May 2000
Document of Safe Manning	07. May 2000
Safety Construction Certificate	22. May 2000
Safety Equipment Certificate	22. May 2000
Safety Radio Certificate	04. May 2000
International Oil Pollution Prevention Certificate	04. May 2000

ISM Certificates were not required at the date of the accident.

1.1.3 Cargo and Stability

Cargo. In Rauma 4.170 tonnes general cargo in 82 x 20’ containers and 92 x 40’ containers had been loaded. Of the cargo, 61 x 40’ containers and 2 x 20’ containers were on the deck. They had been stacked two high in the bays 4, 6 and 8, and elsewhere in one layer only so that there was a good visibility ahead.

The cargo was products from Finnish paper and saw mill industry, paper reels, pulp bales, sawn timber etc. In some containers there were machinery.

According to the hearing in Hamburg the draft had been 6.00 m forward and 6.80 m aft.

The intact stability calculations were based on the loading plan made before departure at Rauma. The results of these calculations compared to the stability requirements are presented below both as tabled results.

The loading condition of the JANRA at the departure from Rauma was:

Displacement	7223 t
Draught, fore	6.071 m
Draught, aft	6.401 m
KM	8.110 m
KG	7.210 m
GM_0	0.90 m
GM_{corr}	-0.01 m
GM	0.88 m

Table 1. The intact stability of JANRA at the departure from Rauma.

Definition	**Requirement**	**Actual value**	**Status**
Area under GZ-curve, 0-30 deg	0.055	0.101 mrad	ok
Area under GZ-curve, 0-40 deg	0.090	0.155 mrad	ok
Area under GZ-curve, 30-40 deg	0.030	0.054 mrad	ok
Max. GZ > 0.2 m	0.200	0.318 m	ok
Max. GZ at an angle (> 25 deg)	25.0	38.182 deg	ok
GM > 0.15 m	0.15	0.88	ok

The stability requirements were fulfilled at the departure.

The master stated in the public hearing that he, after having left Rauma, had performed a stability check after reaching the open sea by putting the helm three times from 25° starboard to 25° port in immediate succession. This has been a habit of his originating from sailing in the timber trade for many years. It had became apparent then that the vessel did hardly heel. The vessel had been stiffer than was to be expected according to the calculated GM.

1.1.4 Manning and traffic restrictions

The Document of Safe Manning was issued at Hamburg on April 7, 2000 and will remain in force until March 31, 2005.

The trading area for the JANRA was unlimited voyages - between West European ports from Gibraltar to Bergen and Baltic Sea. The JANRA has a requirement for a crew of ten: master, chief mate, second mate, chief engineer, four deck hands, one rating engine and one cook. The master, chief mate and chief engineer were German, second mate Russian and the rest of the crew Philippine nationals. On the accident voyage the chief engineer's wife was onboard as a passenger.

It was stated in the Charter Party between the charterer and the ship owner: “Vessel’s crew to undertake the opening and closing of hatches whenever required unless prohibited by local regulations. Lashing and unlashing of container / cargo and placing of stacking cones to be performed by crew subject permissible by local port regulations and free of expenses to charterers.” According to the minimum safe manning document it was not intended that vessel’s crew should perform work to load or unload the cargo.

Concerning the working and rest hours onboard the legislative instrument the JANRA, as a German-flagged vessel, had to follow, are the German Accident Prevention Regulations for Shipping Enterprises by UVV See. On the other hand rest hours onboard are internationally regulated by IMO’s STCW’95 Convention. The German regulation guarantees 8 hours rest per every 24 hour period. The STCW’95 Convention guarantees 10 hours rest per every 24 hour period.

According the Seemannsgesetz (101 §) it is mandatory to keep onboard records of working and rest hours (time sheets). From the documents of the JANRA, which were recovered by the investigators, only a watch list with duty hours at sea could be identified. Some documents on overtime work payments were also found in the master’s cabin but they were not readable due to water damage.

The Amt für Arbeitsschutz (Labour Safety Inspectorate) is in general responsible for controlling the working hours onboard.

The second mate had started working at midnight. He had rested after leaving Rauma on December 22, 2001 at 17:20 and did not consider himself tired. This was his third voyage with the JANRA.

According to the minimum safe manning document a Schiffsmechaniker (i.e. multi purpose rating) according to the Schiffsmechaniker-Ausbildungs-Verordnung (i.e. ordinance on multi-purpose ratings training) should have sailed on board the JANRA. He had not been on board, as the involved ship owner stated in the public hearing of the Marine Casualty Investigation Board. Thus the crew of the vessel corresponded with the manning as required by the minimum safe manning document dated April 7, 2000 in quantity, but not in quality.

1.1.5 Bridge equipment

The view was good from the wheelhouse and it fulfilled the IMO recommendation[1]. The workstation which from the equipment positions can be deduced to be designed for the Officer of the Watch (OOW) is marked with number 5 in figure 3. It had the necessary navigation equipment, steering and speed controls.

[1] Resolution A.708(17), 6 Nov. 1991.

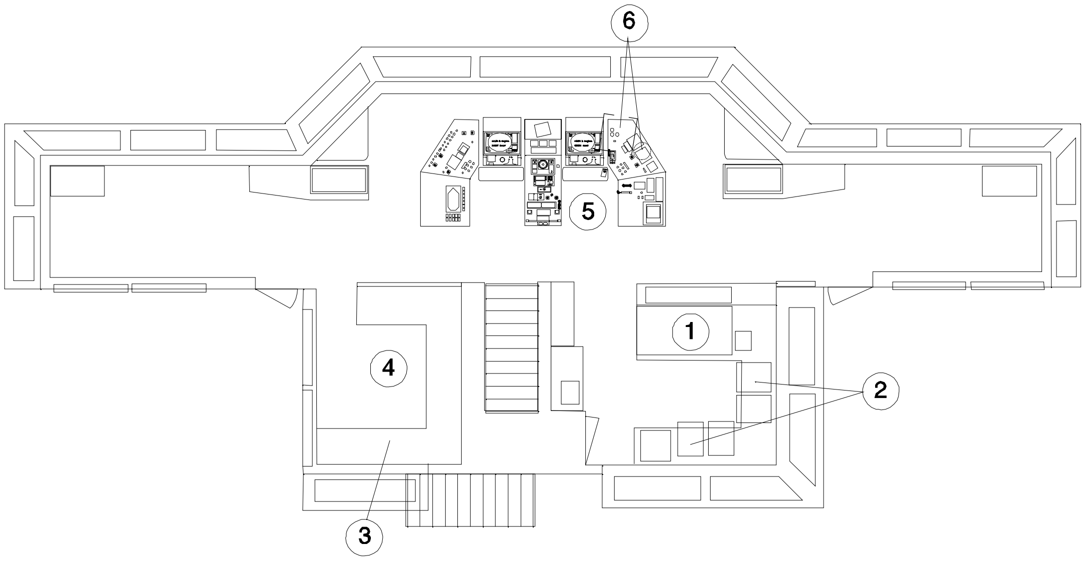


Figure 3. The wheelhouse general layout illustrates JANRA[2].

Table 2. Equipment on JANRA's bridge as illustrated in figure 3.

Item	Explanation
1	Chart table, barometer, clock, FURUNO weather facsimile, ELNA NAVTEX 2. Leica MX 400 Professional DGPS navigator, Magnavox MX 200 GPS Navigator
2	Two computers, one GSM telephone
3	Loading Computer, printer, Scanner, GSM, Facsimile
4	SAILOR COMPACT GMDSS Radio station Six portable VHF sets
5	Navigation and Command Console with navigation, propulsion and steering controls. Workstation designed for the Officer Of the Watch (OOW).
6	Electronic chart display and Search Light control on the ceiling

The equipment was grouped according to functions. Navigation planning was on the starboard side and the radio equipment on the port side of the bridge.

Bridge wings were equipped with following controls and dials:
- Engine remote control (FU and NFU), RPM and pitch dials,
- main engine emergency STOP ME,
- Bow thruster controls,
- NFU rudder control, rudder angle indicator +/- 45°.
- Gyro repeater
- VHF, Talk Back to forecastle and stern, Tyfon.

[2] The detailed drawings are based on photographs from NORRLAND, which was stated to be identical by the owner. This was confirmed after JANRA was turned upright.

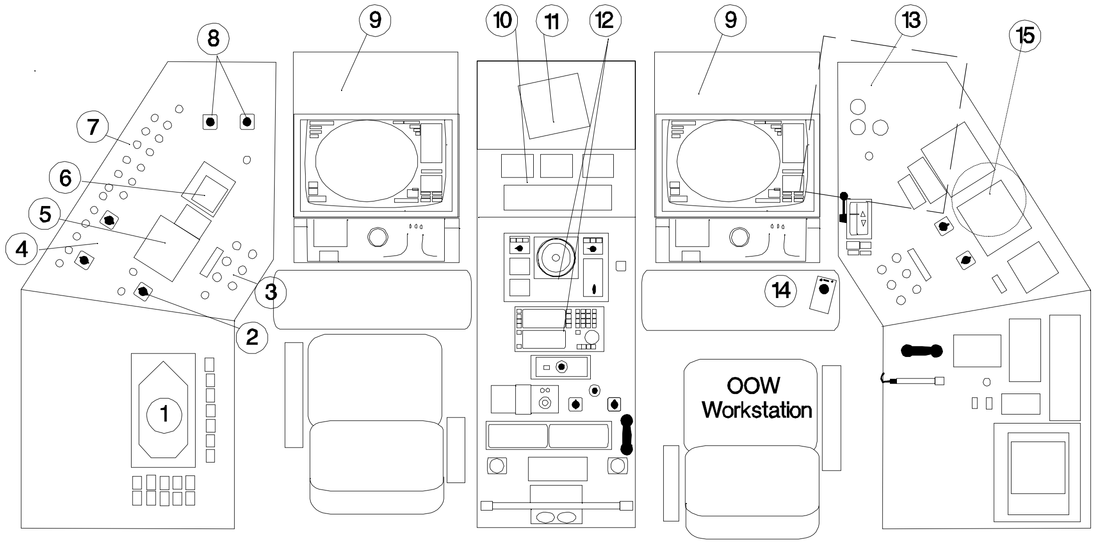


Figure 4. The Navigation and Command Console.

Fire safety, lights, fans and main audible (tyfon) signal are installed in the port side of the console. The main navigation workstation is situated between the starboard and the center consoles. It is illustrated in closer detail in figure 6.

Table 3. Equipment on JANRA's Command and Navigation Console as illustrated in figure 4.

Item	Equipment	Maker or type
1	Navigation lights, Deck lights	IS PLÜ 1.0
2	Fire pumps	
3	Tyfon main control	
4	Fan switches for two cargo holds	
5	Fire control system	Brandmeldezentrale A-TECH 9000
6	Smoke Detection System	DECKMA GmbH
7	Cargo hold flood lights	
8	Dimmers	
9	2 similar radar displays	KELVIN & HUGHES nucleus 5000T
10	Bow thruster control	
11	Rudder angle indicator	
12	Gyro repeater and autopilot	C:PLATH
13	Electronic chart on the ceiling	TRANSAS, NAVI SAILOR 2400
14	Mouse to operate the NAVI SAILOR	
15	Mechanical lever to aim the searchlight	

Figure 5. Photo of the bridge of JANRA's sistership NORRLAND.

OOW has the propulsion control on his right and steering controls on his left hand, if he is sitting on the right chair. The radar and the electronic chart were in front of him. The searchlight could be operated easily by standing up and turning the searchlight-aiming lever. The possibilities for safe watch keeping were good.

The OOW workstation is illustrated in figure 6. It is designed for one man control.

S-band (10 cm) radar antenna on the monkey island is firmly connected with the port side radar display. X-band (3 cm) antenna on the monkey island is connected via an interswitch to both radar displays.

The 2182 kHz SAILOR type R501 Watch keeping receiver was built in the rear end of the center below the NFU push buttons.

The bridge had a good original basic lay-out and it was well equipped. The electronic chart display was a retrofit installation and represented added information to SOLAS requirement for navigation equipment. The OOW workstation designed for one man control contained all the necessary equipment for safe navigation.

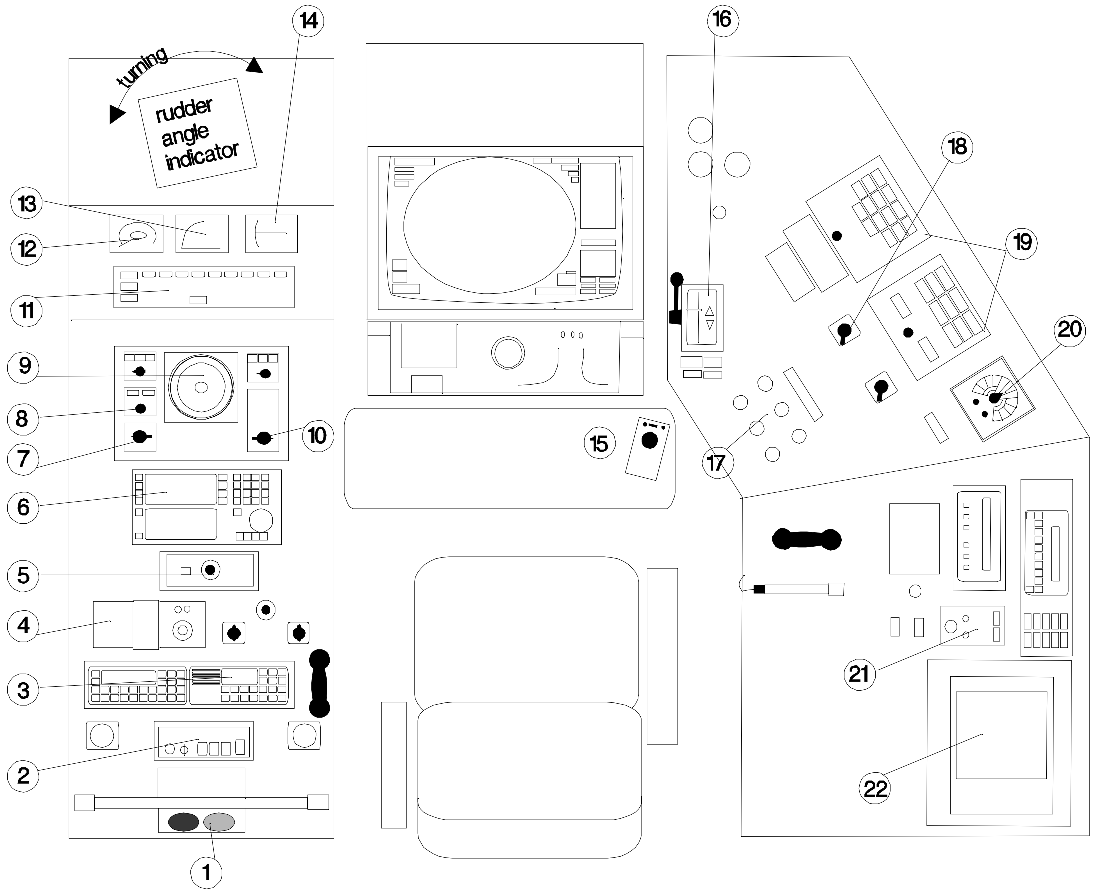


Figure 6. The OOW workstation design at starboard side.

Table 4. Equipment at the right workstation.

Item	Equipment	Item	Equipment
1	NFU steering push buttons	**12**	Propeller RPM
2	Watch Alarm System, STEIN SOHN	**13**	Bow thruster load
3	DSC VHF radiotelephone	**14**	Main propeller pitch
4	Talk Back	**15**	Mouse control for the electronic chart.
5	NFU steering tiller	**16**	Propulsion control
6	Speed log, C.PLATH, NAVIKNOT III Autopilot, C.PLATH, NAVIPILOT V	**17**	Tyfon control
7	Gyro / Magnetic selector switch	**18**	Control station change-over switch Bridge / Engine Control room
8	NFU Override steering for the autipilot	**19**	Engine automation
9	Compass repeater	**20**	Propulsion Back Up Control
10	Selector switch Autopilot / manual	**21**	General Alarm Automat
11	Bow thruster controls	**22**	FURUNO echo sounder

1.1.6 Life saving equipment

The German requirement for life saving equipment follows Chapter III of the SOLAS Convention. The equipment of the JANRA fulfilled these requirements. The lifeboat of the JANRA was of a free-fall type, its position can be seen in the general arrangement drawing, figure 2.

Additionally to IMO's SOLAS regulations concerning lifesaving equipment some countries do have regulations under the fleet of their flags. In Finland and Sweden the Survival Suits are mandatory for the whole crew on a cargo ship. The rule has been set because of the weather conditions in Baltic and other northern waters.

1.2 Deep Water Route

The JANRA collided with the edge mark Tröskeln Västra in the deep water route leading from northern Baltic to Bay of Bothnia, figures 7–8. The deep water route was constructed by the Finnish Board of Navigation in 1986 to safeguard the bulk carrier traffic to Tahkoluoto in Pori, Finland. The edge marks of the deep draught route have fulfilled their task leading the deep draught traffic safely through the passage without accidents. The shallow draft vessels could pass the edge marks safely on either side of the marks.

In the following the history of construction of the deep water route and earlier collisions with edge marks as well as the design of the Tröskeln Västra edge mark are described.

1.2.1 History of the Deep Water Route

The history of the Deep Water route is illustrated with the issues of the Finnish sea chart no. 904 Åland Sea. The charts reveal also the change of general positioning system from relative navigation to absolute position fixing.

At first there were only three buoys to mark the shoals (figure 8). Position fixing was based on visual navigation, radar ranges and radio bearings. Radio Direction Finder was used to approach the sound and radar ranges to navigate through it. Decca Navigator started hyperbolic navigation in 1969.

The Deep water route was introduced 1986 and it was marked at first with buoys (figure 8). The deep water route marked with edge marks is shown in figure 9.

Position fixing method changed from hyperbolic to satellite navigation in the beginning of 1990s. DECCA was abandoned year 2000. Position fixes became absolute with global coordinates with the same accuracy all over the world. Further step was to present the position on an electronic vector chart.

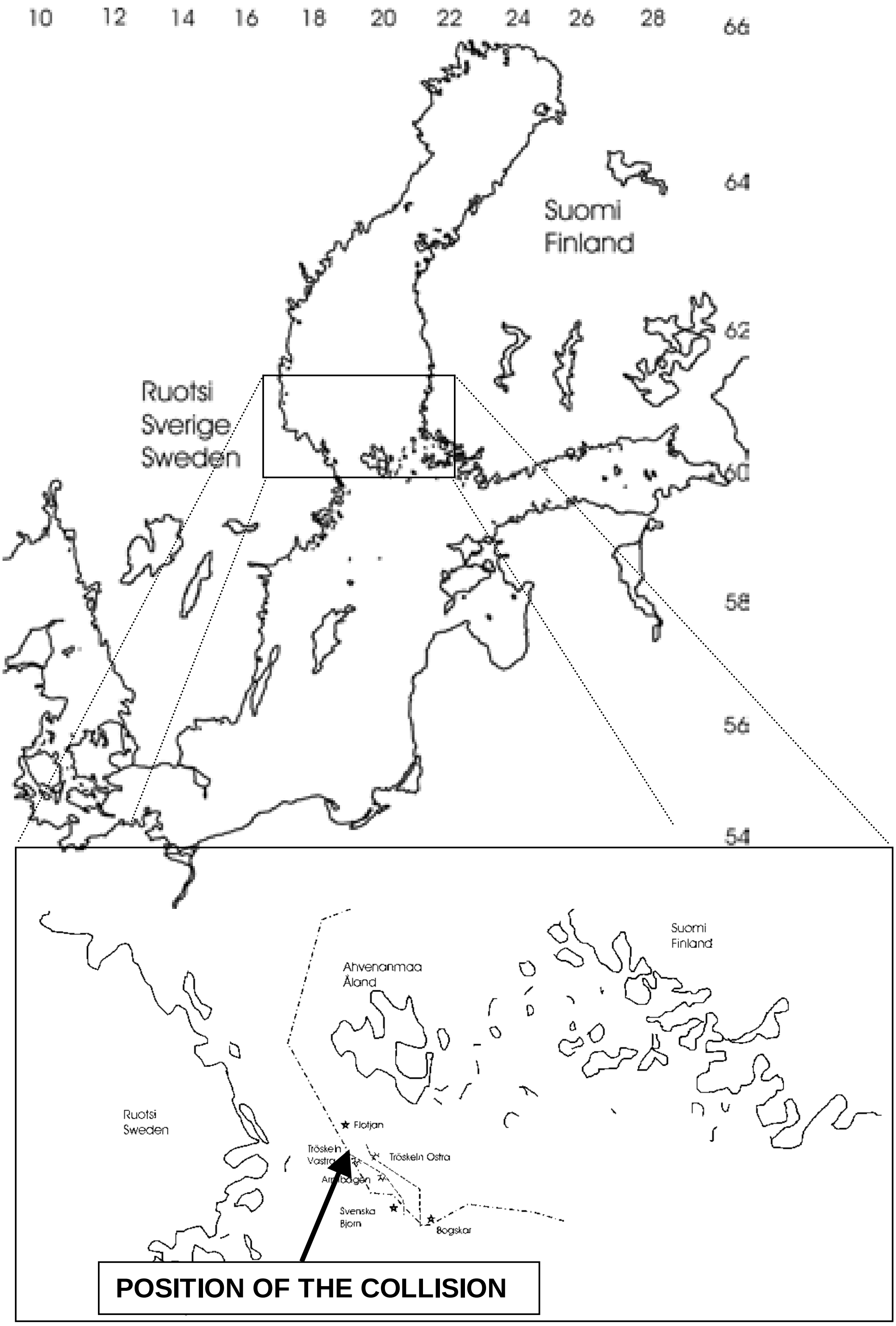


Figure 7. The Baltic Sea and overview of the collision area. The semi-dotted line is the boundary of Finnish territorial waters.

