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MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

Marine Accident Report No. 4/99

Report on the Underwater Survey of the Stern Trawler

GAUL H. 243

and the supporting Model Experiments
August 1998 – January 1999

MAIB
is an
INVESTOR IN PEOPLE

April 1999

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29 March 1999

The Right Honourable John Prescott MP
Deputy Prime Minister and Secretary of State
for the Environment, Transport and the Regions

Sir

I have the honour to submit the report of the underwater survey and supporting model experiments carried out by my inspectors to determine the likely circumstances of the sinking of the stern trawler *Gaul H.243* in February 1974. The survey took place in August 1998 and the model experiments in December 1998 and January 1999.

I have the honour to be
Sir
Your obedient servant

J S Lang
Rear Admiral
Chief Inspector of Marine Accidents

Extract from
The Merchant Shipping
(Accident Reporting and Investigation)
Regulations 1994

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

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Glossary of Abbreviations

BBC	British Broadcasting Corporation
BMT	British Maritime Technology
cp	controllable pitch
CO_2	carbon dioxide
DERA	Defence Evaluation Research Agency
DETR	Department of the Environment, Transport and the Regions
DF	direction finding
FI	Formal Investigation
GA	general arrangement
HMS	Her Majesty's Ship
kg	kilogramme
KNM	Konigelyge Norske Marine
KV	Kystvakt (Coastguard)
kW	kilowatt
Length oa	length overall
Length bp	length between perpendiculars
MAIB	Marine Accident Investigation Branch
NATO	North Atlantic Treaty Organisation
NMI	National Maritime Institute
RFA	Royal Fleet Auxiliary
RINA	Royal Institution of Naval Architects
ROV	remotely operated vehicle
rpm	revolutions per minute
SIT	silicon intensified
SOC	Southampton Oceanography Centre
UK	United Kingdom
USSR	Union of Soviet Socialist Republics (This reflects the name in use in 1974)
VHF	Very High Frequency

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The Marine Accident Investigation Branch wishes to acknowledge the help and co-operation of the following individuals and organisations during this investigation.

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Mr Michael Barclay and the team from Dronik Consultants Ltd
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Mr Aubrey Bowles, *Gaul* Families Representative
Mr Malcolm Breeze of Kort Propulsion Ltd
British Fishermen's Association, Hull Branch
Mr Alan Campbell MP
Mr Ken Collier, *Gaul* Families Representative
Mr Ian Cundall of BBC North
Mr Norman Fenton
Captain Keith Heron and the officers and crew of MV *Mansal 18*
Dr Ian Hill, Consultant Pathologist at Guy's Hospital
Skippers James Hudson and Peter Carmichael of Marr Fishing Vessel Management
Mr Alan Johnson MP
Mr Mike Lambert and the team from Racal Survey Ltd
Dr Colin MacFarlane, Consultant to the *Gaul* Families Association on hull damage
Dr Bramley Merton and the team from Southampton Oceanography Centre
Dr Tony Morrall and Dr Ian Dand, and the team from BMT Sea Tech Ltd
Mr Roger Nichols and the team at BMT/DERA Hydrodynamic Test Centre in Haslar
Skipper George Petty, former mate of *Gaul*
Mr Alfred Shand of FBM Ltd
Skipper Ernest Suddaby, former skipper of *Gaul*
Mr John Williams of Boyd Line

Reproduced from Admiralty Chart 4015 by permission of the Controller of HMSO and the UK Hydrographic Office

Synopsis

The Hull-based stern trawler *Gaul* was lost with all 36 crew in February 1974 in very bad weather on the North Cape Bank to the north of Norway. There was no distress call. Apart from a lifebuoy that was recovered from the sea some months after she disappeared, no wreckage was ever found. A Formal Investigation (FI) was convened to investigate the circumstances of her loss and found, "that *Gaul* capsized and foundered due to being overwhelmed by a succession of heavy seas". Speculation has, nevertheless, persisted that something else caused her loss.

In August 1997, an expedition funded by UK and Norwegian television companies found, and positively identified, the wreck of *Gaul* 70 miles to the north of Norway's North Cape. Following the subsequent showing of the documentary on UK television, the Deputy Prime Minister asked the Marine Accident Investigation Branch (MAIB) whether it was possible to determine the cause of sinking from this new material. The MAIB examined the video footage and concluded that a more detailed examination of the wreck would be necessary before any such judgment could be made. The Deputy Prime Minister therefore directed the MAIB to conduct an underwater survey of the wreck and report on its findings. This report meets that directive.

The investigation was carried out by Mr Owen Brown with assistance provided by Mr Cliff Brand and Mr Jim Lee. Mr Keith Dixon, Principal Inspector, was appointed as the Inspector in Charge. Further support and assistance was provided by the MAIB administration staff and others whose help is gratefully acknowledged in this report.

The MAIB carried out an underwater survey of the wreck in August 1998 from the motor vessel *Mansal 18*. A team from BBC North and representatives of the *Gaul* Families Association accompanied the expedition. The wreck was found without difficulty and a remotely operated vehicle (ROV) was deployed to carry out a full survey. The wreck was found lying 35° from the upright in about 280m of water and parts of it were covered in fishing nets.