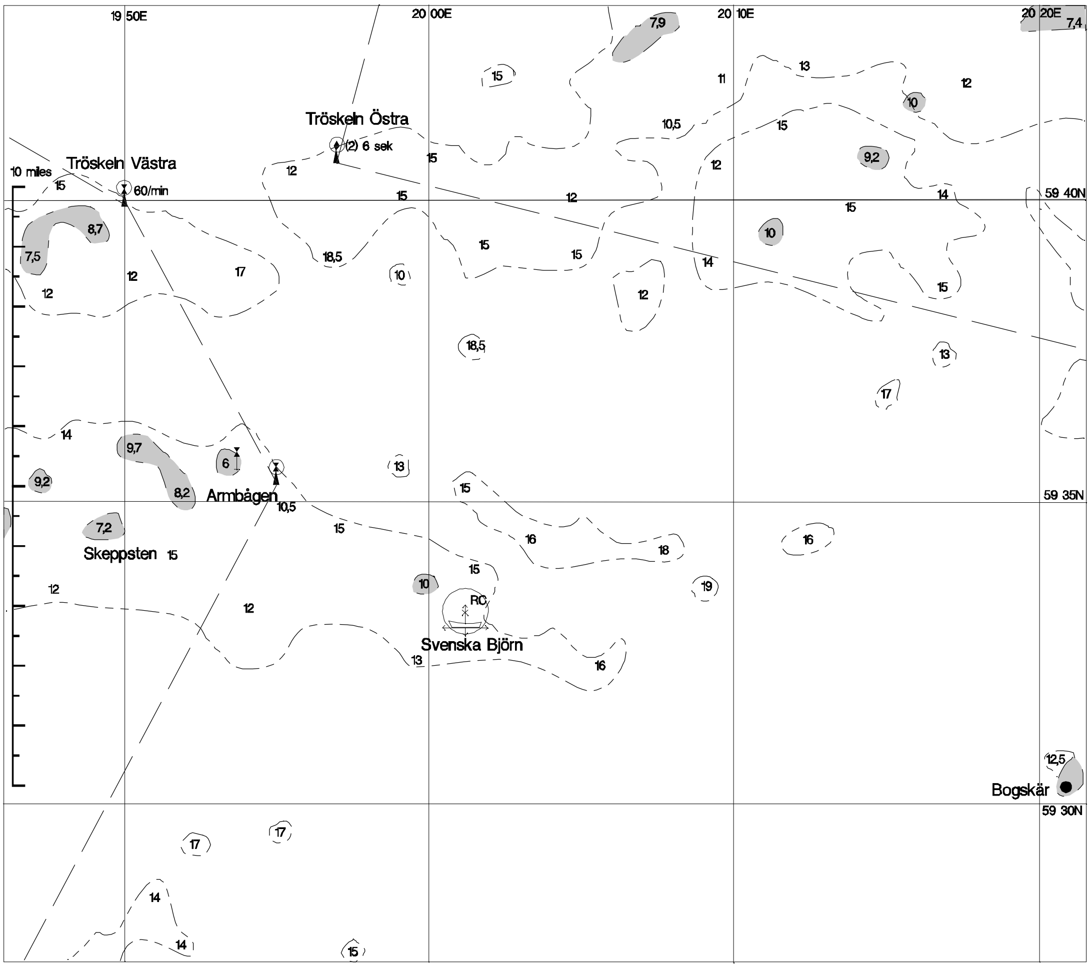


Figure 8. *Tröskeln area 1965 on the Finnish sea chart no. 904. The passage was marked only with buoys. The dotted shallow water (10 metre) boundary is only imaginary and is not printed on the chart. The passage was about 3.3 miles wide and was not considered by the mariners to be a narrow passage.*

Table 5. *The table covers the changes on the Tröskeln area from 1965 to 1985 on the Finnish sea chart no. 904. At first the passage was marked only with buoys.*

Chart published	**Channel markings**
904; 1965 III Coordinates in Finnish KKJ system.	Svenska Björn was marked with a **lightship** and had **radio beacon (fig.8)**. Tröskeln Västra 59°40.0N 19°50.3E was marked with an east buoy at 20 m depth. Tröskeln Östra 59°40.7N 19°57.3E was marked with a west buoy at 18 m depth.
904; 1969 I (Printed 1969 I) (Printed 1969 VI) (Printed 1970 II) (Printed 1971 III) (Printed 1972 X)	**Fixed beacon at Svenska Björn.** – White sector 145°-155° near Tröskeln Västra A white sector leads between Tröskeln Västra and Tröskeln Östra shoals. – Red sector 155°-161° marks the 12 metre shoal – Green sector 161°-166° marks the 12 metre shoal – White sector 166°-171° marks a passage east of Tröskeln Östra buoy.

D 904; 1969 I (Printed 1970 II)	**DECCA** lattice chart. **A new Swedish Decca chain** was introduced. Red and green hyperbolic lines crossed approximately in 75° angle. Good position fixing accuracy was achieved at Svenska Björn and Tröskeln. Fixing changed to hyperbolic.
D 904; 1969 I (Printed 1972 VIII)	**Svenska Björn** got a **RACON** beacon.
904; 1972 X (Printed 1973 I)	No changes in the area.
904; 1977 II, (Printed 1983 II) A-system. **Search and Rescue grid chart.**	New boundary to mark Swedish and Finnish rescue responsibility. Point North West of Tröskeln Västra 59°42N 19°47.1E. (Finninsh KKJ) Point North West of Svenska Björn 59°33.47N 19°59.5E. (Finninsh KKJ) **Bogskär** and **Flötjan** got **RACON** beacons.
904; 1977 II, (Printed 1984 III) (Printed 1985 IV)	The fishing boundaries and national boundaries appeared on the chart. From this on they were on the chart 904.

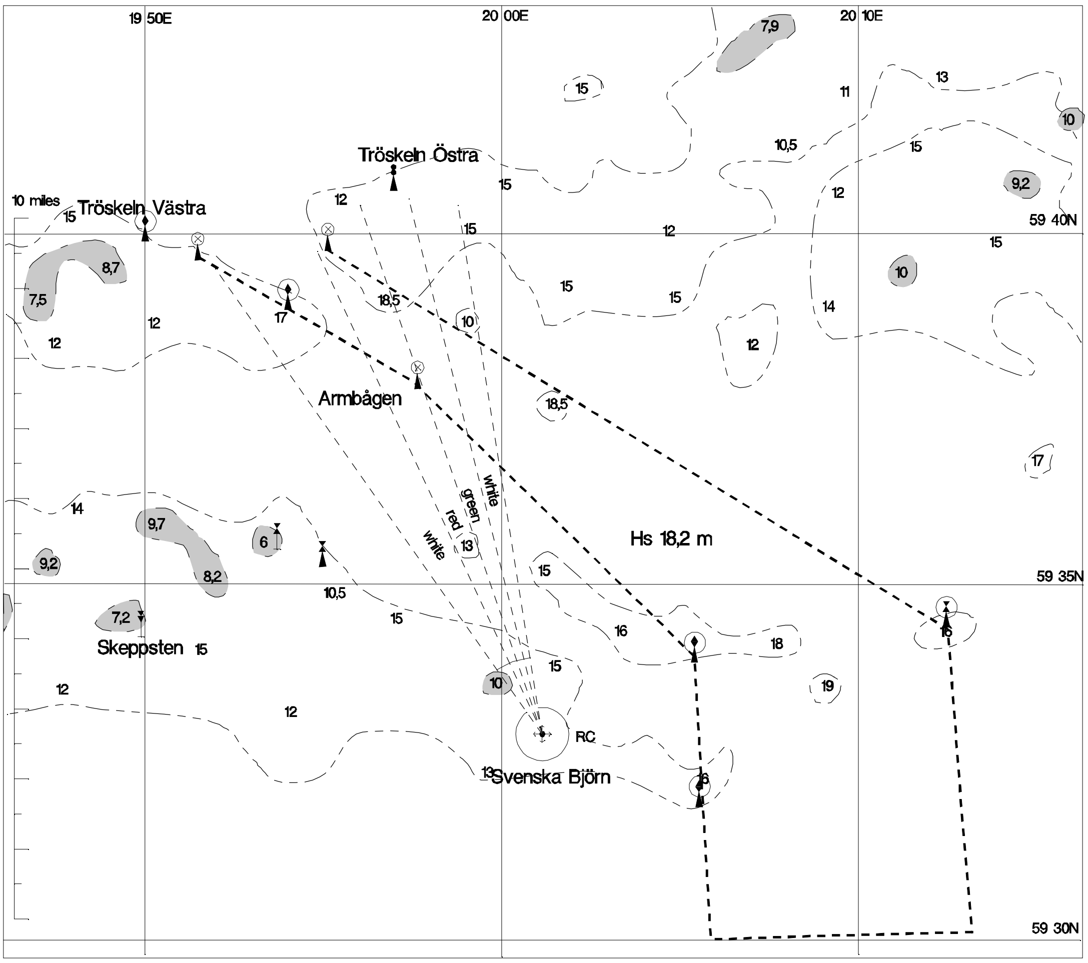


Figure 9. The Deep Water route was illustrated the first time on the chart no. 904 in April 1986. The route was marked with buoys.

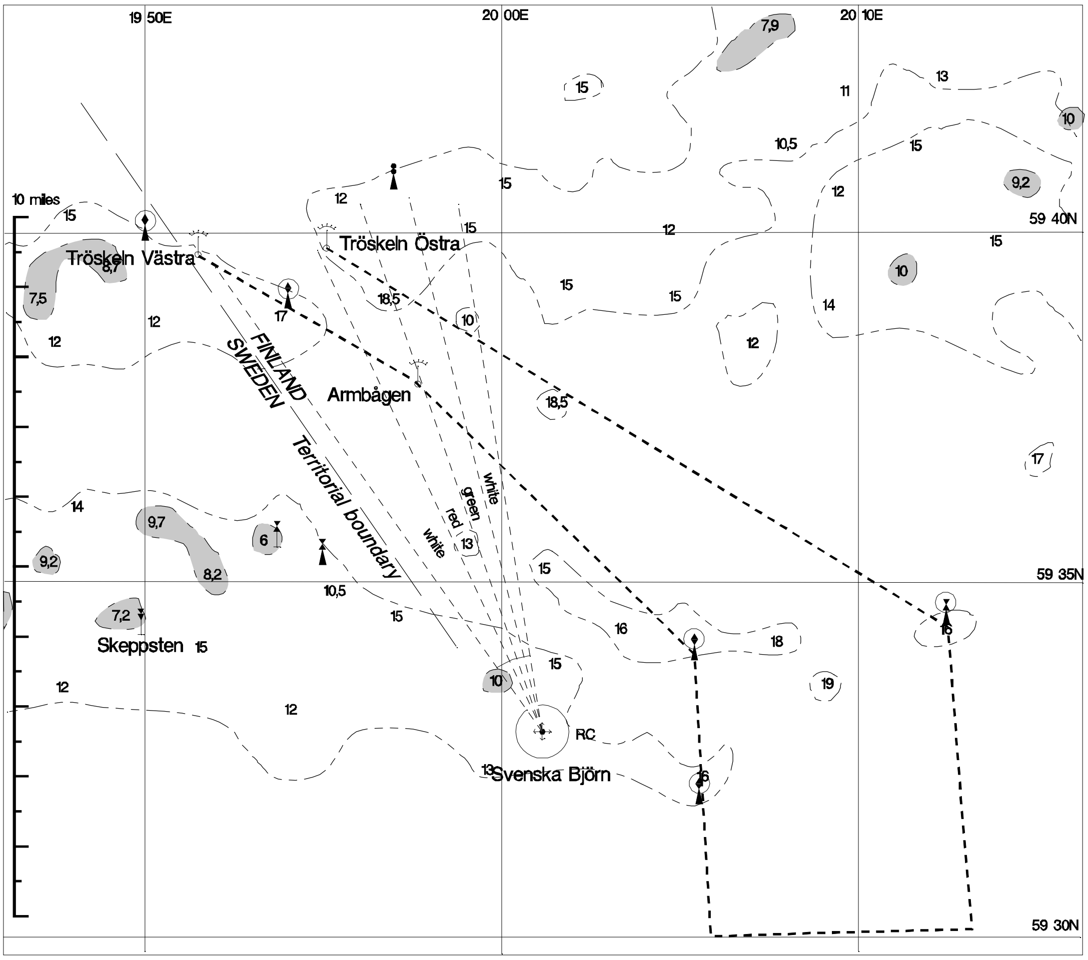


Figure 10. The Deep water route on chart no. 904 in June 1986. The Tröskeln and Armbågen buoys were replaced by edge marks.

Table 6. The Deep water route marking from 1986 to 2001.

Chart published	**Channel markings**
904; 1986 IV	First indication of the Deep Water Route. The Deep Draught route was marked as **HS 18.2 m** with buoys (fig. 9). Old Tröskeln Västra and Tröskeln Östra buoys marking 10-metre shoals were left on their previous locations.
904; 1986 VI	**The edge marks Tröskeln Västra, Tröskeln Östra and Armbågen were built** before June 1986. MS SVANÖ rammed Tröskeln Västra and MS IBN SINA Tröskeln Östra. The damaged edge marks had to be marked with buoys. The edge of the Svenska Björn white sector (145°) is drawn near the Tröskeln Västra edge mark.
904; 1987 VII	Deep Draught route was marked as **DW 18.2 m.** All three edge marks were functioning again. The marking was a combination of edge marks and buoys. Old buoys intended for shallow draft vessels at Tröskeln Västra and Tröskeln Östra were omitted (the buoys in fig. 8).
904; 1990 IV	All buoys had been removed. Årmbågen Östra (East) remained as the only

(904; 1991 V) (904; 1992 VII)	buoy in the whole area. The southwest side edge marks **Tröskeln Västra and Armbågen got RACON beacons**. FINN BOARD rammed Tröskeln Östra 1990.
904; 1994 I	The visual range of the **Svenska Björn light was reduced from 21 miles to 9 miles.** Navigation changed from relative to absolute position fixing with satellites.
904; 1995 VIII (904; 1997 IV) (904; 1999 II)	New fishing boundary between Finland and Sweden appeared on the chart. SKAGENBANK rammed Tröskeln Västra 1998. AROS NEWS rammed Tröskeln Västra 1999. JANRA rammed Tröskeln Västra 2000.
904; 2001 X	Tröskeln Västra was replaced with a buoy because of the JANRA collision.

1.2.2 Vessels involved in the collisions with the Tröskeln edge marks

No incidents or accidents were reported prior the construction of the edge marks. Several vessels collided with edge marks between 1986 and 2000. It was unexpected that shallow draft vessels encountered collisions with the edge marks. The deep draught bulk carriers navigated safely in the channel.

Two collisions occurred the same autumn after the spring when the edge marks were constructed. Then followed a four-year break. Three collisions occurred once a year between 1998–2000. All ships had continued to their destination ports after accidents but JANRA's collision was fatal. All collisions except one occurred in the early morning hours. Navigation systems did not contribute the accidents.

Table 7. Following shallow draft ships have collided with Tröskeln Västra (West) or Tröskeln Östra (East) edge marks during 1986–2000.

Date	**Time**	**Ship's name**	**Brt**	**Nationality**	**Collision with edge mark**	**Damage to edge mark**
16.09.1986	04.25	IBN SINA	5091	Egypt	Tröskeln Östra	Almost broken
02.10.1986	01.13	SVANÖ	3395	Finland	Tröskeln Västra	Helideck loose
09.05.1990	00.20	FINN BOARD		Finland	Tröskeln Östra	Almost broken
22.11.1998	15.00	SKAGENBANK		Netherlands	Tröskeln Västra	Almost broken
15.01.1999	02.10	AROS NEWS	2816	Antiqua	Tröskeln Västra	Totally broken
23.12.2000	03.07	JANRA	3999	Germany	Tröskeln Västra	The edge mark collapsed and the vessel capsized.

1.2.3 Edge mark Tröskeln Västra

Design. The edge mark Tröskeln Västra was built in 1986. Due to the collisions with the mark in 1998 and 1999 it was totally destroyed. The edge mark was rebuilt in 1999.

The latest construction was of steel on a concrete base in the sea bottom. The construction drawing of the mark is in figure 11. The height of the mark above water level was 20 metres and its diameter was 860 mm. On top of the mark was a helicopter platform and an ice deflector cone was at the water level.

The helicopter platform was equipped with Racon and Lights. The Energy source was Batteries which were charged by solar panels. The Batteries were of NiCd-type SUN 143 Ah 12 V and the solar panels Kyocera K 48 48 W. The blinking light was of type Sabik RL-300. The Racon model was Tideland SeaBeacon 2Sys5 X/S.

Energy problems with the mark. When JANRA collided with the Tröskeln Västra in the morning of December 23, 2000 the edge mark was unlit and the racon did not work. These faults were observed in November 4, 2000 and thereafter the warning message ”Remark Tröskeln Västra nr 6385 in Position 59° 39.58’ N 019° 51.72’ E, reported unlit” was sent by the authorities via Turku Radio and Navtex.

The assumed reason for the faults was a lack of energy because the solar panels did not get enough light during the short daylight. This assumption could not be confirmed. The South Western Maritime District of the Finnish Maritime Administration was responsible for service of the edge mark Tröskeln Västra and they had tried to repair the faults on November 12 and 27 and on December 9 and 21, 2000, but the weather conditions had prevented the repair.

1.3 The Weather

The weather information in the Northern Baltic Sea on December 23, 2000 described below was received from the Finnish Meteorological Institute. Weather stations near the area are located at Utö, Nyhamn and Bogskär.

Table 8. Weather at SW coast of Finland December 23, 2000.

	NYHAMN	BOGSKÄR	UTÖ
Wind direction	330	330	310
Wind force	11 m/s	10 m/s	11 m/s
Time UTC+1	02.00	04.00	02.00

The wind was north westerly 10–12 m/s. A weak scattered rain front passed the Sea of Aland to east. The front passed the Tröskeln Västra on the northern side and moved east well before the accident occurred. At the time of the accident the weather was clear and the visibility was probably more than 25 kilometres.

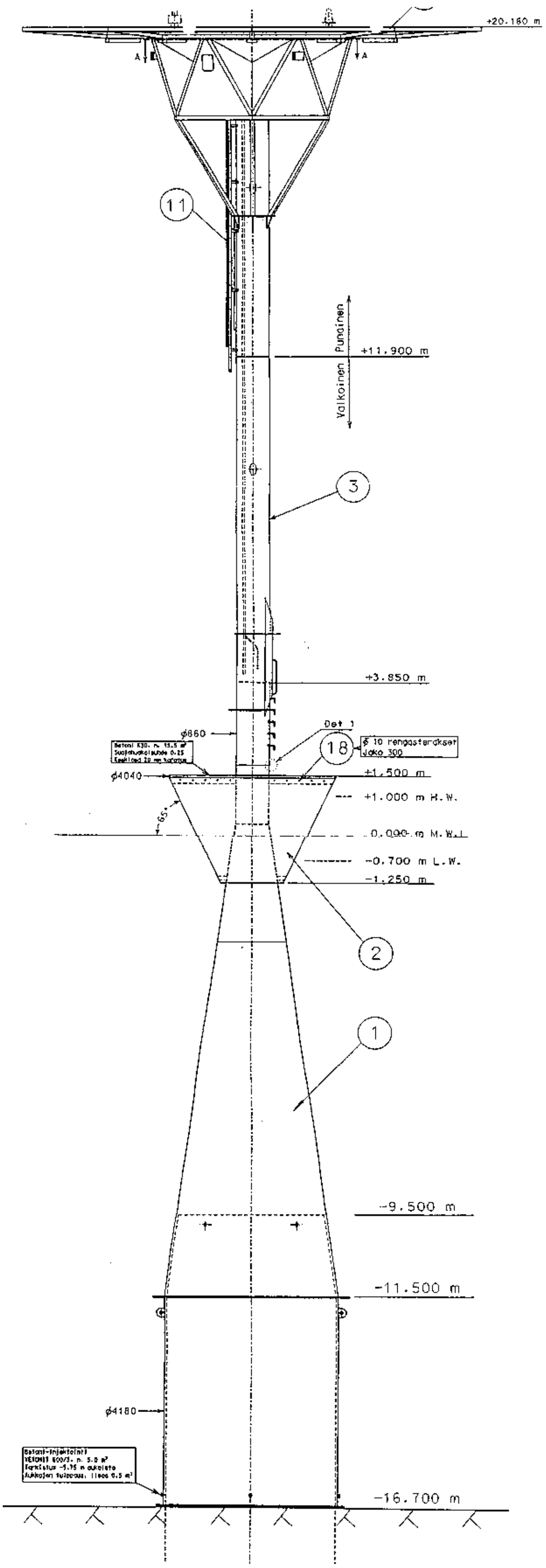


Figure 11. The construction drawing of the Tröskeln Västra edge mark.

1.4 The Voyage

JANRA's voyage could be tracked from Rauma at 17.07 hours on December 22, 2000 to her capsize at 07.42 hours on December 23, 2000 from ship's recording device[3]. The track is described below from the watch change at midnight. The track related statements are included.

1.4.1 JANRA's recorded track

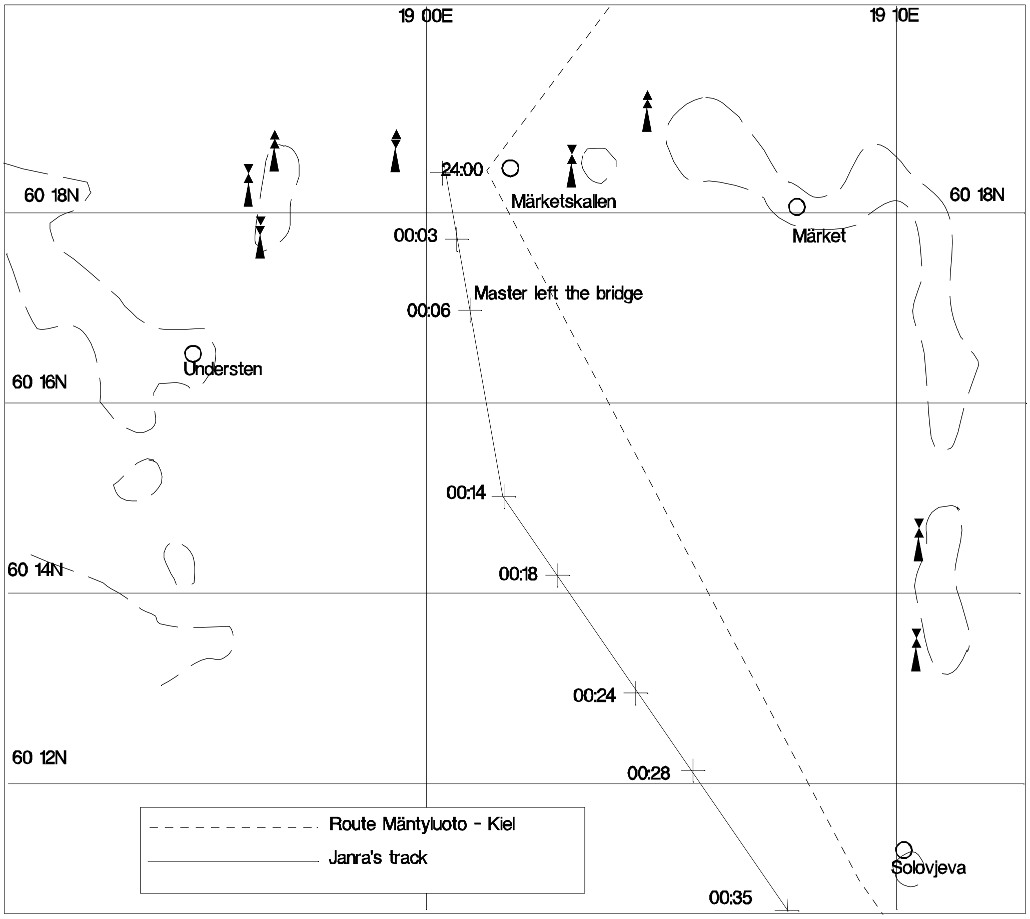


Figure 12. JANRA was using MÄNTYLUOTO–KIEL passage plan although the voyage started from Rauma.

JANRA used the Rauma-Kiel passage plan when she left Rauma at 17:07 on December 22, 2000. The Passage plan was changed to Mäntyluoto-Kiel plan several times between 18:44 and 21:31. Rauma-Kiel plan was turned on again two times between 20:31–21:31. Finally Mäntyluoto-Kiel passage plan was left on at 21:31. JANRA followed closely the plan Rauma-Kiel but it was far away from the loaded Mäntyluoto-Kiel plan which was on the electronic chart as illustrated in figure 12.

3 The recording device is the ship's electronic chart computer. About 98 percent of the contents of its hard disk was retrieved although the computer had been underwater for about 8 weeks.

The second mate took over the watch from the master at midnight when the vessel was turning south at beacon Märketskallen. The speed was 14.4 knots. Master left the bridge at 00:05. He told the mate to watch for the unlit Tröskeln Västra edge mark[4]. Radar was on 6-mile range, north up, off center and automatic anticlutter activated. The master considered the automatic anticlutter to be better on short range than the manual adjustment. The Kelvin & Hughes radar operation manual warns that the 'use of SEA/AUTO function may reduce Radar Beacon responses[5]. Radar literature points out that some weak sea clutter should be left on safeguard the weak targets to be visible. This can be controlled only with manual adjustment observing the short range.

The first officer stated that it was known from NAVTEX that the Tröskeln Västra light was out of order[6].

JANRA turned 00:14 towards Tröskeln Västra beacon, but she had to steer slightly south on to give room for a north-bound vessel. That vessel was not plotted with ARPA. JANRA's speed was 14.9 knots. Solovjeva beacon was abeam at 00:36.

Table 9. Recorded data from JANRA's Navi Sailor program on December 23, 2002, 00:36–02:54. Abbreviations: UTC = Universal Time Coordinated, HDG= Heading, COG = Course Over Ground, SOG = Speed Over Ground, XTE = Cross Track Error.

UTC+1	Route	HDG	COG	Drift	SOG	XTE m	Comment
00:36:00	145.7	145.5	145.0	+0.5	15.5	1439	Passing Solovjena.
01:00:00	145.7	143.8	145.0	+1.2	15.1	1302	***COG 143.5 points clearly between the beacons Tröskeln Östra and Västra.***
01:01:00	145.7	143.5	145.0	+1.5			
01:01:20	145.7	142.8	143.0	+0.2			
01:55:00	145.7	143.0	144.0	+1.0	15.3		
01:55:21	145.7						
02:00:00	145.7	143.5	144.0	+0.5	15.3	479	
02:10:00	145.7	144.8	144.0	-0.8	15.2	358	***Course change 1° to starboard.***
02:20:00	145.7	145.3	145.0	-0.3	15.1	261	
02:28:00	145.7	145.1	146.0	+0.9	15.0	212	***COG 145.5 points on the next waypoint number 5.***
02:30:00	145.7	145.3	145.0	-0.3	15.1		
02:39:00	145.7	144.8	145.0	+0.2	15.0	154	
02:44:00	145.7	144.3	146.0	+1.7	15.0	144	COG 146° passes 0.1' NE of the Tröskeln Västra beacon.
02:50:00	145.7	145.1	146.0	+0.9	14.9	140	
02:52:00	145.7	145.5	145.0	-0.5	14.9	142	
02:53:00	145.7	145.6	146.0	+0.4	15.1	150	
02:54:00	145.7	145.3	146.0	+0.7	15.0	150	

[4] Master's statement 14.06.2001, SEEAMT HAMBURG.
[5] Nucleus Orparator's manual, Kelvin Hughes KH 1300, page 1.9.
[6] First Officer's statement 14.06.2001, SEEAMT HAMBURG.

When the master went down at 00:05 the port radar was on the 6-mile range[7]. At 02:41 Tröskeln Västra was on the 6-mile range. At 02:56 Armbågen Racon was on the 6-mile range. The OOW saw the echo from Tröskeln Västra but he did not plot it with ARPA. He did not mention the Armbågen Racon. The master was of the opinion that the radar beacons were not visible on longer distance than six miles.

The master stated that the Off-Course alarm was set on the electronic chart but he did not know how it was done. The limit is set in degrees and it applies to the whole route and the course limit must be varied along the route. The Off-Course alarm can be switched on or off. The alarm was off on JANRA.

It is possible that the master mixed up the Off-Course alarm with XTE alarm (Cross track error) because he said that he assumed that alarm was set on 0.5 mile[8]. This refers to the Cross Track Error distance. The cross track distance (XTE) can be set separately during the programming stage for all route lines between the waypoints of the route. The XTE limit at the Tröskeln Västra was set on 0.1 miles. The XTE alarm can be switched on or off for all legs on the route. The XTE alarm was switched off. If the alarm had been on, it would have alerted the OOW several minutes before the collision. The limit of 0.1 miles provides sufficient margin when passing Tröskeln Västra.

The master referred also on two different waypoint alarms. Off-Route alarm sounds only when the vessel has passed the last waypoint. This had nothing to do with JANRA's accident. The waypoint alarm is set as 'time to go' to the next waypoint. The time can be set between 1 and 60 minutes. The master had an erroneous view that the waypoint alarm was set as distance to the waypoint and he did not know how to set the distance. The set time limit applies to all waypoints along the route and the limit should be varied according to the hazards around. The master had believed that the waypoint alarm was off at Tröskeln Västra but activated on some other waypoints. The waypoint alarm was off for all waypoints.

The Tröskeln Västra was within the 6-mile range when the lookout went downstairs to make coffee. Tröskeln Västra was visible on the radar screen as stated by the second officer. The use of the radar ARPA function should have revealed that the target (Tröskeln Västra) was stationary. The ARPA should have given a 'Collision warning' or a 'Lost Target' alarm when the echo disappeared. There were no alarms because the ARPA was not used.

The company orders required the watch alarm to be on when the mate was left alone in the bridge. The alarm was off and the OOW could not activate it because the master had the key.

JANRA got closer to the Tröskeln Västra beacon without any activated alarms related to navigation. The ARPA function, the Watch Alarm and the electronic chart alarms were all off. The bridge was silent and vulnerable for fatigue.

[7] Master's statement 14.06.2001, SEEAMT HAMBURG.
[8] Master's statement 14.06.2001, SEEAMT HAMBURG.

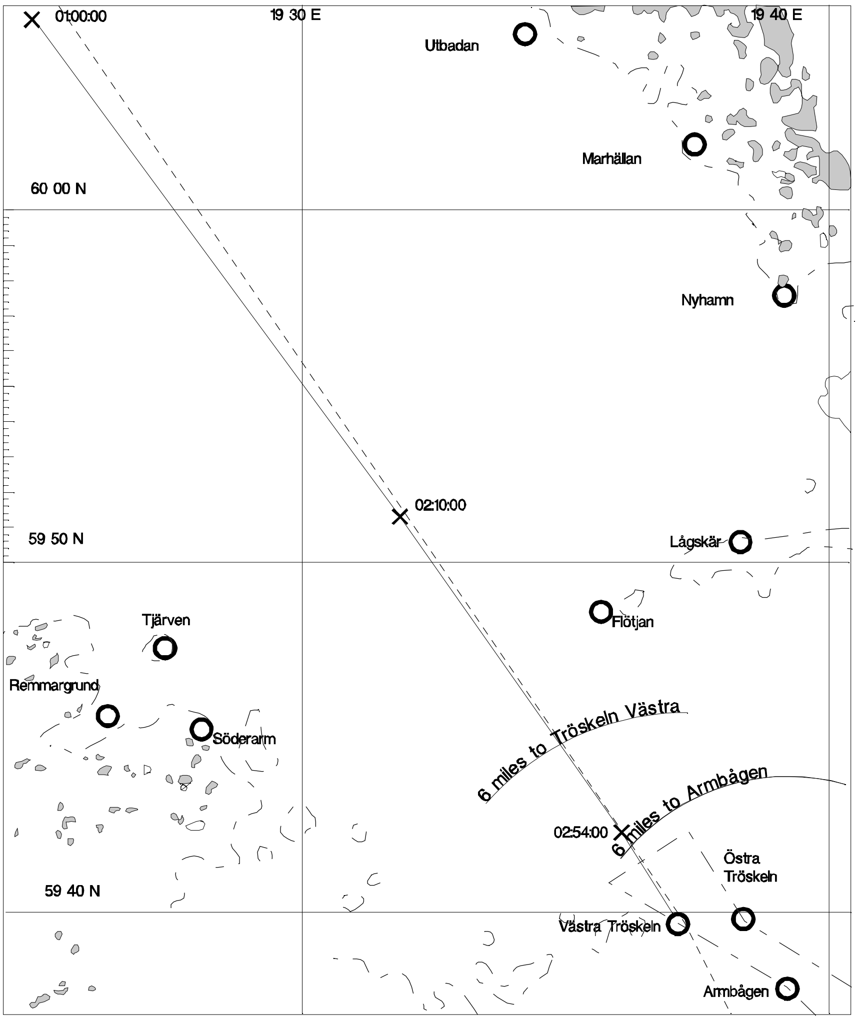


Figure 13. JANRA turned one degree to starboard at 02:10 and two degrees to starboard at 02:54. JANRA had followed the passage plan carefully from 02:10 to 02:54.

JANRA's approach to the northern part of the deep-water route and Tröskeln Västra edge mark is shown in figure 13. At one a' clock she was on the starboard side of her programmed track. JANRA turned one degree to starboard at 02:10, when she was 0.19' on the starboard from the intended track. From 02:10 to 02:54 JANRA followed her passage plan and the cross track error kept decreasing (table 9).

At 02:54 JANRA turned 2° to starboard and kept thereafter an average COG 147.5° until next course change. COG vector pointed one cable North East of the Västra Tröskeln edge mark. Waypoint no. 5 was two cables NE of the beacon position on the chart.

JANRA kept her course for twelve minutes and turned 5° starboard at 03:06:20. Her new course 153° was identical with the new planned course 154° from Waypoint 5 to Waypoint 6.

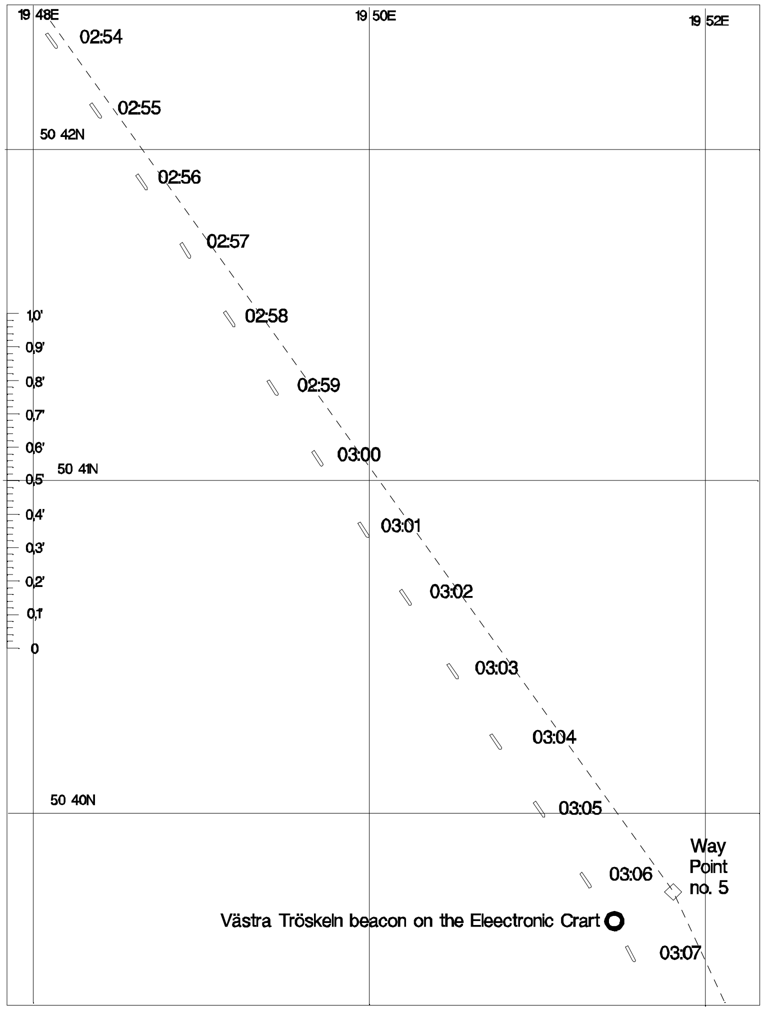


Figure 14. JANRA deviated from the passage plan at 02:54 by turning 2° to starboard.

Table 10. Recorded data between 02:55–03:06:00.

UTC+1	Route	HDG	COG	Drift	SOG	XTE m	Comment
02:55:00	145.7	143.8	146.0	+2.2	14.9	156	On the starboard side of the route
02:56:00	145.7	147.0	148.0	+1.0	15.0	167	***COG 147.5 points on Tröskeln Västra edge mark.***
02:57:00	145.7	147.8	148.0	+0.2	15.1	184	
02:58:00	145.7	146.3	148.0	+1.7	15.0	200	
02:59:00	145.7	147.0	148.0	+1.0	15.0	213	
03:00:00	145.7	146.5	148.0	+1.5	15.0	243	
03:01:00	145.7	147.6	148.0	+0.4	15.0	259	
03:02:00	145.7	147.6	147.0	-0.4	15.1	270	
03:03:00	145.7	146.8	148.0	+1.2	15.2	293	
03:04:00	145.7	146.6	148.0	+1.4	15.0	309	
03:05:00	145.7	147.0	148.0	+1.0	15.0	320	
03:06:00	145.7	147.0	147.0	0	15.0	340	***COG 147 points south of Tröskeln Västra edge mark.***

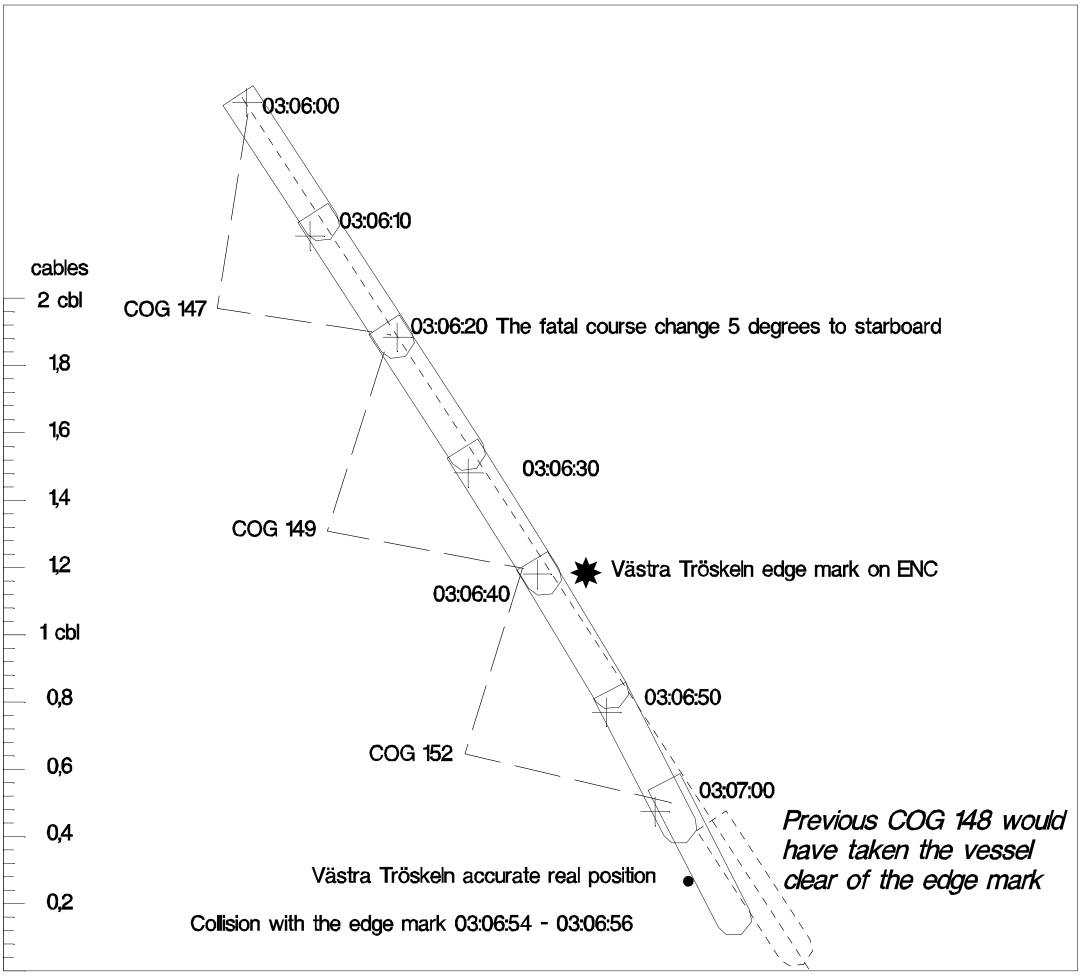


Figure 15. JANRA collides with Tröskeln Västra edge mark.

Table 11. The course change at 03:06 led to the collision. Italics in the table indicate measurements between position fixes.

<table>
<tr><th>UTC+1</th><th>Route</th><th>HDG</th><th>COG</th><th>SOG</th><th>XTE m</th><th>Comment</th></tr>
<tr><td>03:06:20</td><td>145.7</td><td colspan="3" rowspan="7">Navi Sailor records HDG, GOG and SOG only on even minutes. Position is recorded with 10-seconds inter-val.</td><td>342</td><td>Course change 5 degrees to starboard.</td></tr>
<tr><td>03:06:30</td><td>145.7</td><td>353</td><td rowspan="2">COG represents course during 06:20–06:40</td></tr>
<tr><td>03:06:40</td><td>145.7</td><td>353</td></tr>
<tr><td>03:06:43</td><td>145.7</td><td></td><td>Waypoint number 5 is abeam. GPS antenna is abeam the Tröskeln Västra beacon on the electronic chart (UK) A2297.</td></tr>
<tr><td>03:06:50</td><td>153.0</td><td>357</td><td></td></tr>
<tr><td>03:06:54</td><td>153.0</td><td></td><td rowspan="2">Collision with the beacon Tröskeln Västra.</td></tr>
<tr><td>03:06:56</td><td>153.0</td><td></td></tr>
<tr><td>03:07:00</td><td>153.0</td><td>152</td><td>154</td><td>14.5</td><td>357</td><td></td></tr>
</table>

Navi Sailor records on even minutes UTC Time, latitude and longitude in WGS-84 coordinates, Gyro Heading (HDG), GPS Course Over Ground (COG), GPS Speed Over Ground (SOG), LOG speed and GPS status. Latitude and longitude are recorded additionally every 10 seconds. Additional Course Over Ground information has to be measured graphically between position fixes.

JANRA's track can be followed closely with the Replay function in the Navi Sailor software. When the vessel passes an even minute the fields HDG, GOG, SOG and LOG are updated but otherwise they remain fixed.