The exterior of the wreck was examined in detail and revealed, among other things, that some weathertight hatches were open. There was also evidence of pressure damage at the bows. A miniature camera was inserted into a number of cabins through their portholes to try and find evidence of human remains. None was found.

Following the underwater survey, the MAIB spent six months analysing the video photography to find an explanation for *Gaul*'s sinking. This was supplemented by scale model experiments to test a number of theories.

The investigation concludes that *Gaul* was lost due to downflooding through open weathertight doors and hatches on her trawl deck after being "knocked-down" by several very large breaking waves. This finding, which is very similar to the conclusion reached by the FI in 1974, does not seek to pre-empt those of a re-opened FI, but attempts to set the evidence from the underwater survey in a suitable framework for examination by that process.

The report concludes that new and important evidence has been found by the underwater survey and recommends that the Secretary of State for the Environment, Transport and the Regions re-opens the Formal Investigation into the circumstances attending the sinking of the motor trawler *Gaul* and the loss of her 36 crew on, or about, 8 February 1974.

Gaul alongside in Hull

Photograph courtesy of Malcolm Fussey

Particulars of *Gaul* and the incident

The vessel:

Name:	*Gaul* (previously *Ranger Castor*)
Port number:	H. 243
Official number:	338111
Registered owners:	British United Trawlers (Hull) Ltd.
Completed:	Brooke Marine Ltd, Lowestoft in 1972. Ship no 375.
Construction:	All welded steel construction to Lloyd's Register of Shipping Classification + 100A1 + LMC, Ice Class III
Type:	Stern trawler with a factory for fish filleting and freezing
Length oa:	66.07 m
Length bp:	56.85 m
Breadth:	12.19 m
Depth to trawl deck:	7.77 m
Depth to main deck:	5.33 m
Main engine:	English Electric Type 16 RK3M rated at 1939 kW at 750 rpm driving a single 4-blade cp propeller via a reduction gearbox. A steerable Kort nozzle shrouded the propeller.
Capacities:	Fish fillets, 356 tonne Fish meal, 122 tonne

Incident:

Position of accident:	North Cape Bank. Wreck located in position 72° 04.1'N 25° 05.3'E
Date and time:	Unknown, but thought to be between 1109 and 1630 on 8 February 1974.
Casualties:	All 36 crew lost their lives.

SECTION 1
Background

1.1 INTRODUCTION

The two year old factory filleter and freezer trawler *Gaul* was lost with all 36 crew in February 1974. She had been fishing on the North Cape Bank some 60 miles to the north of Norway. Weather conditions were bad. She made no distress call, or none that was heard, and the search found no sign of her or any wreckage. In May of the same year a Norwegian whale catcher found one of *Gaul*'s lifebuoys.

The Formal Investigation (FI) into the causes of the loss was held some months later. The accident was also investigated at length by the Department of Trade and involved scale model tests conducted by the National Maritime Institute. Notwithstanding these investigations and their conclusions, the lack of any firm evidence, specifically the wreck itself, and a perception that insufficient effort had been made to look for it, led to speculation that there was some other explanation for her loss. Much of this focused on allegations that *Gaul* had been involved in some form of intelligence gathering against naval forces of the USSR.

Rumours about how *Gaul* was lost have persisted for many years causing distress to the families of the victims and a long running campaign for the circumstances of her disappearance to be fully explained.

Nothing changed until August 1997 when an expedition funded by UK and Norwegian television companies sailed into the Barents Sea with the aim of investigating the identity of one particular wreck that was thought to be *Gaul*. The expedition was successful and underwater photography confirmed the wreck's identity as *Gaul*. The documentary film of the expedition was shown on Channel 4 on 6 November 1997.

Following this discovery, and the showing of the documentary on television, the Deputy Prime Minister asked the Marine Accident Investigation Branch whether it was possible to determine the cause of sinking from the material now available. The MAIB examined the video and concluded that a more detailed examination of the wreck would be necessary before any judgement could be made. The Deputy Prime Minister directed the MAIB to conduct an underwater survey of the wreck and report on its findings.

The aim of the survey was to visit the wreck and the surrounding area to gather evidence to establish the most probable cause of *Gaul* sinking.

This report meets that directive.

1.2 SCOPE OF THE REPORT

This report gives an account of the underwater survey carried out by the MAIB in August 1998 and the observations made. It describes in detail how the evidence was analysed and draws a conclusion on the most probable reasons why *Gaul* sank with such tragic loss of life.

It does not cover any events before *Gaul*'s final voyage, or the search and rescue operation. An investigation into the reasons why no attempt was made to search for the wreck after her disappearance is outside the scope of this report and is to be the subject of a separate study.

1.3 *GAUL* FAMILIES ASSOCIATION

Building on lessons learned from other marine accident investigations, MAIB inspectors were committed to keeping the *Gaul* Families Association fully informed on the progress of the investigation and to seeking their views on what needed to be done. Briefings were given to the families in both Hull and North Shields and their concerns noted. So far as was possible all their requests for access to relevant data, or for independent views to be sought on controversial issues, were granted.