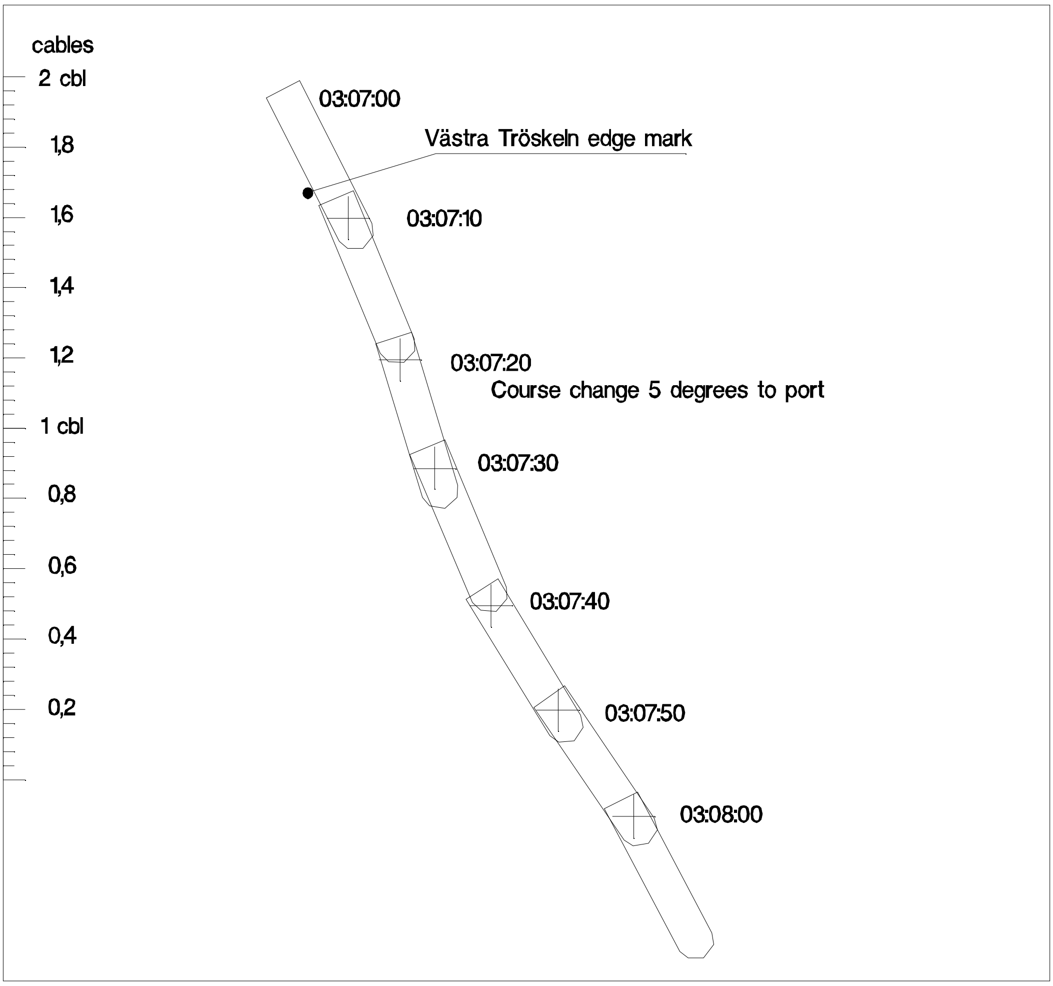
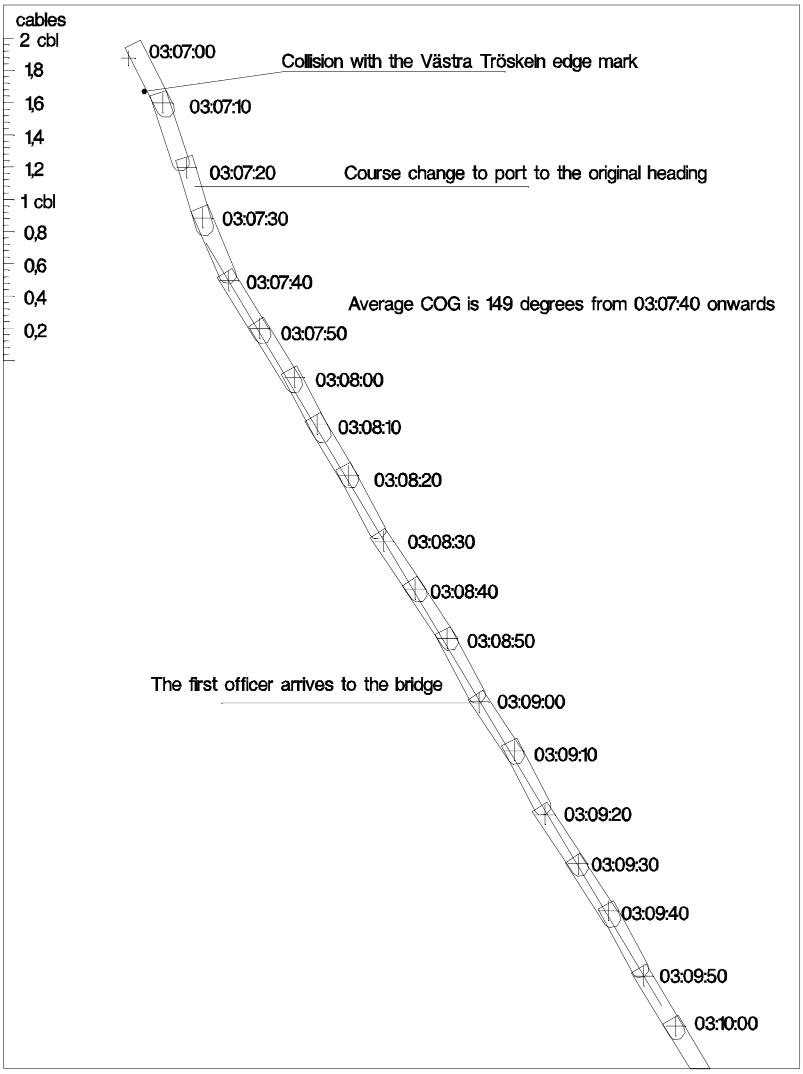


Figure 16. JANRA's s-turn after the impact. Heading is estimated between 03:07:00 and 03:08:00.

Table 12. JANRA's s-turn after the impact.

UTC+1	HDG	COG	LOG	Comment
03:07:00	152.3	152.0	14.4	Recorded by the Navi Sailor
03:07:10	*158*			*Navi Sailor records Heading, Course Over Ground and LOG sped only on even minutes. Position is recorded every ten seconds. Heading is estimated graphically in figure 16 between 03:07–03:08.*
03:07:20	*163*			
03:07:30	*158*			
03:07:40	*149*			
03:07:50	*147*			
03:08:00	151.8	151.0	13.3	Recorded by the Navi Sailor



UTC+1	HDG	SOG
03:08	151.0	13.3
03:09	149.0	14.0
03:10	149.0	14.4
03:11	150.0	14.3
03:12	149.8	14.4
03:13	147.8	14.4
03:14	149.5	11.0
03:15	149.3	9.5
03:16	151.1	7.7
03:17	151.5	6.4
03:18	146.8	5.5

Table 13. JANRA's speed begun to slow down after 03:13 when the list increased rapidly.

Figure 17. JANRA kept approximately straight course with the autopilot from 03:07:40 on.

The first officer woke up in his cabin and felt that something was wrong. The ship had a 2° list. He rushed up to the bridge in one and half or two minutes. He entered the wheel-house (03:09). The list was 5° when he reached the bridge. The second mate stood at the center console behind the NFU steering (figure 6). He didn’t know what had happened. The first officer observed that the port radar was on 6-mile range and he saw some targets and one Racon. The starboard radar was on stand by. Then he checked the position on the electronic chart and observed that JANRA had passed Tröskeln Västra. The OOW appeared to be somewhat hesitant. The first officer did not notice a position fix on the paper chart. He called the master[9]. The lookout was not on the bridge.

JANRA's heading had been 147° at 03:06 soon after that the second mate changed course 5° to starboard. JANRA had never the time enough to settle on the new course 152°. After the impact the second mate turned to port to the original heading (figure 17).

The list was 10° to 15° when the master entered the bridge. After checking the situation on the radar and electronic chart he had changed the propeller pitch to zero[10]. Ship's speed begun to slow down after 03:13. According to the speed table 13 the master entered the bridge between 03:11 and 03:13. The first officer was already on the bridge.

1.4.2 Statements of the Master and Mates

The following is based on the minutes of the Public Hearing on JANRA accident.

Statement of the master. The master stated that he had sailed as master since 1976, and that he was well familiar with the ship type JANRA since he had already been in command of various vessels of that type. He had been on board as master since August, 2000, interrupted by leave of absence in October.

The vessel had been employed in the regular liner service between Hamburg and Bremerhaven and Finland. In Finland predominantly the ports of Rauma and Kotka had been called at. The round voyages had lasted one week on average.

The vessel had been moored in Rauma on December 22, 2000 at 07.15 hrs (ships time UTC + 1). When the cargo on board (105 containers) had been discharged completely, 4.170 tonnes general cargo in containers had been loaded. They had been stacked two high in the bays 4, 6 and 8, and elsewhere in one layer only so that there was a good visibility ahead.

The draft had been 6.00 m forward and 6.80 m aft.

According to the master’s statement the containers were being secured by twistlocks and lashing rods by the crew during loading already, supervised by the second mate, so that the cargo was secured shortly after the loading was finished at about 16.45 hrs. At about 17.05 hrs the ship had sailed, being assisted by a pilot.

9 First Officer's statement 14.06.2001, SEEAMT HAMBURG.
10 First Officer's statement 14.06.2001, SEEAMT HAMBURG.

The master stated in addition that he had performed a stability check after reaching the open sea by putting the helm three times from 25° starboard to 25° port in immediate succession. This has been a habit of his originating from sailing in the timber trade for many years. It had became apparent then that the vessel did hardly heel. The vessel had been stiffer than was to be expected according to the theoretical GM.

At about 19.30 hrs he had taken the watch from the first mate. A lookout had been on the bridge.

The sea watches had normally been organised as follows: master: 8-12; second mate: 12-4; first mate: 4-8.

The master stated furthermore that loading and discharging had always been split up between first and second mate. He would then go additional watch hours at sea if required, in order to relieve the first mate.

The second mate had been off duty since sailing from Rauma to get sufficient rest until the beginning of the next sea watch at midnight.

In addition, the master stated that he had steered the usual course of 242° after departure of the pilot in order to get around the Södra Kvarken lighthouse about one nautical mile north of it. After he had realised, however, that there was no oncoming traffic, and after having passed Storbrotten Bank he had altered course southward and had left Södra Kvarken on starboard. Passing time had been 23.10 hrs. He had set course for Oldbergsgrund buoy past Märketskallen about one nautical mile north of it. When the master had been relieved by the second mate at midnight the position of the vessel had been not far to Märketskallen lighthouse. The position at midnight had been entered into the log book by the master, and then, in order to give an oncoming vessel more room, he had altered course to 168° whilst ordering the second mate to report the “Janra” to the Swedish coast guard via VHF. When changing the watch he had ordered the second officer to revert to the old course after having passed the oncoming vessel. The next waypoint had been about two cables east of Tröskeln Västra.

After the end of his watch the master had read for several minutes, and had then gone to bed.

At about 03.00 hrs he had been waken by the first mate by telephone with the words: ”There has been a bang, we are heeling fast”.

Furthermore the master declared that the vessel had already a list of about 10° to 15° when he entered the bridge. Also he could realise that the vessel was on a south easterly course with full pitch ahead. The autopilot was on. Then he had ascertained on the radar that there were no ships in the immediate vicinity. The oncoming traffic had been well clear on port. Then he had adjusted the propeller pitch to zero.

The radar had been in the 6nm-range, off centre, north up, with anticlutter automatic activated.

The master stated furthermore that he had ordered the first mate to personally wake the entire crew. When doing so he should tell them to dress warmly and to assemble at the muster station. He had not sounded the general alarm because he wanted to prevent a hectic rush on board.

When he had been informed shortly afterwards by the chief engineer from the engine room that no malfunction could be detected in the ballast system he had realised that the vessel must have suffered a severe water ingress. He had then ordered the whole crew except the second mate to board the free-fall lifeboat, to launch it, and to stay near the vessel. This had purely been a precautionary measure. He had not feared the vessel to sink.

According to the evidence of the master he had then asked the second mate what had happened. Thereupon the second mate had answered, “ I don’t know”.

During the public hearing the master also stated that he had contacted Stockholm Radio because of the list, shortly after he had arrived at the bridge. Stockholm Radio had referred him to MRCC Göteborg which he had then told that he did not yet know the cause of the list. Further he and MRCC Göteborg had agreed upon him calling every half hour and reporting the situation on board. He had sent these reports on VHF channel 16[11].

He had not sent a Mayday but had just talked to Stockholm Radio which then had connected him with the Rescue Centre and had told him that they would arrange everything. He had then considered that problem solved, for this was the fastest way.

Then he and the second mate had gone downstairs and had donned the survival suits. The increase of the list had been slower because the engine had been stopped, and he had hoped the vessel would steady at about 30°.

When the list increased all the same he had requested the second mate to abandon the vessel. The master himself had abandoned the vessel shortly after 05.00 hrs when the list had reached about 40°.

When asked whether the dead man’s handle was on, the master stated that the shipping company had issued the standing order to activate the dead man’s handle whenever the bridge was manned by one person only, meaning that the dead man’s handle was on when during daylight the bridge was manned by one person only, and off when at night the ship sailed with a lookout.

He had the key. The dead man’s handle had been set at 15 minutes. He had set the dead man’s handle at the maximum.

When the master was asked how they normally navigated he explained that two way points had been used in the Tröskeln Västra area, separately for north bound and south bound.

[11] According to the master’s statement the communication took place on ch. 16, but according to the Stockholm Radio this happened on ch. 84, except for the opening call.

Statement of the second mate. The second mate had sailed already since 1993 on various foreign vessels which were partly identical with the JANRA. He had reported for duty on board on November 27, 2000. As he said in his statement, he had been fully informed about the vessel and the route by the first mate. Most items such as the navigational equipment had been familiar to him from previous vessels, e.g. both radar sets, the electronic chart and the satellite receivers. His duty on board had been, among others, to update the charts. He had had no problems to understand the Nachrichten für Seefahrer (NfS) (i.e. notices to mariners). The most recent NfS had been No 49/2000 with minor corrections in the Aland Sea area.

Furthermore the second mate stated that, whilst on the JANRA, he had made three round voyages calling at the port of Rauma, and that he had been very familiar with the vessel and the range.

The second mate reported that the whole cargo had been discharged immediately after arrival in Rauma and that the vessel had been loaded immediately afterwards. Since he had been on watch in port from 12.00 to 16.00 hrs, securing and lashing the containers had been done by the crew under his supervision. Shortly after finishing lashing they had sailed. This had been at about 17.00 hrs. After supper he had turned in bed and had been wakened again at about 23.40 hrs.

On the bridge the master had informed him about the shipping situation. There had been little traffic only, with one vessel ahead on almost the same heading and with the same speed. The master had requested him to report the actual position to the Swedish coast guard. The master himself had performed the required alteration of the course to 150° true, had then made the entries in the log-book, and had then left the bridge.

The second mate stated further that he had continued to steer about 150° to give Solovjeva Lighthouse a sufficient berth to port. At about 00.40 hrs the lighthouse had been passed well on port with a speed of about 14.5 knots. Thereupon the course had been altered slightly to starboard.

Further the second mate wrote in his statement that part of his normal routine was to take a position fix every two hours and to enter it into the log-book. Such entries were also made e.g. when passing conspicuous land- and sea-marks as well as when altering the course.

The lighthouses Tjärven on starboard and Flötjan on port had been passed at a sufficient distance. He could clearly recognise Tröskeln Västra, for which the course had been set, on the radar screen. He had been informed via NfS 49/2000 that the racon did not work and that the light was extinguished. He had not particularly been alarmed about it because the presentation of the lighthouse on the radar had been good.

Shortly before 03.00 hrs he had sent the lookout downstairs to the mess room to make coffee. It had started drizzling, but this did not affect the existing good visibility in the dark.

When the vessel had proceeded further towards Tröskeln Västra he had lost the target on the radar screen. Because he had been certain about the position he had altered the course by about 5° to starboard which was necessary after having passed the lighthouse. Shortly afterwards he had noticed the pencil on the chart table rolling to starboard and falling down. Though the vessel had not moved his first thought had been that the vessel must have developed a list. On the inclinometer he had noticed a list of 5° to starboard, increasing fast to 7°. While he had still been looking at the inclinometer the first mate had appeared on the bridge and immediately called the master and informed him about the list. Then the first mate had gone downstairs and had wakened the entire crew.

Few seconds later the master, who asked the second mate what had happened, had appeared on the bridge. The second mate had repeated that he had no idea.

The second mate further stated that the master had then adjusted the propeller pitch to zero, observed the traffic on the radar and observed the inclinometer. Few minutes later the master had sent Stockholm Radio a notice.

The second mate further reported in his statement that the master had ordered him to take a position fix by DGPS. He had then entered that on the chart. The time had been about 03.20 hrs. At this time the list had been about 20°. Meanwhile the lifeboat with all crew members and the passenger had been launched. Only the master and he, the second mate, had remained on board.

On order of the master he had brought the survival suits on to the bridge and later to the main deck where both had finally donned them.

As the second mate stated furthermore, the master and himself had waited on the poop deck. After a short while the master had gone to the bridge again for a few minutes. When he had returned he had ordered him to abandon ship. After the master had lowered a life buoy with light the second mate in the survival suit had jumped over board and had then been picked up by the lifeboat. Later on the master had been taken on board by a Swedish rescue boat.

Statement of the first mate. The witness who sailed as first mate on the JANRA confirmed in his statement the master’s watch system as mentioned previously. He explained furthermore that the lookout was divided into two watches, viz.: 6–12 and 12–6. The lookout was manned regularly at night and during bad visibility. According to the ship owner’s order the automatic dead man’s handle was to be activated whenever there was no lookout on the bridge.

The first mate stated further that he had introduced the second mate who had been on board the JANRA since the end of November, 2000, into the handling and use of the navigational equipment on the bridge. When doing so he could establish that the second mate had had no problems whatsoever with the equipment. Altogether he had had the impression that this was an experienced mate who had already sailed even as first mate.

The first mate confirmed that unloading and loading had taken place in Rauma on December 22, 2000. Immediately after mooring the vessel had been discharged completely. During that time he had checked the stowing plan, which, having been prepared by the time charterer, was on board, and had then discussed it with the master. Both of them had then found the stowing to be all right.

The first mate reported in the public hearing that the crew in the port wrote down the container identification numbers which he then compared on the bridge with the loading list and subsequently fed into the computer.

After lunch the first mate had lain down on the sofa in his cabin and had slept for about one and a half hour.

Further, he explained that loading had been completed shortly before 17.00 hrs. Immediately afterwards the vessel had sailed. After he had eaten he had relieved the master on the bridge. At about 19.30 hrs he had been relieved by the master again. As the first mate explained furthermore he had been rather tired and had fallen asleep in his bunk soon afterwards.

Around the end of his off-watch the first mate had woken up by an unfamiliar sound or a shudder, what it had exactly been he could not tell anymore. At the same time he had noticed a slight list to starboard, such as would be caused by a pronounced change of course.

When that heeling did not abate he had dressed and gone up to the bridge. There the second mate had stood amidships in front of the conning position. The second mate had been unable, however, to explain him what had happened.

According to the statement of the first mate about 1.5–2 minutes had passed when he had appeared on the bridge, and the list had amounted to 10° to starboard. On the radar he had not seen another vessel in the immediate vicinity. On the electronic chart he had seen the vessel being in the triangle of the lighthouses Tröskeln Västra / Östra and Ambågen and steering full speed ahead with a south easterly heading. Shortly after this orientation he, the first mate, had woken the master by telephone. When doing so he had told the master that something had happened and that the vessel had developed an increasing list. When the master had been on the bridge shortly afterwards he (the master) had immediately changed the propeller pitch to zero and, having got an idea of the situation, the master had requested him to personally wake the people up and to urge them to assemble at the muster station. When he had left the bridge the list had been about 15° to 20°.

The first mate reported further that the lookout had encountered him on the stairs at B-deck level when he had left the bridge to wake the people up.

In the public hearing the first mate gave evidence that the crew had appeared at the muster station partly in beach sandals and without lifejackets. Considering the general situation he had not however sent the crew back but had ordered them to board the lifeboat.

As the first mate wrote in his statement furthermore he had released and launched the lifeboat when the crew and the passenger had been assembled in the boat. About 15 to 20 minutes might have passed[12].

He had stayed near the stern of JANRA with the life boat, and he could thus see that the list was ever increasing. Also he had seen the master and the second mate on the after deck, both having donned survival suits.

In addition the first mate could observe the master climbing to the bridge several times via the outer stairs.

Whilst the second mate, who had jumped into the water secured by a painter, had been taken on board by the lifeboat, the Swedish rescue boat which had meanwhile arrived had taken the master on board.

1.4.3 Statements of the Owner and the Chief engineer

Statement of the ship owner. The ship owner gave evidence that he had issued a standing order of how the watches were to be manned and that the dead man's handle was to be activated at sea whenever there was only one officer of the watch on the bridge.

Asked which crew member had sailed as multi-purpose rating on the voyage the ship owner answered that the first nautical officer had a multi-purpose ratings certificate. As this did not correspond with the application for issuing a minimum safe manning document and with the particulars concerning the requirements (application form SBZ) according to the Schiffsbesetzungsverordnung (Ordinance on Safe Manning) at the See-Berufsgenossenschaft (i.e. professional association for mariners), ship owner told the Marine Casualty Investigation Board that he could not get an other certified multi-purpose rating from the labour exchange. Also, he had had a Philippine boatswain according to STCW. In practice a bosun with a boatswains examination was worth more than a multi-purpose rating with little experience.

Further the ship owner gave evidence that the lingua franca on board normally was English. Since the crewing requirements with certain qualification profiles were sent to a crewing agency, they sent on board only people capable of speaking English. He had got the second mate, too, by a crewing agency. Since this one had already previously been occupied by another German shipping company he had inquired there. There had been no problems, neither alcohol, nor other negative points.

Statement of the chief engineer. The chief engineer who had sailed on the JANRA since about 1996 explained in his statement that he had switched the engine to sea mode after leaving Rauma. At about 22.00 hrs he had made a last inspection round through the engine control room (MKR) and the engine room. At that time all systems worked without malfunctions.

[12] The launching of the free-fall boat took place approximately at 3:20-3:25.

At about 03.00 hrs he was wakened by his wife, who was on board as a passenger, with the words “Wake up, the vessel develops a list”.

At first he believed that the list was caused by a change of course. When the vessel did not right again he dressed. At that time they were requested by the first mate to proceed to the muster station on B-deck.

Furthermore the chief engineer stated that after having sent his wife to the muster station he had gone into the engine room to look for possible causes of the increasing list. When he had not found any malfunction in the MCR and had not noticed water ingress in the engine room either, he had gone further down to check the positions of the valves of the ballast system. Since several loose parts had started to move on account of the increasing list he had considered the situation to be critical and had hurried on deck in order to board the free-fall lifeboat together with his wife. Immediately afterwards the boat had been launched.

1.5 Rescue operation

1.5.1 SAR agreements, organization and Radio services

The collision took place in the Finnish territorial waters. The rescue responsibility border is illustrated in figures 7 and 18. The Tröskeln Västra beacon lies near the border on the Finnish side.

Rescue operations were guided according to an agreement between Sweden and Finland[13]. The agreement declares that the rescue organization that learns of a distress on the other side of the rescue border has to inform the appropriate rescue organization in the other neighboring state. The agreement did not encourage the rescue units to cross the rescue responsibility border. However the agreement gave the possibility for the rescue organizations to reach an agreement on local level to coordinate operations[14].

Based on the national agreement between the states, the Finnish Boarder Guard (Coast Guard) and the Swedish Board of Navigation made an agreement about co-operation in rescue operations[15]. The agreement did not give permission to cross the border without the permission of the other state. However agreement gave possibility to agree between the MRCCs about methods of co-operation. Some verbal agreements have been agreed upon, but they have not been documented. Officially rescue units are not permitted to cross the rescue responsibility border without permission.

The agreement above did not deal with the distress traffic. The Global Maritime Distress and Safety System (GMDSS) rules were in force. According to GMDSS procedures the rescue Coordinating centre acknowledging the distress alert is responsible for control-

[13] Spr. 27/1994. Agreement with the Kingdom of Sweden about maritime- and aerial rescue operations.
[14] Spr. 27/1994, article 5, mom. 2.
[15] 1st february 1994.

ling a search and rescue operation and shall also coordinate the distress traffic[16]. Around the Tröskeln Västra area the responsible rescue organization was the Finnish Maritime Rescue Coordinating Center (MRCC) in Turku.

The maritime radio services in Finland are divided between MRCC Turku and Turku Radio. Coast Guard personnel operates the MRCC Turku coast radio station. The Finnish Maritime Administration (FMA) established the Turku Radio station on 1 May 1997 and FMA personnel operate the station. MRCC Turku is responsible for distress and urgency traffic. Turku Radio is responsible for safety and Radio Medical communications. Turku Radio acts also as a back-up station during distress traffic.

All radio relay stations on the Finnish coast are linked to Turku Radio and Turku MRCC. Both radio stations hear all communications along the coast. However when a coast station connects itself to a relay station the other coast stations are blocked from that relay station and they are unable to monitor the traffic.

Neither Turku Radio nor any other Finnish coast station support general radio calls to telephone network. Telephone calls must be directed to Tallinn or Stockholm radio.

Stockholm Radio acted also as a Maritime Rescue Sub Center (MRSC). According to the Swedish system there is always an On Scene Coordinator (OSC) on duty in the MRSC. The Swedish Maritime Rescue Coordination Center (MRCC) is in Gothenburg. The Swedish system is clear because the radio station and the rescue center are united.

Despite the agreements between Finland and Sweden, the rescue operation has to be coordinated by the rescue organization, which has acknowledged the distress alert.

1.5.2 Radio traffic and Distress Alert Relay

The master of JANRA was familiar with the radio traffic between other ships and Radio Stockholm. When JANRA suddenly listed the master felt it natural to contact Stockholm Radio. His call was a normal call on VHF channel 16 on Saturday December 23 at 03.16 hours (UTC+1). MRCC Turku heard JANRA calling Stockholm radio but noted it as a general traffic call. The situation was deemed as distress and six minutes later at 03.22 MRCC (Gothenburg) broadcasted a Shore-to-Ship Distress Alert Relay[17] (MAYDAY RELAY) announcing that JANRA is in distress in position 59° 37.7’ N and 19° 53.6’ E. The ship was heavily listed and had 11 persons onboard. MRCC Gothenburg took the command of the rescue operation.

Six merchant vessels answered to the Distress Relay message.

[16] ITU, Manual for use by the Maritime Mobile-Satellite Services, Chapter N XI, Article N 39, N 3148.
[17] ITU, Manual for use by the Maritime Mobile-Satellite Services, Chapter N XI, Article N 39, N 3117.

Table 13. Vessels reporting to MRCC Gothenburg.

Reporting time UTC + 1	Vessel name	Insignia letters	Distance to go	ETA
03.23	SCHELDEBORG	PHIZ	10'	1.5 hours
03.27	OBBOLA	SEBR	8'	
03.27	KRISTIINA	OJDK	13'	
03.34	DON	P3XY6	3'	
	MARINA	SFAW	11'	

The master of mv ICE STAR (PCAE) was ordered by MRCC Gothenburg at 04.44 to act as the OSC (On Scene Coordinator).

In addition to the vessels mentioned above, six other vessels reported to MRCC Gothenburg. They got permission to continue their voyages because they were too far away from JANRA. The Finnish icebreaker BOTNICA (OJAC) was also on the scene but got permission to proceed on her voyage.

1.5.3 Rescuing the people

The SAR (Search and Rescue) helicopter base in Visby, Sweden received the alert from MRCC Gothenburg at 03:26. Shortly after the helicopter base in Berga was also alerted as well as Swedish Coast Guard's surface units from the Kapellskär area (Kustbevakningen Öst). Also the Swedish Life Boat Association's units MÖJA and RONALD BERGMAN and the pilot cutter from Kapellskär's pilot station were called to.

JANRA got a starboard list and the list increased steadily. Eight crew members and chief engineer's wife abandoned the ship with the free-fall lifeboat. This took place about at 3:20–3:25. The master and the 2nd mate stayed onboard. The lifeboat stayed close to JANRA. The 2nd mate also left the ship and was picked up by JANRA's lifeboat. When the Dutch vessel ICE STAR had arrived at the scene, the lifeboat went alongside it and the crew moved onboard ICE STAR. They were served hot tea.

When the rescue vessel RONALD BERGMAN arrived at the scene, the master left JANRA and boarded RONALD BERGMAN from poop deck. The crew went from the ICE STAR to RONALD BERGMAN. RONALD BERGMAN took the lifeboat on tow. The tow started at 05:25. The life raft had been opened at some stage and it was recovered. The crew was brought ashore at Råfsnäs, Sweden and then they were transferred to a hospital by Swedish police. No one had physical injuries.

According to RONALD BERGMAN's master, JANRA's crew was lightly dressed. Most of them were wearing only t-shirts, shorts and open sandals. They had no identification papers or personal belongings with them. All had life jackets on and were sea-sick.

The Master stayed in the vicinity of the JANRA onboard the pilot cutter which had also arrived at the scene.

The track of JANRA after the collision is shown in figure 18. The rescue activities and the development of the list are listed in table 14 and the corresponding location of the vessel is shown in figure 18.

Summary of crew activities onboard after the collision

Master — was informed by the Chief Mate that something had happened. When he entered the bridge, he tried to get a general view what had happened. Preventive he set the propeller pitch to zero, switched on the deck and the n.u.c.(not under command) lights, gave order to the chief officer to make sure that everybody of the crew will be awake and goes to the muster station with warm clothes on and after that he informed Stockholm Radio “I’ve got a problem, 11 persons onboard, gave position”. He gave the order to abandon the ship with the live boat. He put on a survival suit. After some additional activities he gave order to the 2nd Mate to get over to the life boat. The master himself was rescued later on by the rescue boat RONALD BERGMAN.

As stated in the public hearing, the behaviour of the master was a good circumspect work, based on former knowledge and experience with the “ISM-Code”.

Fact is indeed, that the first alert to onshore rescue system was not according to the international radio regulations.

Chief mate — waked up by something abnormal noise like a hit, went Immediately to the bridge, stated a list of the ship, asked the 2nd Mate “what has happened” and called the master. When the master arrived at the bridge, he got the order to make sure that everybody of the crew will be awake and come to the muster station with warm clothes on to abandon the ship.

As stated in the public hearing, the behaviour of the chief mate was a good circumspect work as well.

Fact is indeed, that most of the crew members didn’t have warm clothes when they were picked up by rescue boat RONALD BERGMAN.

2nd Mate — A few seconds after changing the course he stated a list. Unable to answer to the questions of the chief mate or the master obviously he had lost the general view. Together with the master he watched the inclinometer. It was a circumspect behaviour of the master to make sure that the 2nd mate put on a survival suit. Some minutes after the crew he abandoned the ship with a lifebuoy and was picked up by life boat.

Ch. Engineer — Informed by his wife about the list he straight went to the control room and checked ballast system. He couldn’t find any faults so that other reasons must be responsible for the increasing list. According to the increased list he went back to his cabin, picked up his wife and warm clothes and went to the muster station.

Correct and circumspect action to go to the control room and after that follow evacuation orders.

Ch.Eng. wife Realized the list and had a feeling that something was wrong. Immediately she woke up her husband, put on warm clothes and followed her husband to the muster station.

Correct and circumspect action to go inform the husband about the list and put on warm clothes and follow evacuation orders.

Crew Were informed by the chief mate to put on warm clothes and went to the muster station in a composed behaviour.

Fact is indeed, that all crew members were in light clothing. The reason for that is unknown; were the crew members equipped with warm clothes or were warm clothes stored in the locker for the working overalls or was it a lack of knowledge and training.

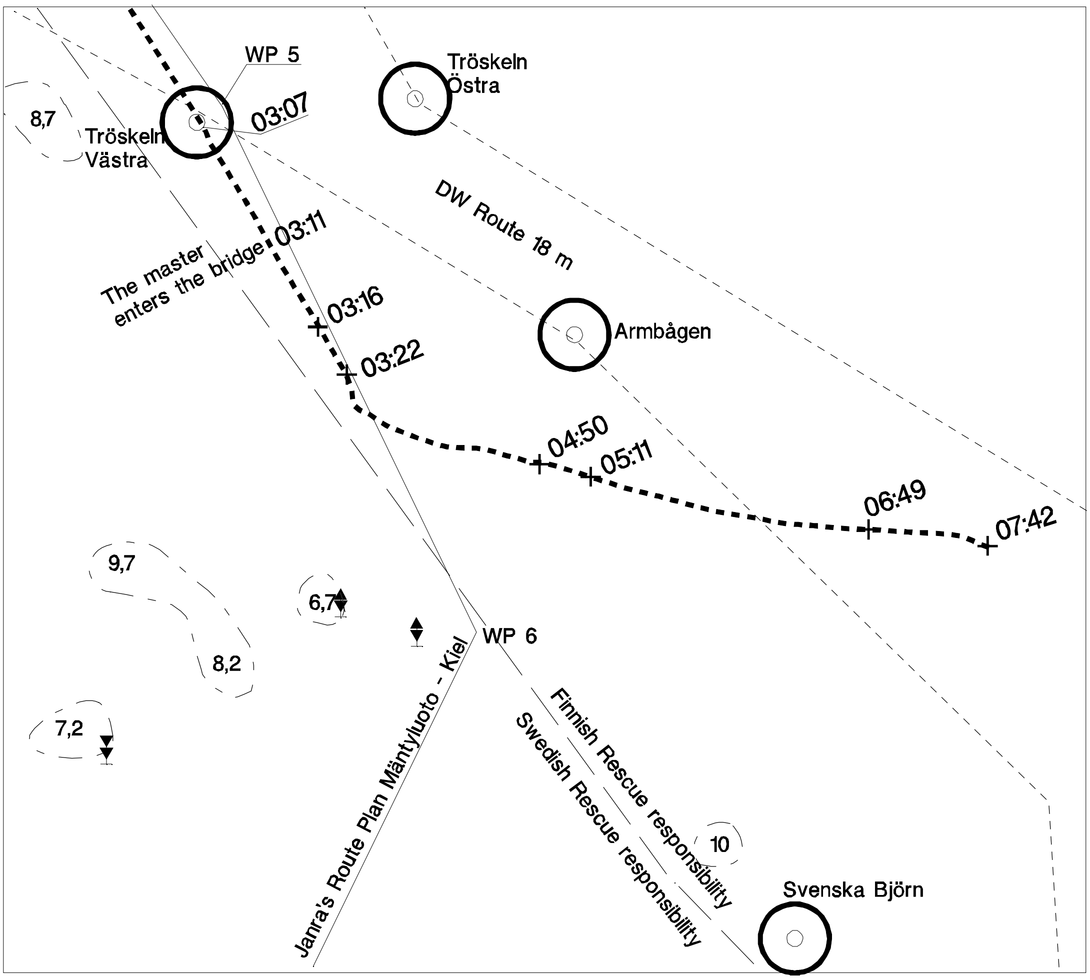


Figure 18. The track of JANRA after the collision. All activities took place on Finnish rescue area.

Table 14. The rescue activities and the development of the list. JANRA's drift after the collision is shown in figure 18.

TIME UTC+1	WGS-84	SPEED knots	Comments
03:07	Collision	14.0	The accurate beacon position is on table 16. The collision is Illustrated on figs 31 and 34.
03:08			List 5°-7° according to the second mate.
03:09			List 10° according to the first mate after his arrival to the bridge.
03:11			List 10°-15° according to the master after his arrival to the bridge.
03:13			The master slows down the speed.
			List 20° according to the first mate when he left the bridge.
03:16	59 37.970 N 19 53.360 E	7.8	The master took a normal call to Stockholm Radio and explained the situation.
03:20			List 20° according to the second mate when he was taking a GPS fix.
03:20–03:25			The launching of the free-fall life boat.
03:22	59 37.540 N 19 53.850 E	3.8	Gothenburg MRCC announced promptly MAYDAY RELAY for JANRA.
04:50	59 36.810 N 19 57.040 E	1.2	Rescue vessel RONALD BERGMAN arrived. RONALD BERGMAN took JANRA's lifeboat on tow.
05:11	59 36.710 N 19 57.820 E	1.2	RONALD BERGMAN rescued JANRA's master. JANRA's list was 35°-40°.
06:49	59 36.270 N 20 02.360 E	1.5	JANRA's list was 90°.
07:42	59 36.120 N 20 04.340 E	1.1	JANRA capsized and the recording computer stopped.

The Swedish pilot, who had been assigned as OSC and was arriving at scene, discussed with JANRA's master at 05:30 about the situation via VHF. The master reported that:

- JANRA is drifting and is abandoned,
- the main engine is running and pitch is on zero,
- the ship is heavily listed,
- sea is washing the forecastle and
- it seems that she is sinking.

The Swedish patrol boat KBV 311 reported at 06:49 that JANRA had fallen on her side, her propeller is running in the air and the deck cargo has begun to get loss. At 07:53 JANRA was upside down and her keel towards the sky. At about the same time JANRA's EPIRB was activated and the patrol boat picked it up.

1.5.4 The rescuing of the vessel

Figure 19. JANRA photographed on December 24, 2000 at 11 hours. The tow is fastened to her rudder.

The Salvage Company reported about the salvage agreement at 14:00 hours on 23 December, 2000 and their tug was leaving Hanko immediately for JANRA. The salvage tug began to fasten the tow line in the following morning. The towage towards Aland Archipelago began at noon. A Finnish Coast Guard vessel escorted and assisted the tow. The speed was 1.5 knots. The area for salvage in the archipelago was accepted by Finnish authorities and the provincial government of Aland.

The Aland government set the following requirements on salvage operation:

- at first the fuel tanks must be made airtight,
- in case of rough weather the salvage company must continuously have enough tug capacity available to tow JANRA to a safe area,
- the salvage company shall report regularly,
- both cargo and ship shall be salvaged,
- the fertilizer containers shall be salvaged first and
- the shipping company is responsible (i.e. a quarantee at deposit), if pollution takes place.

On Friday December 29, 2000 some tugs and a pontoon with mobile crane and other salvage material arrived at the scene. JANRA was anchored to stay in same position despite of weather conditions. Then all hull and tank openings were closed and JANRA was surrounded by oil recovery booms. After these operations the deck cargo was dropped to the bottom.

Then JANRA was towed to Kungsholmen bay in the inner archipelago. A floating crane with maximum lifting capacity of 800 t had arrived and its cables were attached to JANRA. The first try to turn JANRA by the crane assisting with ballasting and de-ballasting JANRA's intact tanks and air was pumped to holds. This effort was not successful due to a too small lifting capacity of the crane and too marginal buoyancy of the vessel. JANRA sank when air locked in the engine room escaped uncontrollably. The starboard side of the bridge was damaged and was later found to be full of mud. The salvage company succeeded in surfacing JANRA again in a few hours, but still upside down, with pumping air into intact tanks.

The second try to turn JANRA was made when a bigger floating crane (lifting capacity of 3 600 t) from the Netherlands arrived. Meanwhile the containers of deck cargo, which had earlier been dropped to sea bottom, were lifted up and transported to Rauma. In the evening on February 16, 2001 the second, successful, operation started. On the following morning JANRA was pumped empty enough and it floated once again.

Figure 20. JANRA turned upright. *(Oy Alfons Håkans Ab)*

In the evening on February 17, 2001 JANRA's tow to Turku begun in order to discharge the cargo.

The owner wanted JANRA to Germany for repairs. Finnish authorities demanded the following:

- discharging the cargo before leaving Turku
- the hull to be repaired temporarily in an acceptable way,
- stability calculations to be made and to be acceptable,
- the hatchways to be tightened and fastened,
- the windows and other openings to be covered in two decks,
- the classification society to present a certificate for the tow to Germany,
- the towing company to be skilful enough,
- the rudder to be kept mid ships,
- the propeller shaft to be locked and
- the wind force during the towing should not exceed 10 m/s.

All these demands were fulfilled on February 26, 2001 at 12.30 o'clock and JANRA could be towed to a dry dock in Hamburg, where she was repaired and got back to service.

1.6 Damages to the vessel, the cargo, the edge mark and the environment

1.6.1 Damages, the Ship

The damages of the JANRA were assessed for the first time at the beginning of the salvage operation, when she had been towed to Aland. The damages to the underwater part of the hull were videofilmed by the divers. As these damages were later repaired under water to facilitate the turning, the videofilm gives the only information about the actual form of the hole to the hull plates. The ship damages are shown in figure 21.

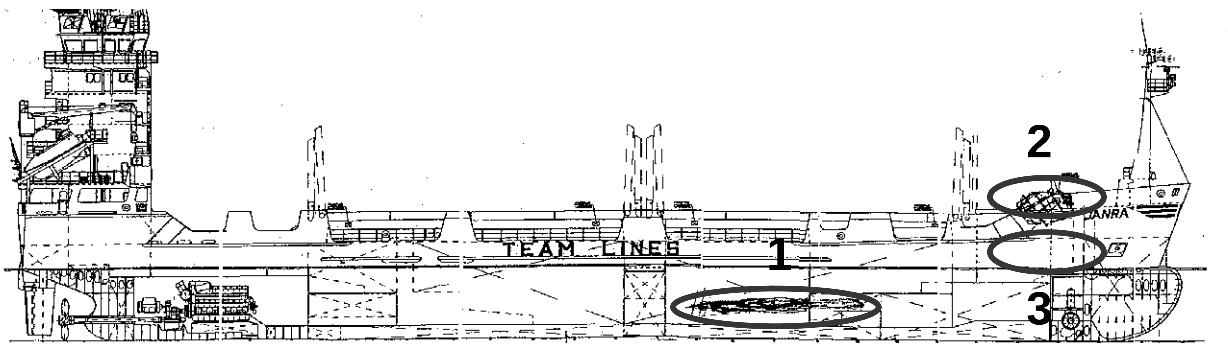


Figure 21. The damages on the starboard side of JANRA.

The damages were found in three main areas of the hull. One long hole was below the waterline on the side just forward of the midship (marked by number 1 in figure 21). This hole was a longitudinal rather narrow cut just above the bilge, see figure 22. As a result of this hole the side tank (SB wing tank nr. 1) was damaged. This cut also extended to an area where no double hull existed at hold no. 1.

Figure 22. The damage on the side plating below waterline, damage no. 1 in figure 21. The cut is very sharp and the bow is to right. The hole is still temporarily repaired for the voyage from Turku to Germany. (Note that this picture is a composition and the perspective is not correct.)

Figure 23. The temporarily repaired damage in hold no. 1.

Another area of damage was on the starboard side of the forecastle, which had been damaged at two places. This area can be seen in figure 24. One damage was at the end of the reeling of the forecastle (number 2 in figure 21). This damage opened the forecastle to the sea. The other narrow cut was on the side of the bow above waterline (number 3 in figure 21 and figures 24 and 25). This hole damaged the starboard double bottom tank (SB DB tank nr. 1).