One of the families' principal objectives was to establish whether there were any human remains on board.

Three representatives of the association were embarked for the survey and had full access to the entire video take as it occurred.

The unedited tapes were subsequently shown to many of the families who had expressed a wish to see them.

The MAIB wishes to place on record their gratitude to the *Gaul* families for their co-operation and the courtesy extended to its inspectors at the several meetings conducted during the investigation.

1.4 FORMAL INVESTIGATION

The FI into the loss of *Gaul* and her crew was held in the City Hall, Hull, in the autumn of 1974. It lasted fourteen days. Important aspects of the vessel's design and operation were minutely examined by the wreck commissioner and his assessors. Evidence was taken from 60 witnesses. The court found "that *Gaul* capsized and foundered due to being overwhelmed by a succession of heavy seas".

The published report of the FI contained detailed descriptions of the vessel, the last voyage (as far as it was known), the weather at North Cape Bank on 8 February 1974 (the day she was presumed to have sunk) and the freezer trawler reporting system. It also covered the conduct of the search for the missing vessel. A copy of the FI report is at **Annex 1**.

The MAIB had access to the transcripts of evidence presented to the FI and has drawn on the contents as part of the analysis of the new evidence.

1.5 RESEARCH CARRIED OUT BY THE NATIONAL MARITIME INSTITUTE

The FI considered several possible causes for the loss of *Gaul* and expressed the hope they would be investigated by Department of Trade naval architects with a view to improving and promoting greater safety. This was done in a comprehensive and ambitious project lasting two and a half years. *Gaul*'s stability was calculated and a 1/20th scale model was constructed for testing in waves. Full scale trials were carried out on a sister vessel, *Arab*, that included time off the North Cape of Norway in January 1976.

The model tests were carried out in testing tanks and in realistic open sea conditions in the Solent. It showed that *Gaul* had excellent sea-keeping characteristics and a large range of intact stability. The model proved impossible to sink or endanger unless the factory was initially flooded to the equivalent of 100 tonne of water full scale to give the vessel a list of about 10° to starboard. It was then found that substantial quantities of water would reach the trawl deck and enter the access door to the factory. The tests revealed that the heel increased to the point where the door was continuously immersed and the vessel was lost.

Two theories were advanced for the source of the initial flooding of the factory. One was that the water supply to the factory machinery had been inadvertently left running, the other was that waves breaking onto the trawl deck caused continual flooding through the open factory access door.

A paper on the results of this project was presented at the spring meeting of the Royal Institution of Naval Architects (RINA) in April 1980 and later published in their transactions. It contained the following conclusion: "The findings of this investigation are consistent with the view that the *Gaul* was not lost as a result of inadequate intact stability or poor sea-keeping qualities. It would seem most probable that the cause of her loss was due to the effect of the severe waves and wind and the possibility of encountering a large steep wave or waves at that time in the area of the North Cape Bank associated with some unknown circumstances such as flooding from some cause".

A copy of the paper is at **Annex 2**.

1.6 INTELLIGENCE GATHERING

For many years speculation had persisted that *Gaul* had been involved in intelligence gathering either before, or at the time of, her loss and that this had something to do with her disappearance.

Such speculation was already rife by the time the FI was convened. Because a rumour was circulating in Hull that *Gaul* was still afloat and in a Soviet Union port, the FI examined the possibility that she had been seized by a foreign power. The evidence showed that this was impossible given the sea conditions prevailing at the time she disappeared. The FI concluded that the rumour "was totally unsupported by any evidence acceptable to the Court" and rejected it.

Despite this judgement the rumours persisted, fuelled by denials that trawlers had been used for intelligence gathering purposes. When the Ministry of Defence eventually acknowledged that some had been used in such activity, it did nothing to reduce the speculation despite statements that *Gaul* herself had never been involved. By the time the

MAIB was tasked to examine the wreck, *Gaul* had become a legend. In many peoples' minds she had disappeared in mysterious circumstances and the refusal to search for the wreck merely served to confirm charges of a 'cover up'. Against this unpromising background the MAIB prepared to conduct its investigation.

Despite the conspicuous lack of any evidence to indicate that she had been involved in intelligence gathering, the MAIB retained an open mind throughout the investigation. Had anything emerged to suggest that her loss was somehow connected with such activities the inspectors were ready to investigate it thoroughly.

As part of this process the Chief Inspector asked representatives of the *Gaul* Families Association, on three separate occasions at open meetings in Hull and on Tyneside, for any information, or evidence, to support the intelligence gathering theory. None was forthcoming.

At no stage of the investigation did the MAIB receive any information to connect *Gaul* with intelligence gathering. Her skipper and mate from earlier voyages have confirmed that while they were serving in her she was not used for that purpose.

1.7 OPERATIONAL HISTORY

Gaul (then named *Ranger Castor* SN.18) was the fourth and last of the Ranger "C" class of stern trawlers built by Brooke Marine Ltd for the Ranger Fishing Company of North Shields. The three sister ships remain in operation but only one is still used for fishing.