Figure 24. The two areas of damage on the bow of the JANRA. The photograph has been taken after the ship had been turned. (The lower hole had been temporarily repaired under water.)

Figure 25. The damage on the side plating above waterline in bow, this is damage nr. 3 in figure 21.

The damage sequence. When JANRA hit the Tröskeln Västra the two damages in the starboard bow area occurred simultaneously. The one in the forecastle reeling was caused by the hit to the edge mark tube. The sharp cut on the bow side plating above water line was probably made by the ice cone upper edge. The cone was found to be slightly damaged and it was at the corresponding height, see figure 26.

The damage on the side plating forward of the midships which was below waterline is also a long cut and it was caused by the remaining part of the edge mark. It is supported by the fact that the height of the remaining edge mark part below water level corresponds to the damage of the ship, see figures 22 and 26.

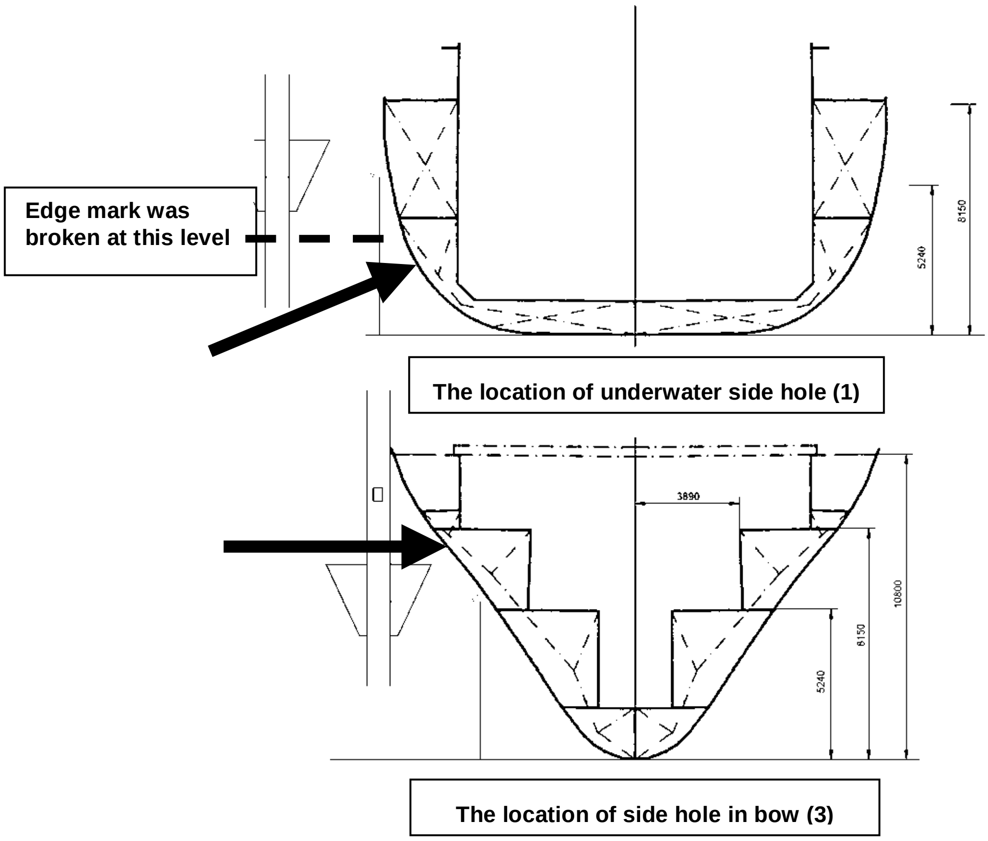


Figure 26. The Tröskeln Västra edge mark compared to the damaged cross sections of JANRA. Note the level where the edge mark had broken (dotted line) in the upper drawing and the level of the ice cone sharp edge in the lower drawing compared to the location of corresponding damage. The view is from bow to stern.

Other damages. When the JANRA had been turned up, it was found out that also the bridge of the ship had had a bottom touch and the windows on the starboard side had been broken. As a result of this the starboard side of the bridge had been filled with mud, which caused some difficulties in the retrieving of the navigation computer.

The costs of the damages. The final assessment of the damages was carried out at the Norderwerft in Hamburg. The insurers described JANRA as a total loss. The cost of damage to the cargo is still pending. The cost of the collision is made up by:

- JANRA ca. 7 million EURO
- salvage money ca. 4–5 million EURO
- damage to the lighthouse ca. 0.75 million EURO
- oil pollution combatting (security deposit) ca. 1 million EURO

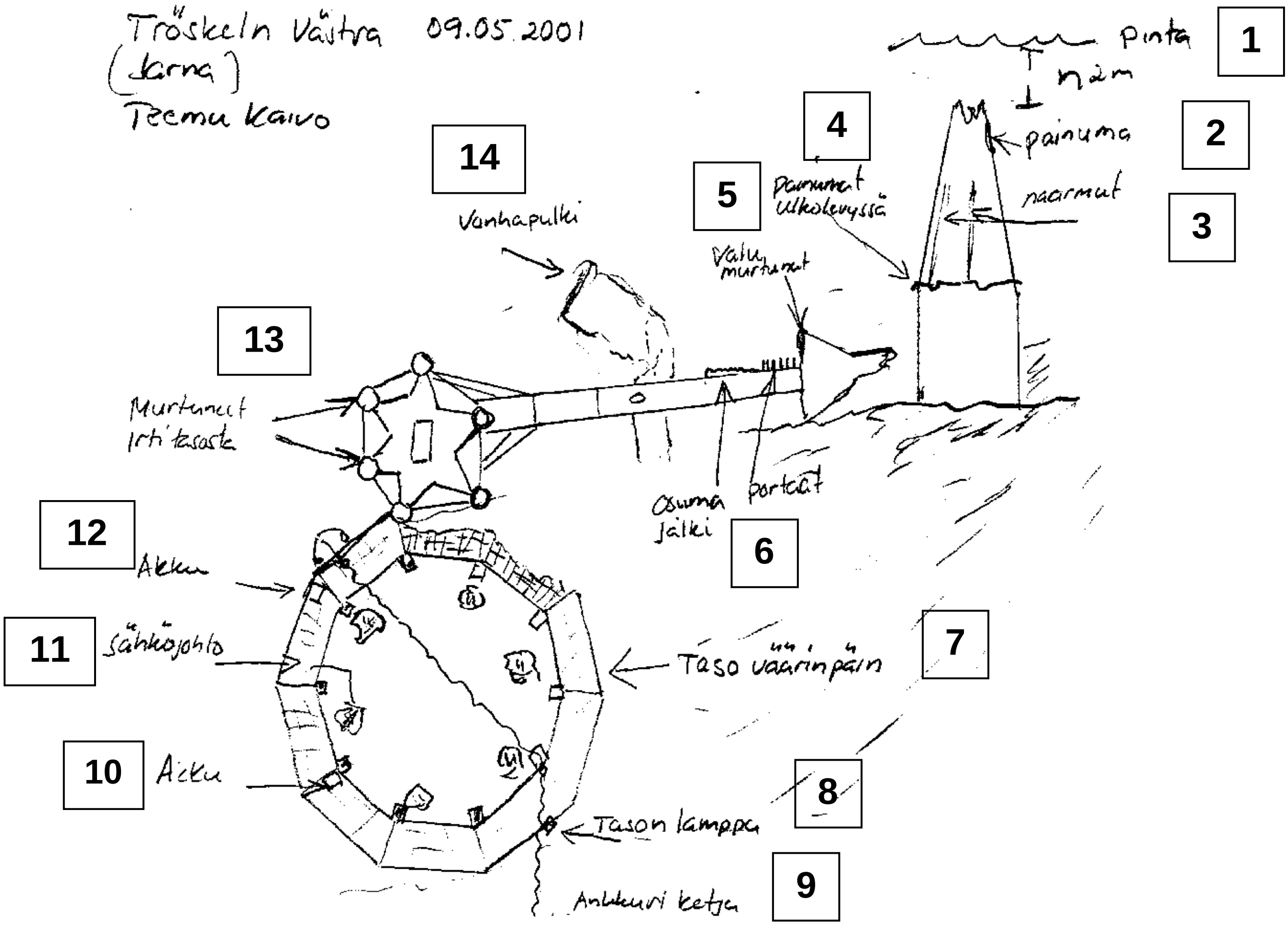
1.6.2 Damages, the cargo

JANRA's cargo was in containers. It consisted mostly products from Finnish paper and saw mill industry as, paper reels, pulp bales, sawn timber etc. Some containers were loaded with machinery. One container was loaded with 21 tonnes fertilisers and there were two tank containers with liquid named "Nessol Liav 250". Neither of these chemical containers were declared to be listed in the IMDG Code. When JANRA capsized, six cargo containers got loose. Four of these sunk rapidly while two stayed partly on surface. They sunk later. The cargo which was still in the ship got wet and was considered a total loss.

1.6.3 Damages, Tröskeln Västra edge mark

The Edge Mark was totally destroyed. It was cut off some metres below the surface. In the upper part there were traces of a hit in the area where the door to enter the mark had been. See the diver's sketch and photo of the point of impact on the recovered part of the edge mark in figures 24 and 25. According to the divers the fallen edge mark was near its original position and was not moved away by the ship.

Figure 27. Position of the impact on Tröskeln Västra. In the middle is the door opening.



1. Water surface, distance mark = about 2 m
2. Dent
3. Scratches
4. Dents in the girder
5. Broken concrete
6. Impact and stairs (Figure 25)
7. Helicopter platform upside down
8. Platform light
9. Anchor chain
10. Battery
11. Electric wire
12. Battery
13. Broken from the platform
14. Old edge mark

Figure 28. Diver's sketch of the damaged Tröskeln Västra, the figure, north is approximately up.

1.6.4 The environment, precautions and damages

Figure 29. The oil prevention booms around JANRA during the rescue operation in Aland.

Oil prevention during initial salvage actions. The Finnish Environmental Center sent the oil prevention vessel HALLI to the accident scene. JANRA had caused a minor oil spill. HALLI arrived at the scene on December 24, at 0.30 am. JANRA was drifting approximately to South at a speed of 0.7 knots. During the night tugboat NEPTUN owned by Alfons Håkans Ab had arrived. The company had made a salvage agreement for the vessel. The Coast Guard vessel UISKO was warning bypassing traffic of the accident. The waves were too high to collect oil.

In the morning, December 24, 2000, NEPTUN tried to attach the tow to JANRA without success. The bow thruster of the tug faulted but HALLI suggested to launch a workboat to attach the tow. An officer from HALLI climbed on the bottom of JANRA and sled the towing rope around the rudder. After this the workboat took the rope to the tug and it was attached there.

HALLI escorted the tow to Rödhamn located in the Southern Aland. It is a sheltered place with sufficient dept. HALLI assisted the navigation in narrow passes and JANRA was towed without further damage to the area. JANRA had submerged more during the tow and sank during the night. The propeller, rudder, and a small area of the bottom remained visible above the sea level.

Oil prevention in the shelter area. HALLI had 550 metres of heavy sea oilboom. Halli beamed the area during the night. After booming HALLI left for Pansio to get more boom and other required material. In the pictures taken next day one could notice that the booms had moved with the wind but JANRA had not, so the booms were laying against the vessel. Ms SVÄRTAN corrected the rigging of the booms. There was some oil spill from JANRA inside the boomed area.

Because it took some days to mobilise the salvage company's resources it was agreed that the JANRA didn't need more booming before the new year. It was decided that HALLI left for JANRA next time on January 2, 2001. On December 31, 2000, the Environmental Center received information that air had been blown in JANRA's engine room and this had caused an oil spill.

The salvage company started to prepare JANRA for turning by closing the air pipes to the fuel tanks. Aside to this they had to blow air to the engine room to keep the vessel from sinking. The crew on HALLI had a plan for booming around JANRA and they intended to build a square with side length of 400 metres. The salvage company announced that they will remove JANRA for a better shelter so there was no point in booming this place. Relying on the schedule of the company was a mistake. During the job the oil spill increased slowly. When the containers which were on the deck were dropped oil was released between them. HALLI collected oil from the sea with its collectors. Although some oil stranded to shore also.

JANRA was removed on January 16, 2001 to a better shelter and a boomed square with side length of 400 m was built around it. On one side there was a gate that could be opened. The anchoring of the corners of the square was made with concrete anchors of 6.5 tons. JANRA was kept from sinking by pumping air to the engine room during the turning. When the pumping was paused, pressure changed in the engine room and caused an oil leak. HALLI collected oil from beaming approximately 35 m^3 during the turning operation. After turning some oil was pumped by HALLI from JANRA. The total amount of oil collected by HALLI was c. 37 m^3.

The oil prevention costs to the state were circa 0.55 million €. Additionally provincial government of Åland demanded a compensation of 0.4 million €. The expenses of the state consisted of the vessel's (HALLI) capital, maintenance and fuel costs, labour costs and buying outside services.

1.7 Special studies by the Investigation Commission

1.7.1 Retrieving the evidence from the ship

When JANRA had been turned to upright on February 17, 2001 the Finnish and German investigators went onboard. They searched for evidence from the bridge as well as from the ship's office. The main interest on the bridge was directed to the electronic chart computer, which could be located in and extracted from the navigation console. The hypothesis was that the recorded track in the electronic chart could provide important objective information on the navigation of the ship before collision.

Difficulties for this retrieval was caused by the 1 metre high layer of mud which had been accumulated to the bridge when the ship sank to the bottom during salvage attempts.

Figure 30. The investigators searching for the electronic chart computer.

After retrieval the electronic chart computer was immediately stored in the sea water and in this condition it was transported to Norway. A specialist Norwegian company could retrieve 98 percent of the contents from its hard disk. The computer had been under water for about 8 weeks between the capsize and turning upright.

The investigators took from JANRA in addition to the navigational hardware some other available evidence such as ship documents which were later dried.

1.7.2 Position of the edge mark and the practise to use charts

Satellite navigation provides an absolute position fix based on measurements from space. The result is presented in absolute latitude/longitude co-ordinates. There are no systematic errors and the normal distribution is only about 10 metres with 95% probability. Even the accuracy can be displayed, which was not possible with the terrestrial systems. The accuracy is superb for coastal navigation. The only problem is the large number of co-ordinate systems in use.

JANRA had her satellite position presented on an electronic vector chart. The TRANSAS NaviSailor software was designed to present the chart always with the international WGS-84 co-ordinate system. The satellite receiver must be switched to the same system. It can be verified that JANRA's GPS-receiver was on the WGS-84 system. There were no confusion with the co-ordinate systems.

The electronic chart was digitised from the U.K. chart A 2297. On the electronic chart the beacon position deviated 168 metres from the real beacon given by Finnish Maritime Administration. The error cannot depend on confusion between Finnish and international co-ordinate systems because the Finnish KKJ (Finland Heyford) deviates mainly in longitude from WGS-84 (figure 27).

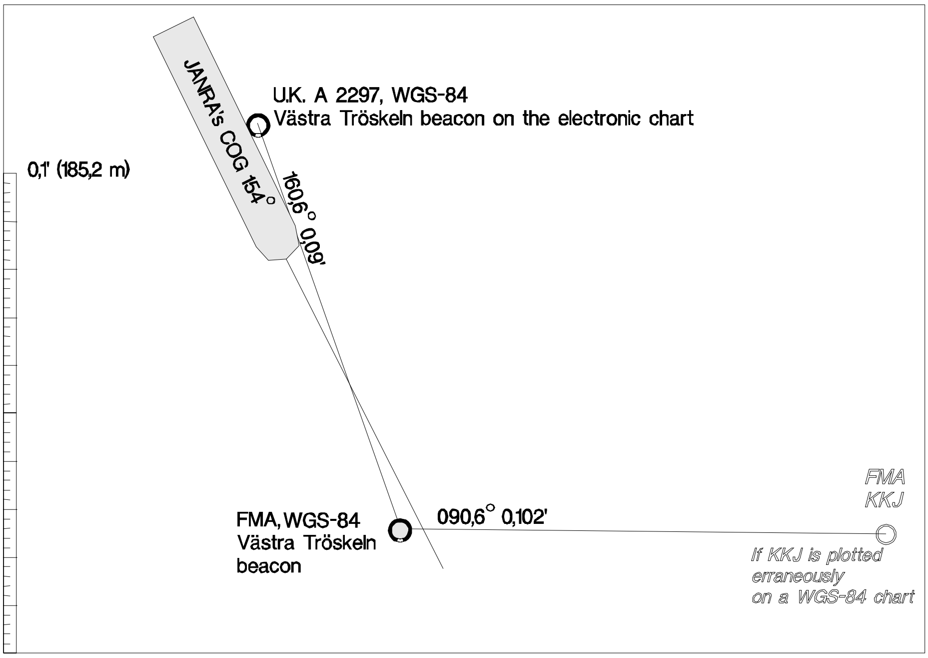


Figure 31. Different Tröskeln Västra beacon positions on a WGS-84 electronic chart.

Finnish Maritime Administration (FMA), WGS-84 = the correct beacon position.
UK. A 2297 = beacon position on JANRA's electronic chart.
FMA, KKJ = the Finnish co-ordinate system was not displayed on JANRA's electronic chart.
COG = Course Over Ground

Table 15. Different position data about Tröskeln Västra beacon. FMA = Finnish Maritime Administration.

Data origin	Västra Tröskeln beacon	Coordinate System	Latitude	Longitude
U.K. A 2297	Position on JANRA's electronic chart is marked with sufficient accuracy	WGS-84	59° 39.666' N	019° 51.461'E
FMA	Accurate beacon position on WGS-84 chart	WGS-84	59° 39.581' N	019° 51.520'E
FMA	Finnish beacon co-ordinates are allowed only on Finnish national charts	KKJ, Finland Hayford	59° 39.580' N	019° 51.721'E

The direction between the beacon position on the electronic chart and the real position was almost the same as JANRA's course. By avoiding the beacon mark on the chart one avoids the actual beacon also.

JANRA's position fixing on the electronic chart was correct. The beacon was displayed with sufficient accuracy for coastal navigation.

The practice to monitor the position. The master stated that position fixing had to be frequent in the Tröskeln area[18]. That was possible with the electronic chart. Both the master and the first officer testified that they thrust the satellite positioning system and the electronic chart. Confidence to the new system was built up by comparing it with the radar picture, which represented traditional relative navigation. The acts of the first officer and the master demonstrated the position monitoring practice. When they entered the bridge after the collision they checked the position from the electronic chart and the radar.

It can be understood from the master's statement that the second officer was given the responsibility to maintain and store the route plans in the electronic chart route directory. The master told that the second mate had previously followed the passage plan satisfactory. The mate followed the programmed passage plan from 02:10 to 02:54, which indicates that he was monitoring the electronic chart. If he had monitored with the radar, he would have used the ARPA and he would have seen the echo of Tröskeln Västra.

The practice to document the position. The master and the officers did not mention of any standard procedure to document positions. All statements referred to habits. The position is documented every second hour on all ships. The second mate called it a normal routine. The first mate testified that the GPS or the radar were basis to the documentation. The passage plan courses were drawn also on the paper chart. The master called them to be 'almost compulsory courses[19]' which reveals that a standard procedure was not agreed.

The master expressed himself clearly that on an area with dense traffic and hazardous objects, only the position monitoring is frequent. Position documentation cannot be frequent because it would prevent navigation and manoeuvring. The master was asked at the hearing if this two-hour time interval was a standard procedure of JANRA. The master answered that the position documentation takes place every second hour on all ships.

The master stated that German chart Nr. 170 (fig. 32) was used onboard and the chart was correct. The investigators have not found the paper chart. A fix every second hour illustrates the track roughly and the time schedule. It did not serve navigational purposes. The electronic chart software records the position automatically every ten seconds.

[18] Master's statement 14.06.2001, SEEAMT HAMBURG.
[19] Master's statement 14.06.2001, SEEAMT HAMBURG.

The habit to fix position for documentation can not be judged to be a habit to navigate through the Tröskeln outlet to the Baltic by plotting ships path on a 1:125000 scale paper chart where the accuracy is 125 metres per millimetre. The accuracy of the NaviSailor electronic chart system is far better and suites monitoring needs better.

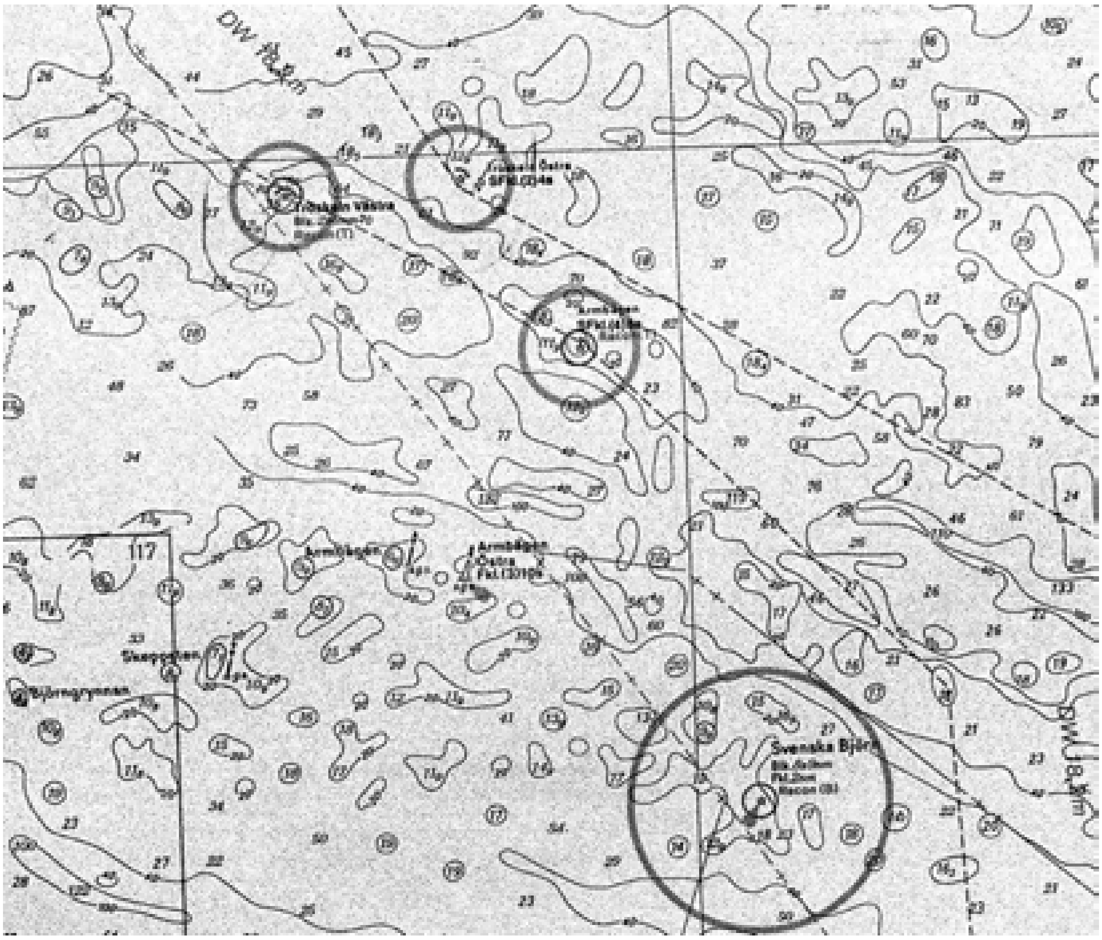


Figure 32. German paper chart nr. 170 in the area of Tröskeln Västra. Reprint authorized by the Federal Maritime and Hydrographic Agency.

The FMA warning on the position accuracy of Tröskeln Västra in charts based on different coordinate systems was released after JANRA accident. The director of the Archipelago Maritime District, Finland, issued a navigational warning on January 9, 2001, at 15.39 UTC:

„FINNISH NAVIGATIONAL WARNING 08

SEA OF AALAND

ON RE-CONTROLLING OF THE POSITION OF THE BEACON TRÖSKELN VÄSTRA HAS BEEN FOUND ERROR BETWEEN TRUE POSITION AND WGS 84 COORDINATION SYSTEM BASED CHARTS THAT THE BEACON IS MARKED 0.20 MINUTES (0.10 nm) TO EAST FROM ACTUAL POSITION.

THE POSITION IS CORRECT ON FINNISH AND SWEDISH CHARTS.

INVESTIGATION IS GOING ON IF THE FOUND ERROR IS SYSTEMATIC ON ALL WGS 84 BASED CHARTS ON FINNISH WATERS.

NAVIGATORS ARE STRONGLY RECOMMENDED NOT TO PASS THE POSITION OF THE BEACON TRÖSKELN VÄSTRA TOO CLOSE, ESPECIALLY ON WESTERN SIDE."

The message was broadcasted by Turku radio repeatedly and by Navtex.

The Bundesamt für Seeschiffahrt und Hydrographie (BSH) (i.e. Federal Maritime and Hydrographic Agency) told the Marine Casualty Investigation Board, Hamburg, on request:

"I can inform you that the lighthouse Tröskeln Västra is entered in the German chart No 170 on the position 59° 39.6'N 019° 51.7'E. This chart is based on the basis of Finnish and Swedish charts. This chart is drawn not in the WGS 84, but in the Finnish KKJ-system."

The chart No 170 contains the following remark:

"Positions gained by satellite navigation in the World Geodetic System 1984 (WGS 84) are in the Finnish area to be shifted 0.00 minutes to the north/south and 0.21 minutes to the east, in the Swedish area 0.04 minutes to the north and 0.23 minutes to the east in order to coincide with this chart."

The "error" published in the aforementioned FMA navigational warning cannot be considered as an "error" of the co-ordinates of the lighthouse but has generally to be taken into account as correction when using GPS positions on the German chart No 170. Therefore the word "error" in the navigational warning is incorrect.

1.7.3 Damage stability calculations

The stability of JANRA was analysed at two basic conditions. In this analysis both the initial intact stability and the damaged stability after the collision were calculated. The calculations were carried out for the commission by Ship Consulting Ltd in Turku Finland, which used the NAPA software in these.

The three dimensional calculation model of the ship had been created for the salvage work of the JANRA as the same consulting company had also calculated the stability of the ship during the turning operation in Aland for the salvage company.

The intact stability calculations were based on the loading plan made before departure at Rauma. The results of these calculations compared to the stability requirements are presented below both as tabled results.

The loading condition of the JANRA at the departure from Rauma was:

Displacement	7223 t
Draught, fore	6.071 m
Draught, aft	6.401 m
KM	8.110 m
KG	7.210 m
GM_0	0.900 m
GM_{corr}	-0.01 m
GM	0.880 m

Table 16. The intact stability of JANRA at the departure from Rauma.

Definition	**Requirement**	**Actual value**	**Status**
Area under GZ-curve, 0-30 deg	0.055	0.101 mrad	ok
Area under GZ-curve, 0-40 deg	0.090	0.155 mrad	ok
Area under GZ-curve, 30-40 deg	0.030	0.054 mrad	ok
Max. GZ > 0.2 m	0.200	0.318 m	ok
Max. GZ at an angle (> 25 deg)	25.0	38.182 deg	ok
GM > 0.15 m	0.150	0.880	ok

As can be seen from the table the stability requirements were clearly fulfilled at the departure.

In the damaged stability calculations the state of the vessel immediately and later after the impact was analysed, based on the damages to the hull and the description of the crew members as well as the photographs and videotapes taken from the ship during the rescue operation.

Two cases of damaged conditions were used in the calculations and in both the wing and double bottom tanks are damaged. In the first (case 1) the forecastle was considered as intact and in the second (case 2) the forecastle was damaged i.e. not providing any buoyancy.

According to the calculations the vessel has a large heeling angle of 28 and 30 degrees respectively in the cases 1 and 2 when the wing and double bottom tanks are filled, see also figure 33. The differences of the two cases appear when the calculations are continued further with partly filling the forward hold.

If the forward hold is filled first with 50 tons and then with 100 tons of water, the ship capsizes according to the calculations with the latter amount in the case 2 calculations with forecastle not giving additional buoyancy. In the case 1 the stability is not much better although the ship is still up.

Table 17. Comparison between heeling arm GZ in initial and the calculated damaged conditions. Case 2 with damaged forecastle.

Initial condition		**Damaged stability**	
HEEL, deg	GZ, m	HEEL, deg	GZ, m
0.0	0.00	0.0	-0.226
10.0	0.16	10.0	-0.136
		15.0	-0.098
20.0	0.26	20.0	-0.083
		25.0	-0.057
30.0	0.30	30.0	-0.008
		35.0	0.021
40.0	0.32	40.0	-0.004
50.0	0.12	50.0	-0.190
60.0	-0.23	60.0	-0.501
70.0	-0.65	70.0	-0.869
80.0	-1.08	80.0	-1.244
90.0	-1.49	90.0	-1.591

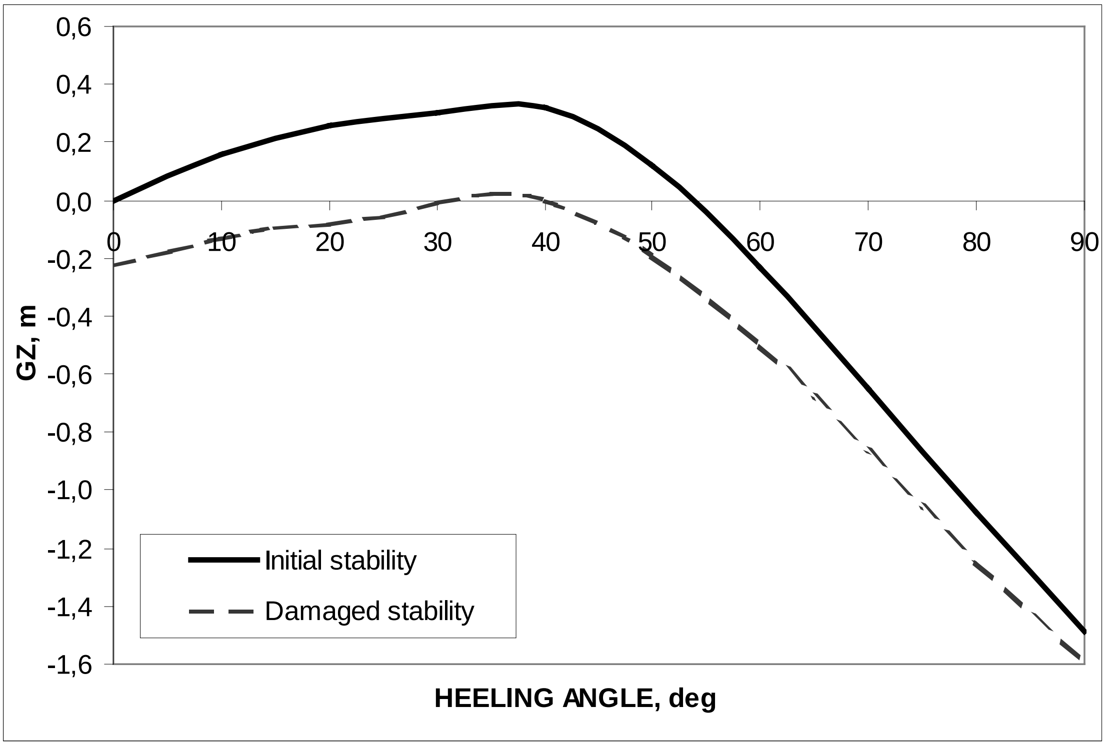


Figure 33. The GZ-curve of the JANRA's initial stability and the GZ-curve of the JANRA's damaged stability. Case 2 with damaged forecastle (no water in the hold no 1).

In the actual case of the JANRA the deck cargo of two tiers of containers have probably been providing extra buoyancy until the containers had filled with water.

The course of capsizing. The capsizing of JANRA can be described based on the damaged stability calculations and the nature of the damages. The course of capsizing started with the cut into the starboard wing tank, which filled in 10–15 minutes. The volume of the tank is 228 m^3. The heeling angle due to this asymmetric flooding is 20°. This can be calculated from the heeling moment compared to the initial stability.

The same cut into the starboard wing tank extended also to hold no. 1. The hole was small and that compartment filled slowly. In addition the hold was also full of containers which means its permeability is near one. The containers also leaked slowly.

Due to this heel of 20° the other hole on the side plating in the bow was immersed although the hole initially was clearly above waterline. With this second hole immersed the starboard double bottom tank began to fill (figure 26). This leak is also contributing to the asymmetric flooding and the heeling angle increased to 30° when the tank was full of 254 m^3 of water.

The initial and this intermediate conditions of stability are compared in figure 33 and table 17. The positive stability is very limited in the damaged condition.

The final capsize is due to the hold no 1 filling and consequently the slow filling of the containers in the hold. According to the calculations the ship heels over if there is 50 m^3 of water in the hold. To this effect it is needed as additional condition that the forecastle is not contributing to the positive stability. If the forecastle is calculated to be intact the vessel can stand 100 m^3 of water in the hold.

In reality also the deck cargo of containers was contributing positively to the stability, because they filled only gradually. The above description of the course of capsizing corresponds also to the crew statements in respect of the time schedule of the events.

The large heeling angles which developed soon after the impact and which initiated the capsize were due to the large asymmetrical flooding condition permitted by the design of the ship.

The damaged stability requirements for JANRA type of vessel. In the SOLAS regulations which applied to the JANRA – a cargo ship of less than 100 metres in length and built in 1995 – **there were no requirements for damaged stability calculations**. These rules are incorporated into The Code for the Intact Stability of all IMO Ship Types, Resolution A.749(18) which dates November 4, 1993.

According to this Code the cargo ships of more than 100 m in length (Ls) shall comply with following damaged stability and subdivision rules: SOLAS 74/88 chapter II-1 part B-1 and Maritime safety Committee resolution MSC. 19(58) dated May 25, 1990.

The class of JANRA type of ships have later been included in the rules for damaged stability. The above mentioned Code has been amended with MSC resolution MSC.47(66) dated June 4, 1996 with which cargo ships between 80 and 100 m in length have to comply. This resolution applies to ships that are built after July 1, 1998. These rules do not retrospectively apply for JANRA.

2 ANALYSIS

2.1 Navigation and Watchkeeping

Position fixing in coastal navigation has always been relative to terrestrial objects. Visual bearings and horizontal angles were plotted on paper chart, which represented an analogue computer to solve geometrical problems. The use of radio did not change this philosophy. The fix was plotted on the paper chart with hyperbolic lines, bearings or distances. The position was measured for documentation with absolute latitude/longitude coordinates but the fix remained always relative. A relative fix was affected by systematic errors and the scatter had a normal Gaussian distribution. The relative fix was safe in the respect that the fix is relatively correct on all charts whatever the chart datum.

The navigation changed unconsciously from relative to absolute fixing with satellites. The absolute fix is not disturbed by systematic errors. Only Gaussian scatter is possible. The position is indicated automatically on the electronic chart. The benefits are obvious. Absolute position fixing requires knowledge of correct chart coordinate system and their correct use in satellite receiver and the electronic chart.

JANRA is equipped for both navigation philosophies. The accuracy and the correct use of chart datum can be verified when figures 34 and 24 are compared.

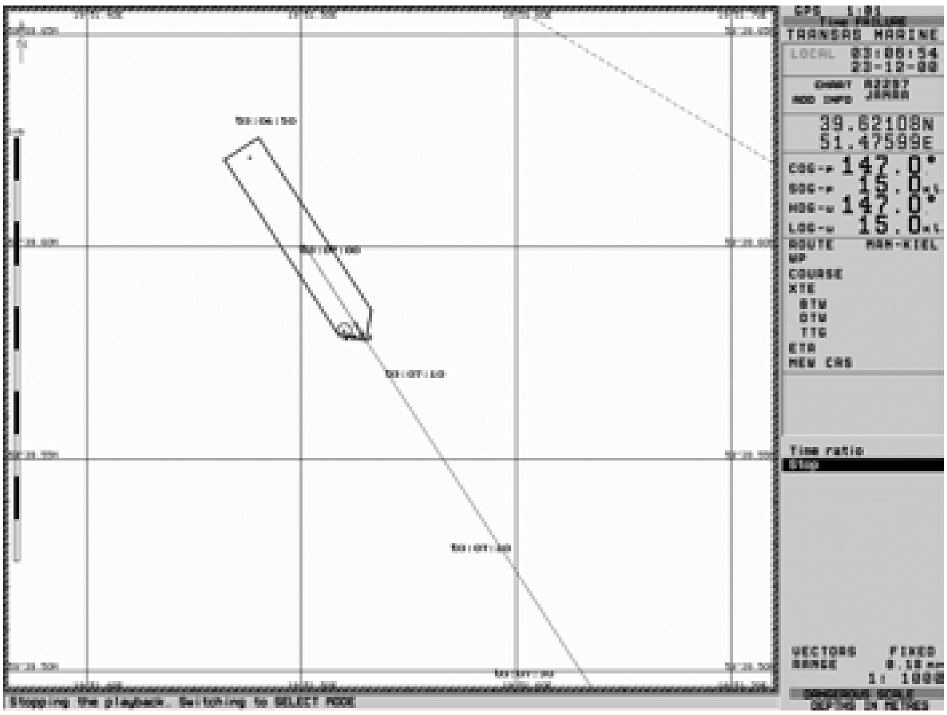


Figure 34. JANRA's collision with the edge mark illustrates clearly that the chart datum was correct and the accuracy was about 3 metres. See also damage in the bow in figure 24.

The instruments to monitor the passage plan were the electronic chart and the radar. The easiest way to program the route is to enter the waypoints with the mouse on the electronic chart. The electronic chart software can copy the route to the radar and the radar is able to store the waypoints. The radar displayed the copied waypoints from the electronic chart and the GPS locks the both systems for absolute position fixing.

The master testified that the waypoints were entered manually from the paper chart in the GPS receiver and the GPS sends them to the radar. This is a cumbersome operation and is liable for human errors. According to the master's statement the waypoints were visible on the radar and they had different origin with the waypoints on the electronic chart. The two basic philosophies were mixed. This indicates incorrect operation of the navigation system.

The first officer stated that the second officer was familiar with the radar, its ARPA function and he was able to enter routes and waypoints into the electronic chart. According to the chief officer the system was used correctly.

It was known onboard that the Tröskeln Västra beacon was not lit (paragr. 1.2.3). An ARPA plot should have been appropriate in these circumstances. Data from the NaviSailor software illustrates JANRA's minor use of the ARPA function.

Table 18. The table presents recorded data from JANRA. The recording reveals insufficient use of ARPA. Only 26 targets were plotted during two months.

Date	**Place**	**Number of ARPA targets**	**Janra's course**	
14.10	Söderarm	2 ferries	Southbound	
15.10	Ystad	1 target	Southbound	
0016.10	Kieler Bucht	1 target	Westbound	
22.10	Tainio/Kotka	1 target	Eastbound	
24.10	Porkkala	2 targets	Westbound	
26.10	German Bight	4 targets	Westbound	Janra plotted 12 targets in October 2000
29.10	Rügen	1 target	Eastbound	
Two weeks without any use of ARPA				
15.11	Öland	1 traget	Eastbound	
16.11	Osmussaar	2 targets	Eastbound	
One week without any use of ARPA				
24.11	Gotska Sandön	1 target	Eastbound	Janra plotted 5 targets in November 2000
26.11	Trelleborg	1 target	Westbound	
06.12	Lolland	3 targets		
One week without any use of ARPA				
14.12	Visby	2 targets	Northbound	
Six days without any use of ARPA				
21.12	Ölands Södra	4 targets	Eastbound	9 targets in December 2000

The *Collision Avoidance Rules* (rule 7, b) require “proper use of radar” to avoid collision with moving or stationary targets. Insufficient use of ARPA does not indicate proper use of radar. Moving targets were observed by Finnish VTS radar in that area prior to the accident but those targets were not plotted on JANRA. It is assumed that relative fixing with radar was as scantly used as the ARPA. Thus the main position fixing system on JANRA was satellite navigation on the electronic chart.

Table 19. JANRA’s previous passing distances to Tröskeln Västra on the electronic chart.

Date	JANRA passed Tröskeln Västra Beacon	Passing distance to Trösken Västra is 0.18' in the Passage Plan
14.10	Rauma–Kiel	0.17' to NE
24.11	Kiel–Rauma	1.23' to NE
02.12	Rauma–Kiel	1.14' to NE
07.12	Kiel–Rauma	1.05' to NE
09.12	Rauma–Kiel	0.35' to NE
21.12	Kiel–Rauma	1.16' to NE

History information about passing the edge mark Tröskeln Västra was recorded with the NaviSailor software. The planned passing distance was followed previously. The passing distances going southwards varied between 0.17–1.14 miles. JANRA did not follow the normal practice during the early morning hours in the night December 23, 2001.

The edge marks were designed to warn deep draught vessels. The deep draught bulk carriers have always navigated safely between the edge marks without accidents. This proves that the fairway making has been effective. The deep draught route marking has been successful and justified what comes to the original goal to safeguard the bulk carrier traffic. The impacts have happened only to vessels with shallow draft. The problem is concentrated on shallow draft vessels, which do not really need the deep draught route at all. Hence the edge marks have become a danger for the shallow draft vessels because the edge marks are inside the navigational area for shallow draft vessels. JANRA is not alone in this group.

Before introducing the Deep Water Route the traffic lane was about 3.5 miles wide. The general course sailing southwards is 149° towards the beacon Svenska Björn. Navigation was always relative to some fixed target. Approaching the Tröskeln sound the position fixes were based on radio bearings or the Decca hyperbolic lattice. The sound was passed taking radar bearings and ranges on the buoys. The fixes were marked on paper charts. There is no documented evidence about incidents prior the introducing of the 18.2 metre Deep Water Route. The width of the deep water route is about one mile.