She was delivered on 3 August 1972. By the following January she had completed two trips. Over the next 11 months, to mid December 1973, she completed a further three trips, each with Skipper Ernest Suddaby in command. On the last trip of this series Mr George Petty sailed as mate and Mr James Sim as the chief engineer. Mr Sim had been the chief engineer since joining after her maiden trip.

These senior officers were in no doubt that the vessel was very seaworthy. She had performed extremely well in service with few problems. A pump and a motor were replaced on the steering gear on separate occasions and apparently cured the original problems. Elsewhere, however, recurrent weld fractures in a lubricating oil pipe to the main engine proved troublesome and caused the main engine to be stopped several times on most trips. The affected pipe was replaced before the final voyage.

At least once during her penultimate trip, water accumulated in the factory during fish processing when the drain pumps' suctions choked. The blockages were cleared and the water pumped overboard. The relatively small quantities of water which accumulated on these occasions presented no threat to the vessel.

Ranger Castor was sold to British United Trawlers in October 1973 and re-located to Hull. She was renamed *Gaul* and re-registered with the port number H.243.

1.8 FINAL VOYAGE

1.8.1 *Gaul's* last known movements

On 22 January 1974, *Gaul* left Hull for the Norwegian fishing grounds under the command of Skipper Peter Nellist. Mr George Petty sailed as mate but fell ill on the outward voyage and was replaced in Norway by Mr Maurice Spurgeon. On the passage to Norway she stopped to carry out a repair to the automatic steering at the request of the chief engineer. This apart, the voyage to Norway passed without incident.

Both Skipper Nellist and Mr Spurgeon were experienced freezer trawler fishermen but neither had previously sailed in *Gaul*. The second engineer had replaced Mr Sim as chief engineer when the latter left to take a job ashore. The second mate and third mate were new to the vessel.

On 29 January 1974 *Gaul* joined the fishing fleet in the Barents Sea. Weather conditions were favourable. On 3 February *Gaul* damaged her trawl and replaced it with a spare. Fishing continued without interruption from bad weather.

By Thursday 7 February, after ten days fishing, she had about 19 tonne of boxed, frozen fish fillets in her hold. That morning, on the 1030 skippers' schedule, she reported that she was fishing in position 72° 15'N 24° 50'E, about 12 miles north-west of where her wreck was eventually found.

Throughout most of that day *Gaul* fished on the North Cape Bank in the company of her sister vessel *Kelt*. She developed a fault on a steering gear pump during the morning but this was rectified without difficulty. A separate problem with the automatic pilot control for the steering caused the chief engineer to request advice from the owners in a telephone link call at 1530. He was advised to "check the power circuit lines from the master compass to the tiller unit". No further calls were made on the matter.

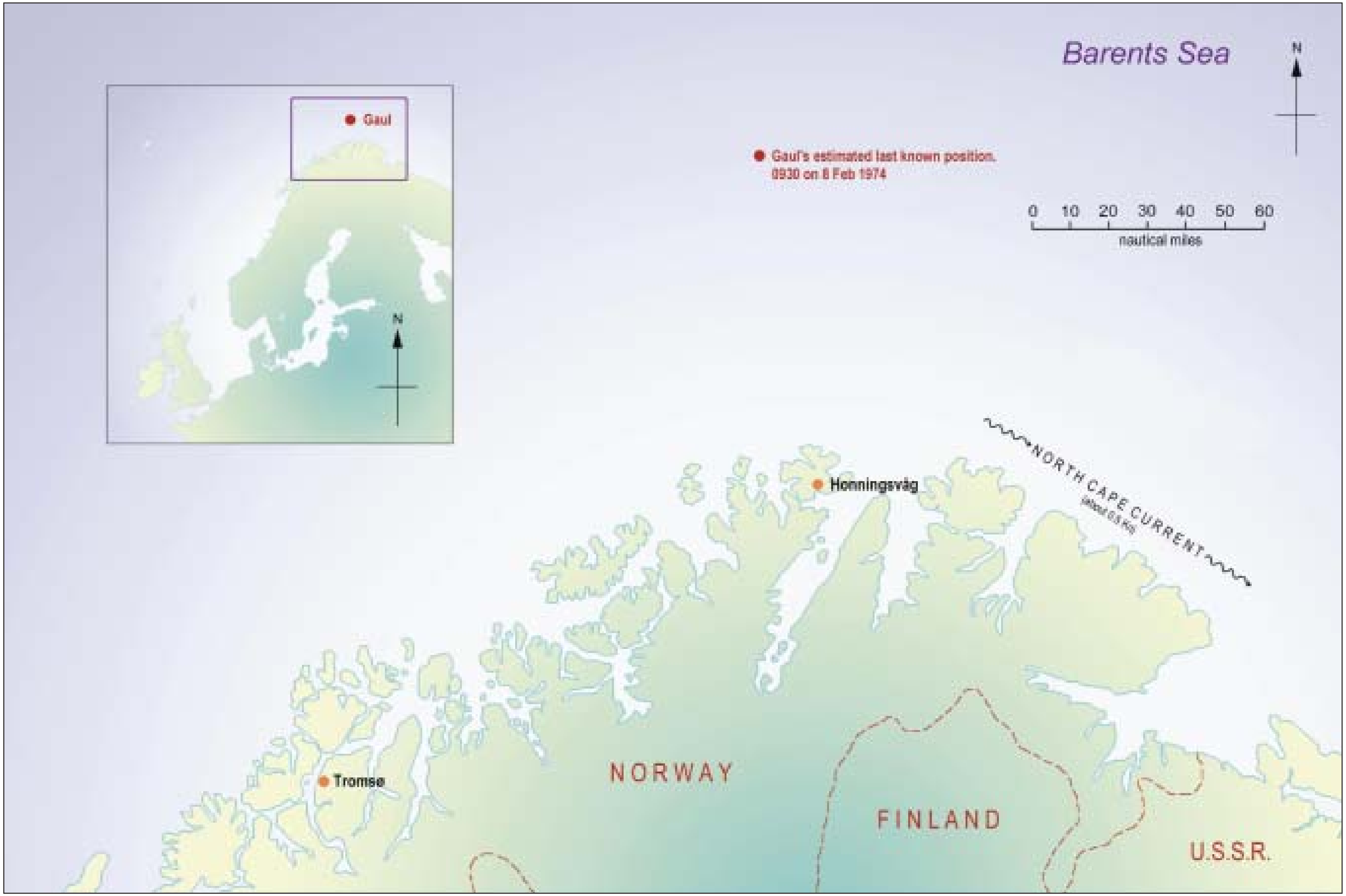
Skipper Kenneth Madden in *Kelt* told the FI that the vessels had separated when *Gaul* stopped to haul her trawl. *Gaul*'s location at this time was estimated as a Decca reading of lane 8.5C, and between lanes 36.2F and 34G which, when translated into a position, indicated she was between 17 miles north-west of where the wreck was eventually found, and 8 miles south-west of it.