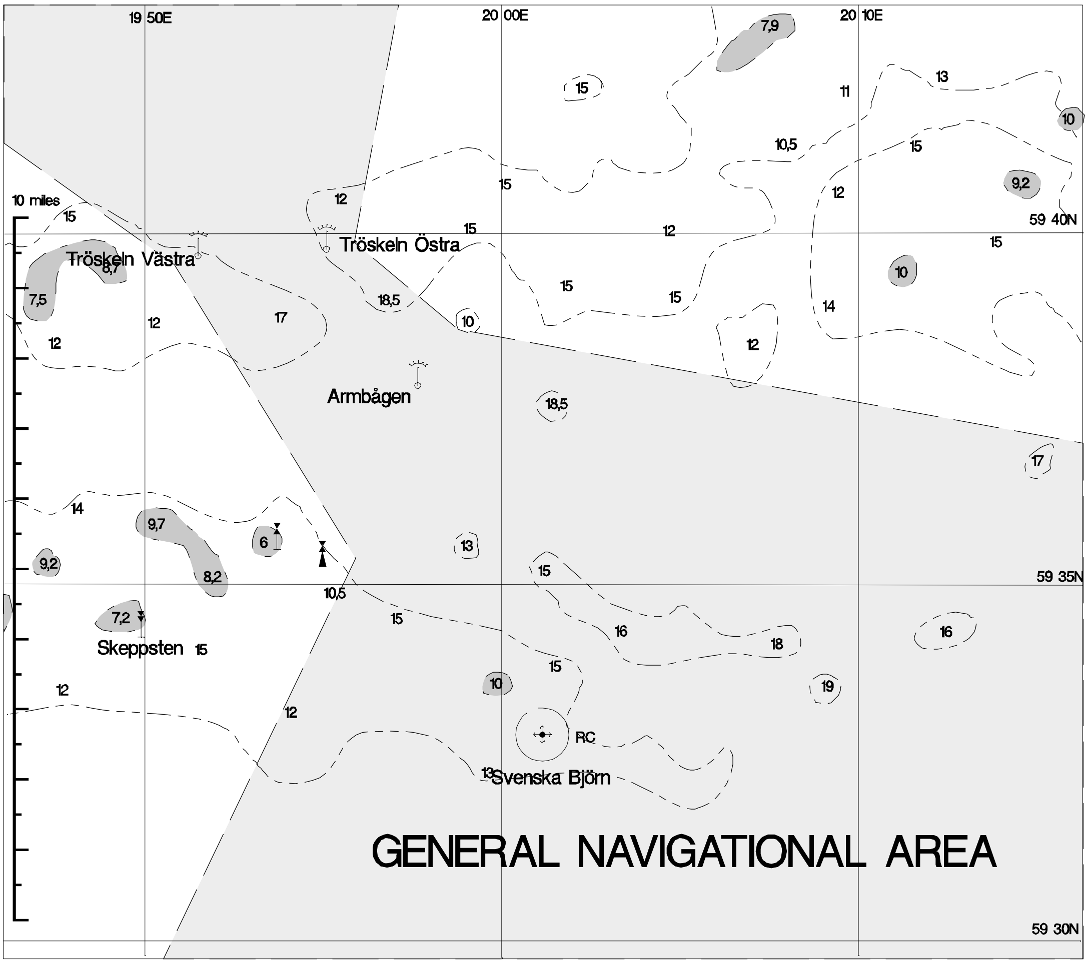


Figure 35. The area can be seen as a wide 'shallow water' route on board a shallow draft vessel.

In the beginning of 1990s navigation changed from relative position fixing to absolute fixing. The accuracy of the absolute position fix increased during ten years from 30 metres to 2–3 metres. Generally the modern satellite position fixing method has contributed to the safety. In the Tröskeln sound this improvement had no effect. The accidents even increased.

The cause of the accidents cannot be accused on poor navigation technology on ships. The edge marks have been visible on the radar even without a functioning RACON. Information of the edge marks were on the charts and messages of malfunctions have been broadcasted and received. Still the accidents repeat themselves. This gives reason to study watch keeping routines and procedures.

The lookout went downstairs before 03:00. At 02:54 the course was changed 2° to starboard (figure 14, table 10). After this course change the Course Over Ground vector pointed directly on the Tröskeln Västra beacon. The distance to the beacon was over 3 miles. The automatic sea clutter function could not obscure the echo of the Tröskeln Västra edge mark at this distance. When the OOW changed the course he operated the autopilot and he was close enough to the electronic chart. He did not check if the course change was safe. His alertness had reduced prior to this course change.

According to OOW's statement he saw the beacon echo on the radar, but it is not known on what distance. An ARPA plot should have revealed that it was a stationary target and a plot should have given an audio Loss Of Target Alarm when the echo disappeared. The OOW lost the beacon on close range but that it did not raise any doubts.

At 03:6:20 the beacon on the electronic chart was only two ship lengths ahead when the OOW changed the course 5° to starboard (figure 15, table 11). The manoeuvre was not bold enough to avoid the beacon mark on the chart. The motive for the course change could neither be a short cut south of Tröskeln Västra, because in that case the course change should have taken place earlier and the course change should have been larger.

The collision took place at 03:06:54 (figures 15 and 16, table 11). The OOW felt the ship shake. He changed the course 5° to port back to the original course at about 03:07:20 (figure 16, table 12). The reaction was involuntary. He felt that the course change to starboard caused something evil and he tried to have it 'undone' by a course change back to the original course. When the first officer rushed to the bridge and asked the OOW "What happened?" the answer was "I do not know". The ship was on original course 147° again. The OOW had cancelled the course changes from his mind. The master was not informed about the latest course changes. Average Course Over Ground after the accident was 149° and before the accident between 147°–148°.

The behavior of the OOW indicates fatigue. At first he was careless with small course changes. A small course change does not appear dangerous. The situation deteriorates without OOW realizing the magnitude of increasing danger. Finally when a small vibration was felt in the hull the OOW turned back to the original course.

The statements reveal that there were no standard watchkeeping procedures. Fatigue is strongly suspected to be the main cause of the accident. A human is vulnerable for fatigue if there are no standard watchkeeping procedures and all alarms were switched off.

2.2 Fatigue

The IMO has paid special interest on fatigue in association with marine accidents in the resolutions for Guidelines for Investigation of Accidents (Res.A849(20) and Res. A884(21)).

IMO has defined fatigue as follows: "A reduction in physical and/or mental capability as the result of physical, mental or emotional exertion, which may impair nearly all physical abilities including: strength; speed; reaction time; co-ordination; decision making, or balance"[20]

[20] A 21/Res.884, Appendix 3

The causes of fatigue are listed in IMO's Guidelines on Fatigue:

- Lack of sleep,
- Poor quality of sleep,
- Insufficient rest between work periods,
- Poor quality of rest,
- Stress,
- Boring or repetitive work,
- Noise or vibration,
- Ship movement,
- Food (timing, frequency, content and quality),
- Medical conditions and illnesses,
- Ingesting chemicals,
- Jet lag,
- Excessive work load.

According to the aforementioned resolutions the 96 work and rest hours' history of persons involved in accidents should be checked. This could not be done in this case because there were no time sheets or other information available. The investigators got no information of the 2nd mate's personal habits, medical conditions or other possible affecting factors. The Swedish police took an inhalation alcohol test some time after the accident. The test result was negative, there were no signs of alcohol in the 2nd mate's test.

The 2nd mate had been relieved at 17.20 and he had returned to watch at midnight. Of his rest period it can only be said that he had had the opportunity to the legal minimum rest of 6 hours before his watch. The investigators have no information if this rest was disturbed or undisturbed.

The IMO Guidelines on Fatigue do suggest means of relieving fatigue. Some of these countermeasures are:

- Bright lights, cool dry air, music and other irregular sounds,
- Caffeine,
- Any type of muscular activity
- Conversation.

Bright lights are impossible in the bridge, the 2nd mate has not mentioned of any music listening, muscular activity or conversation. The working station of the OOW has been designed ergonomically to be a comfortable one. If one is already in a drowsy situation, i.e. under fatigue, it is not easy to get up and get some muscular activity. This design criteria is a controversial to the one of ergonomics. In his statement the 2nd mate has said that the look out was sent down to make some coffee when JANRA was approaching Tröskeln Västra. There is no evidence whether he had had coffee since he came to watch.

The 2nd mate was not asleep as he altered the course 2 degrees to starboard three miles before the collision. Just prior to the collision, he altered the course 5 degrees more to starboard. Because he failed to follow the planned route, the investigators have concluded that he lost his alertness.

The possible effects of fatigue are tabled in the Guidelines of Fatigue. The investigators have found some signs and symptoms which do correlate the situation and the statement of the 2nd mate. These are marked with bold in the table 21.

Table 21. IMO's Guidelines on Fatigue in A 21/Res.884, Appendix 3.

Performance impairment		Signs/Symptoms
1	**Inability to concentrate**	• Unable to organise a series of activities • Preoccupied with a single task • Focuses on a trivial problem, neglecting more important ones • Reverts to old but ineffective habits • **Less vigilant than usual**
2	**Diminished decision-making ability**	• **Misjudges distance, speed, time, etc.** • Fails to appreciate the gravity of the situation • **Overlooks items that should be included** • **Chooses risky options** • Difficulty with simple arithmetic, geometry, etc.
3	Poor memory	• Fails to remember the sequence of task of task elements • Difficulty remembering events or procedures • Forgets to complete a task or part of a task
4	Slow response	• Responds slowly (if at all) to normal, abnormal or emergency situations
5	Loss of bodily control	• May appear to be drunk • Inability to stay awake • Affected speech e.g. it may be slurred, slowed of garbled • Feeling heaviness in the arms and legs • Decreased ability to exert force while lifting, pushing or pulling • Increased frequency of dropping objects like tools or parts
6	Mood change	• Quieter, less talkative than usual • Unusually irritable • Increased intolerance and anti-social behaviour • Depression
7	**Attitude change**	• **Fails to anticipate danger** • **Fails to observe and obey warning signs** • Seems unaware of own poor performance • Too willing to take risks • **Ignores normal checks and procedures** • Displays a "don't care" attitude • Weakness in drive or dislike for work

The fatigue cannot be closed out of this case because no technical reason to collision can be found and the 2nd mate had lost his alertness some time before the collision.

However, as mentioned in paragraph 1.2.2, there has been other collisions with the Tröskeln edge marks beginning from year 1986. Four of these (total 5) accidents have occurred in fair weather between midnight and 6 a.m., which is the time when one's internal clock makes sleep almost irresistible. Ships with a deep draught have had no accidents in the sea area. The OOW on a deep draught vessel will navigate with special care if there are limitations in the vicinity. The improvements of the navigation system have had no effect to safety for shallow draught vessels.

2.3 The danger of asymmetrical flooding

The following analysis is to show the dangers in the allowable design and the asymmetrical flooding. The capsize of the JANRA was the result of a rather confined damage which ruptured two large tanks, one below and the other above waterline.

The wing tank no 1 is at the side of the ship and the double bottom tank no 1 extends from the side only to the ship centre line. The centres of the gravity of the tanks are considerably on the starboard side the ship. The flooding of the second compartment (double bottom tank no 1), which was holed above waterline, was only possible due to the large heeling angle resulting from the filling of wing tank no 1. The consecutive filling of both these tanks contributes to the fatal asymmetric flooding condition of the vessel.

The large heeling angles which developed quickly after the impact and which initiated the capsize were due to the large asymmetrical flooding condition permitted by the design of the ship. There were no damaged stability rules for cargo ships under 100 metres of length when JANRA was built.

The dangerousness of the allowable design can also be illustrated with a hypothetical example. If the only damage to JANRA would have been of the same size and immersion as the real underwater hole but it would have been situated some 10 metres more aft, it would have ruptured two wing tanks instead of one. The asymmetrical flooding due to this damage would have capsized JANRA immediately. Larger heeling angles than 20 to 30 degrees which would have developed sooner in JANRA's case would have endangered (prevented) also the launch of the free-fall life boat.

The SOLAS regulations, presently in force, on subdivision and damage stability of cargo ships of 100 metres in length and over, as contained in part B-1 of SOLAS chapter II-1, are based on the probabilistic concept which takes the probability of survival after collision as a measure of ship's safety in the damaged condition. These regulations are primarily based on the probabilistic approach with only very few deterministic elements and there is no need for special treatment for specific parts of the ship.

Thus there is no deterministic rules on maximum allowable heeling angle in damaged condition. There are only some features which are in-built into the calculation formulas which indicate that a heeling angle of up to 25–30 degrees is acceptable[21].

It is possible that, using the new damaged stability rules, compartments which cause dangerous asymmetric flooding conditions may exist.

2.4 Life-saving equipment

The danger was imminent that JANRA's list would have prevented the launch of the life-boat. The rapid list due to the asymmetrical flooding was unexpected. It was fortunate that the first officer decided to launch the boat in spite of the light clothing of the crew. The list reached quite soon after the launch an angle where the launch of the free fall life boat might have been impossible.

If the crew had not succeeded with the launch, only the life raft had been available. In the life raft the survivors will soon get wet and the hypothermic process starts immediately. Without survival suits in cold water areas like the Baltic, time for survival is very limited. The majority of the crew were from southern hemisphere and not used to the cold climate. In these conditions it would have been feasible to have a survival suit for each crew member[22].

The crew might not have personal warm clothes in their cabins. The warm working clothes provided by the company are often kept in cupboards situated in other parts of the ship. Regulations require now three survival suits for deck work. Better warm clothing is needed in an evacuation situation.

2.5 Alarms and lack of procedures

The owner had given two standing orders. The first was a simple order to activate the watch alarm. The second was to give standard watch keeping procedures with the principles laid down in the STCW convention. The first order was fatally deteriorated and the second was ignored.

The company order was to activate the **watch alarm** when the OOW was alone on the bridge but the master modified that standing order. The master switched the alarm off and took the alarm key at 18:00 when the lookout came to the bridge. This is according

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21 In the calculation of the "subdivision Index A" in flooded condition due to certain compartments the full positive effect (addition) is gained only if the heeling angle is less than 25 degrees and the compartment has no positive effect (value) to stability if the heeling angle is above 30 degrees.

22 According to Finnish requirements there must be a survival suit for every crew member onboard. This means that in case of emergency everyone can put on the survival suit, and they have much better possibility to survive under winter circumstances. The Finnish authorities require moreover the SOLAS requirements 12 emergency torches and 6 emergency smokes .

to the IMO Guidelines[23]. The IMO circular in its wording is controversial with the common practice. It is usual that the lookout goes down for fire-watch and making coffee etc.

The alarm was off every morning when the lookout went down at 06:00. The master began his watch again at 08:00 in the morning and switched the alarm on[24]. The OOW was alone from 06:00 to 08:00 when the alarm was off. The Company standing order was thus violated because the OOW could not switch the alarm on.

The investigators have concluded that the master's idea was that the OOW did not need the alarm key during the night to switch the alarm on and off. The master had adjusted the alarm to 15 minutes. This limit was intentionally adjusted to maximum value to meet the situation when the lookout went down to make coffee. According to the master the watch alarm was not necessary because the look-out was downstairs less than 15 minutes.

During the night - with the watch alarm off - the OOW was left alone for some periods of 15 minutes. The time from the dangerous course change (02:54) to the collision was only 13 minutes. Thus the alarm interval should be shorter in areas other than open sea. There is a need for a procedure to wary alarm intervals in the passage plan according to the sea area. The OOW should have the possibility to switch the alarm on when the lookout goes downstairs.

The master justified the absence of watch alarm during night by the long alarm period adjusted for the day watches. The procedure not to activate the alarm when the OOW was alone on the bridge did not meet the owner's order. A long alarm time interval does not justify the violation of company order.

JANRA's master did not send the **distress alert**. He opened general traffic with Stockholm Radio, which meant that radio secrecy applied to the message. MRSC Stockholm realized immediately that the situation required distress traffic and contacted MRCC Gothenburg. MRCC Gothenburg sent the Shore to Ship Distress Alert Relay and this message placed the rescue responsibility on MRCC Gothenburg. It is apparent that marine rescue agreements between Sweden and Finland rely on an assumption that the vessel in distress acts according to the radio regulations as MRCC Turku was at first unaware of the distress.

Without master's distress alert the rescue operation becomes tangled. The prompt actions of MRCC Gothenburg launched rescue operation without delay but the rescue operation did not follow the rescue responsibility border. This led to only one disadvantage. The Swedish police did not interview the crew because the accident happened on the

[23] IMO had organized a trial for one-man watch in 1994. The trial was based on IMO circular SN/circ. 162, 15.10.1993. In conjunction with the trial the Watch alarms were tested. For the equipment on the bridge the requirements were based on Maritime Safety Committee circular MSC/circ. 566, 2.6.1993. According to the circular the Watch alarm should be such that only the master could adjust the alarm interval. Also the equipment could be switch on and off by the master only.

[24] Master's statement 14.06.2001, SEEAMT HAMBURG.

Finnish rescue responsibility area. The crew was interviewed only in Germany several days later.

The master was of the opinion that it was not compulsory to send a Distress Alert. He stated that the Distress Alert was not necessary because JANRA was within VHF communication area[25]. He was of the opinion that GMDSS Distress Alert procedures were too time consuming, because the equipment was in the rear of the bridge[26]. The master had the GMDSS capable VHF DSC equipment at his disposal in the center console (figure 6). To send the GMDSS distress alert requires only pushing the DISTRESS button without any verbal communication. Radio Regulations include standard procedures to be used in distress but the master did not comply with them.

General Alarm is the signal which starts a ship abandoning procedure. The alarm was not used. The master defended his decision not to alert the crew with the General Alarm by stating that the crew could get confused and panic. He ordered the first officer to wake everybody up one by one, to take the crew to the lifeboat, launch the lifeboat and stay with the lifeboat beside JANRA. This procedure was too time consuming when the rapidly developing list is taken into account. Without the alarm the crew didn't realize how serious the situation was, because they came to the lifeboat lightly dressed. The right way to alert the crew would have been to sound the General Alarm. The General Alarm is documented to the muster list and is familiar to every seafarer. The master is required to do everything to save lives and the General alarm is mandatory in this respect.

The operation manuals for the Transas NaviSailor electronic chart and the Kelvin Hughes radar specify **navigational alarms**, which could have counteracted the effect of fatigue but they were all switched off. The technical systems gave the possibility to set up an alarming system with different instruments to safeguard a one man watch against the fatigue.

There were no preventive alarms activated. The ARPA function, the Watch Alarm and the electronic chart alarms were all off. The distress alert was not sent and the alarming of the crew were inadequate.

The company had delegated the making of the **procedures** to the master and these had not been made. The Company orders were to arrange watch keeping according to the International Convention of Training, Certification and Watchkeeping for Seafarers (STCW-95)[27]. The watchkeeping standard consist of 18 pages. It is an outline to be used for constructing practical decision support procedures for the OOW in his watch-

[25] Master's statement 14.06.2001, SEEAMT HAMBURG.

[26] MF DSC was installed in after part of the bridge and the VHF DSC was installed between the radar displays (fig. 6 and 7) on the bridge.

[27] The master called it STCW-72.

keeping. The master shall provide practical watchkeeping procedures based on the convention and suitable for the vessel and the trade. The STCW-95 was in the captain's cabin and it was not used. Thus the alarms were not considered.

3 CONCLUSIONS

3.1 The Accident

JANRA collided with the edge mark Tröskeln Västra in the Northern Baltic regardless of the good weather conditions. The bridge was well equipped with modern navigational and control systems available.

The lookout went down before the collision for such a long time that JANRA's two-person watch changed unintentionally to one-person watch without proper procedures and alarms to safeguard it. The lack of watchkeeping procedures regarding the use of navigational alarms and equipment eliminated safety barriers from the system. The consequence of the lack of all navigational alarms is fatigue, which is suspected to be the immediate main cause for the accident.

3.2 Contributing factors leading to collision

All alarms were switched off. A strong tendency was present not to use any audible alarms related navigation. Even general alarm and distress alert were not used. This is clear evidence of missing procedures.

The main tasks in the coastal watchkeeping are lookout, collision avoidance and position monitoring. Documented procedures should define how ships instruments should be used to perform these tasks. The master shall provide practical watchkeeping procedures suitable for the vessel and the trade. The master should ensure that all navigating officers share the same watchkeeping and navigation principles.

3.3 Contributing factor to the capsize

JANRA’s collision resulted a rather confined damage, which ruptured two large tanks one below and the other above waterline. The consecutive flooding of the tanks was asymmetric and caused a large heeling angle, which led to ships’ capsize. There are no damaged stability rules for cargo ships under 100 metres of length. It is not allowed in some types of ships to design ballast tanks that will cause asymmetric flooding. The design fulfilled the regulations for a ship of JANRA's class and size. A collision with other vessel can cause a similar asymmetric dangerous heeling or capsize as well as the collision with the edge mark.

The construction of the edge mark with the ice cone can be dangerous for ships. The ice cone caused the worst possible damage to JANRA. The cone is protecting the mark against the ice motion. The investigation has concluded that the edge marks have fulfilled their purpose in safeguarding the deep draught traffic. Obviously the navigators on vessels with deep draft do take the edge marks seriously. Present position fixing technology has replaced the edge marks as navigational aids for position fixing.

3.4 Life-saving equipment

Not all ships operating in the Baltic do carry survival suits for the whole crew. If the ship has to be abandoned in winter circumstances, the situation can turn out to be fatal very quickly without the survival suits.

4 RECOMMENDATIONS

The IMO's role is to give guidelines for decision support systems. These should provide practical aid for shaping normal and emergency procedures. The Companies should work the procedures out with the masters. With proper procedures it is possible to safeguard against fatigue. The onboard procedures on the use of one-man watch alarm should follow the relevant IMO guidelines.

The investigation commission recommends to ship owners that:

1. *The normal and emergency procedures should be documented with special emphasis to safeguard against fatigue on one-man watch.*

The international regulations require only three survival suits for each cargo vessel. In all vessels trading in cold water areas like the Baltic Sea this is not enough. The regulations and the practices of the shipping companies concerning life saving equipment do not secure survival possibilities for the whole crew.

The investigation commission recommends to German Maritime Administration and ship owners that:

2. *All vessels, trading in the Baltic Sea, should carry survival suits for each person on board. Every lifeboat should be equipped with sufficient thermal protective aids for every person the lifeboat can carry.*

The JANRA case shows that the asymmetric flooding is dangerous. A list of more than 25 degrees makes the abandoning of the ship difficult and endangers the launch of lifeboats. The regulations for feeder class ships' (small cargo vessels) damaged stability are inadequate.

The investigation commission recommends to Finnish and German Maritime Administrations that:

3. *That the administrations take such international initiatives that small cargo vessel damaged stability will be reviewed to safeguard against dangerous asymmetric flooding*.

The structure, ice cone, which was built to protect the edge mark caused major damage to JANRA.

The investigation commission recommends to Finnish and German Maritime Administrations that:

4. *If ice cones are used in structures like edge marks, light shafts and wind mills the design criteria should include a risk assessment for the damages caused to the ships by a possible collision.*

Helsinki, August 25, 2003

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