When *Kelt* hauled at 2030 she had lost sight of *Gaul,* but Skipper Madden had heard on the VHF that *Gaul*'s net had been badly damaged and that she was laid and mending. This information was included in the report from *Gaul* on the skippers' schedule at 2330.

It was not known if *Gaul* had shot her trawl after 2330 but, by 0200, the weather had deteriorated to such an extent that *Kelt* (and presumably *Gaul*) was forced to lay and dodge. Another freezer trawler in the vicinity, *Pict*, had her gear pulled away in the deteriorating weather at 0200 on 8 February. After this, she stopped fishing and was laid and dodging. *Gaul* reported "laid and dodging" on the office schedule at 0900 and the skippers' schedule at 1030 on 8 February. These were the last fishing reports she made.

On the morning of 8 February, between about 0900 and 0930, the mate on the freezer trawler *Swanella* saw *Gaul* lying beam on to the weather about 3 to 4 miles away. *Swanella*

Figure A: **Gaul's last known position**



was dodging into the wind with *Gaul* fine on her starboard bow. Winds were east-south-east force 7 – 8. *Swanella* called *Gaul* on VHF and was told "You're all right, we'll be under way shortly and we'll get out of your road because we're going to dodge more into land". *Gaul* started making way and turned to port to run before the weather, passing *Swanella* about a mile off her starboard beam. As she passed, *Swanella*'s mate looked at her and saw nothing unusual. *Gaul* was never seen again.

The position of *Swanella* and *Gaul* at the time was given, very approximately, as 72° 25'N 25°E (**Figure A**). The mate on *Swanella* was firmly under the impression that *Gaul* was lying beam on to the seas carrying out a job that would have prevented her dodging head to the weather. It also transpired during the conversation that *Gaul* was waiting for the 1030 skippers' schedule to see what other trawlers were catching on the Malangan Bank where the weather had not stopped them fishing.

The mate of *Somerset Maugham* told the FI that he had heard someone called Pete, whom he took to be *Gaul*'s skipper Pete Nellist, saying on VHF that he was heading for Honingsvaag for repairs or supplies.

From time to time the mate on *Swanella* looked at the radar and last saw the echo of *Gaul* about 6 miles astern. When the skipper came to the bridge at about 1045, the echo was no longer there.

Between 1106 and 1109 *Gaul* sent two private telegrams via Wick radio. This was the last occasion when anything was heard from her.

1.8.2 Sea conditions on 8 February 1974

Weather conditions continued to deteriorate. Sometime between 1100 and 1130, *Swanella* was hit by a group of three huge waves. The impact twisted the engineers' derrick round the front of the bridge and knocked the vessel off course. Some other skippers reported that conditions that day were as bad as they had ever experienced. Winds were estimated to be force 10 at times. (A force 10 is defined as a storm in the Beaufort Scale of Wind Forces and has a wind speed of between 48 and 55 knots. The sea state associated with this wind strength is described as "very high waves with long overhanging crests and large patches of foam; the tumbling of the sea becomes heavy and shock like; visibility is affected.")

The testimony of Skipper Alfred Eagle of *Farnella* to the FI illustrates the difficulties which the weather posed during this time: "We had continuous snow over these two days which was very heavy indeed and making visibility extremely reduced. Thus it was not possible to see what seas were approaching the vessel until they almost hit the ship. I should also emphasise, of course, that at that time of the year it is almost constantly dark through the greater part of the day and this does not assist visibility."

Photography courtesy of Snowbow Productions Ltd

At the FI an expert assessed the sea conditions for that morning. He stated that the significant wave height was 22 feet (6.7m) at 1030 and, by 1630, had risen to 25 feet (7.6m). He added that the corresponding highest waves to be expected in any three hour period were 43 feet (13.1m) and 48 feet (14.6m) respectively. He said this did not preclude higher waves occurring, but they would be encountered less often. In seas of 22 feet (6.7m) significant wave height there was a 10% chance that waves higher than 49 feet (14.9m) would occur. The FI was left in no doubt that it was "likely that some exceptionally high waves were present from time to time in the area of the North Cape Bank during the 8 February."

1.8.3 The search for *Gaul*

Gaul did not report on the office schedule at 0900 on 9 February. This was noted but, since it was not unprecedented, no further action was taken. She failed to report on the following day at 0900 whereupon efforts were made to contact her. They were unsuccessful, and the UK Trawlers Mutual Insurance Company Ltd was informed.

During the evening of 10 February the insurance company's agent in Tromso alerted fishing vessels off the coast of Norway that *Gaul* was missing and he was also aware that HMS *Mohawk* had been alerted. At 0925 on 11 February the insurance company sent the following via Wick radio: "To all vessels fishing North Bank, Norway – all vessels please report any contact with *Gaul* last reported fishing North Bank. Nil reports not required." By 1235 the Rescue Co-ordination Centre at Bodo was on full alert.

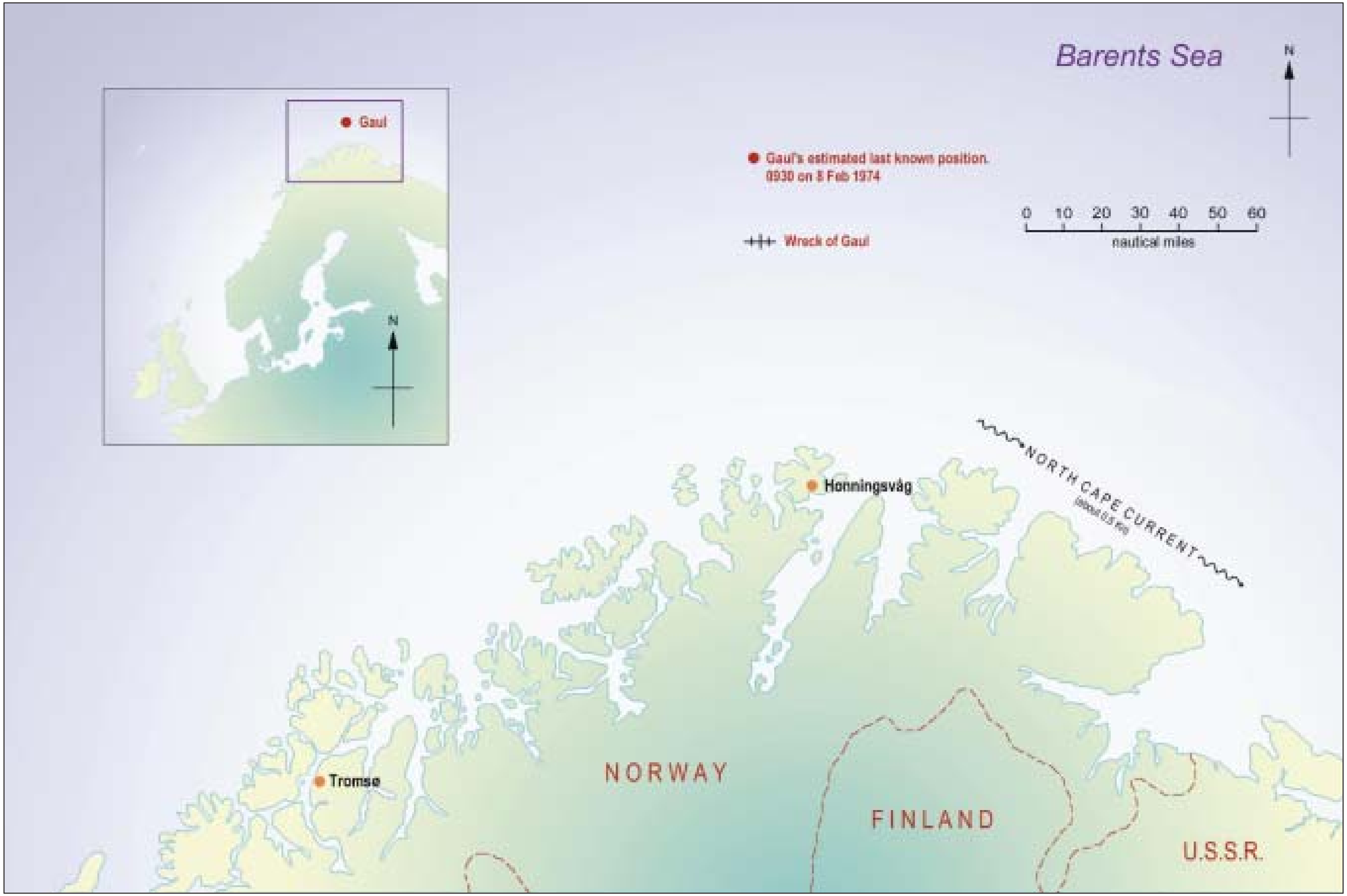
The air and sea search continued until 15 February and during this time an area of 177,000 square miles was searched by many ships and aircraft including those involved in a NATO exercise taking place in the general area. The search involved twenty three trawlers; the aircraft carrier HMS *Hermes*; the Tribal class frigate HMS *Mohawk*; the fleet tanker RFA *Tideflow*, KNM *Stavanger* and *Trondheim*, and KV *Nordkappe* and *Senja*. Nimrod and Orion long range patrol aircraft were also tasked to the search as were Sea King helicopters. No trace of *Gaul* was found.

1.9 POST VOYAGE EVENTS

In May 1974 the Norwegian whale catcher *Rover* recovered a lifebuoy from the water in position 71°25'N 28°15'E, about 75 miles south-east of where the wreck was eventually found. This was positively identified as belonging to *Gaul*. Expert examination of the lifebuoy found that its condition reflected immersion in the waters off northern Norway since February. No other wreckage was found.

In the years following *Gaul*'s disappearance trawlers have snagged gear on wrecks on the North Cape Bank. One such snagging involved the Norwegian trawler *Rairo* losing her gear on some form of underwater obstruction in position 72°04'N 25°05'E on 15 November 1975.

Figure B: **Position of wreck of Gaul**



1.10 FINDING THE WRECK

In August 1997 a team funded by Anglia Television and the Norwegian Television Company, NRK, and led by Mr Norman Fenton, sailed from Hammerfest, Norway to find the wreck of *Gaul*. They headed for an area on the North Cape Bank (Nordkapp Banken) which contained the wreck discovered by *Rairo* which Mr Fenton believed to be the missing vessel. Once at the selected position a side scan sonar was used to locate the wreck and after several hours searching, a promising target was found. A remotely operated vehicle (ROV) was lowered to the seabed, manoeuvred close to the contact and positioned to identify it. It was the wreck of a trawler and positively identified as *Gaul*.

Her position was established as 72° 04'N 25° 05'E (**Figure B**) and she was found to be lying with a list to starboard at a depth of about 280m.

The survey of the wreck was limited in its extent but was sufficient to show that the bridge front was undamaged and its windows unbroken. It also showed a mass of fishing net around the starboard funnel. The results of the survey were broadcast on television in the UK in a Channel 4 "Dispatches" programme "Secrets of the *Gaul*" on 6 November 1997.

Following this showing the MAIB was asked whether the new material gave any indication as to why *Gaul* had sunk. With the help of the makers of the television documentary, the unedited film was examined in detail but, apart from confirming that the wreck was indeed *Gaul*, there was nothing to explain why she had been lost. The MAIB concluded that in order to establish the cause, a more detailed examination would be necessary. The Deputy Prime Minister, the Right Honourable John Prescott MP, directed the MAIB to undertake an underwater survey of the wreck during the summer of 1998.

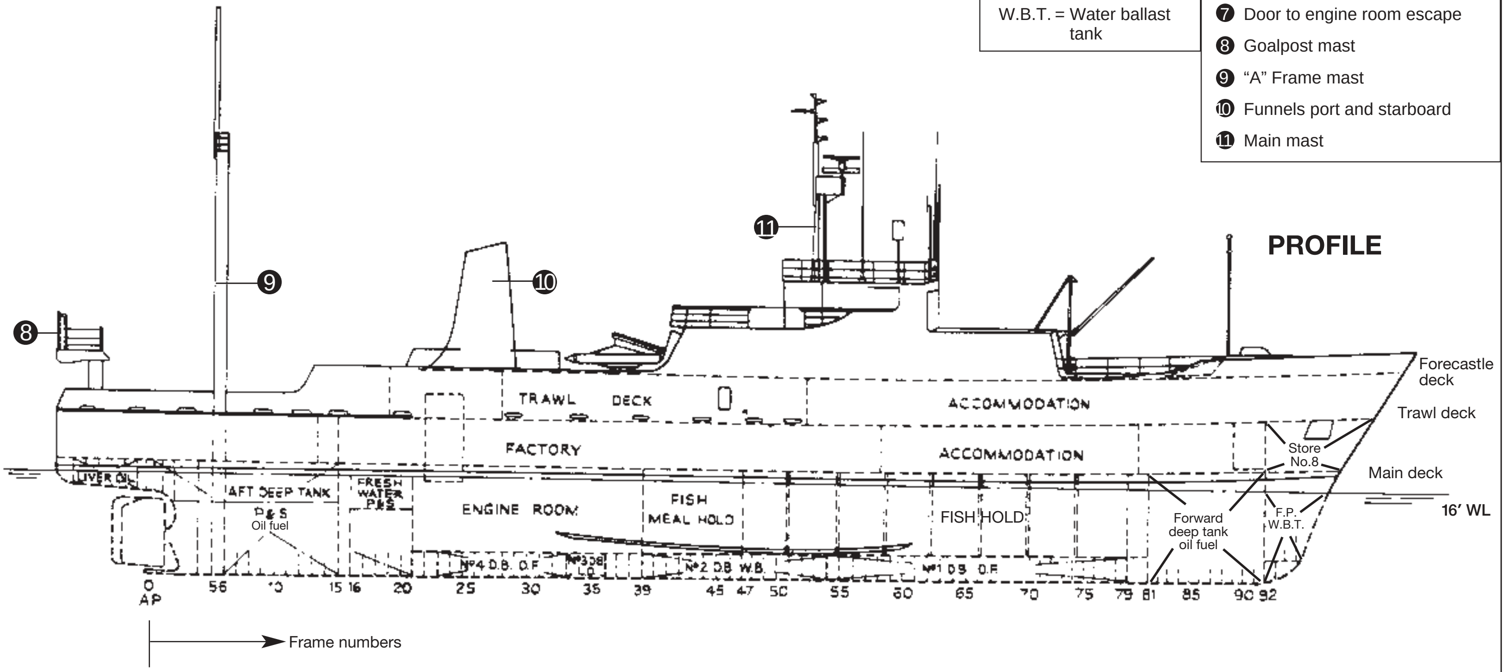
Figure C: Gaul – general arrangement drawing

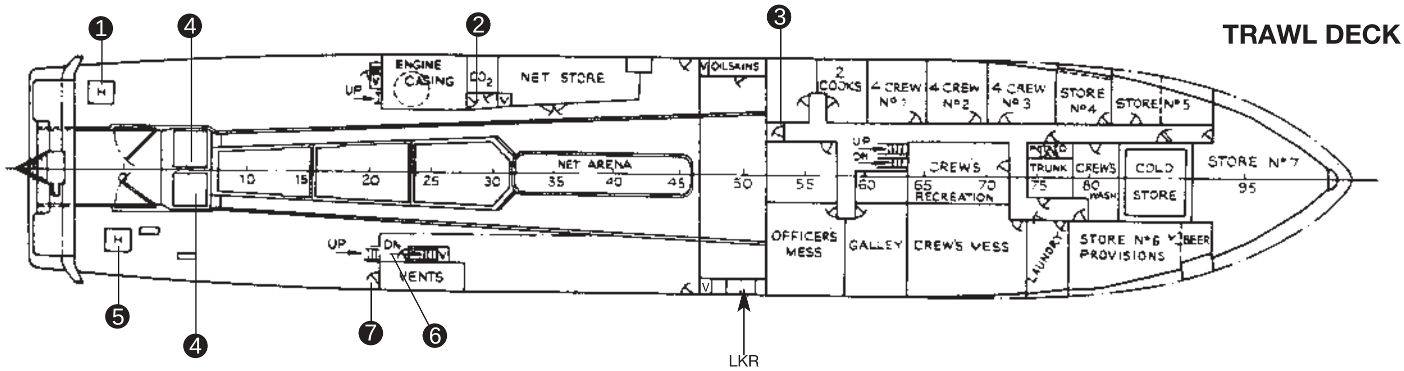
ABBREVIATIONS:

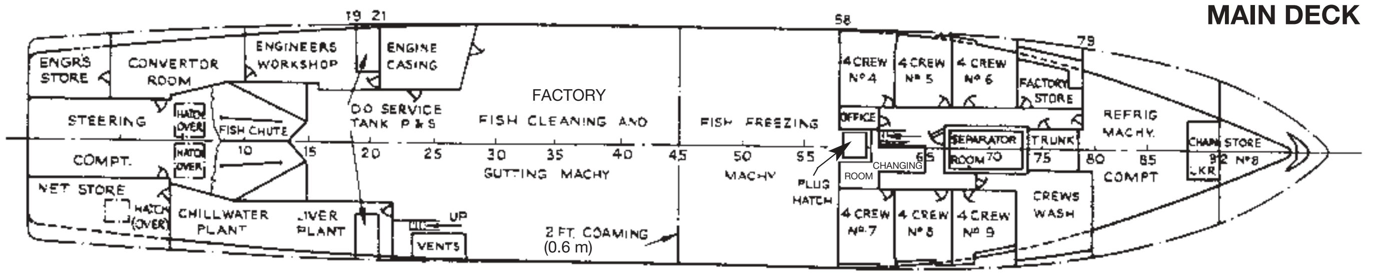
- D.B. = Double bottom
- O.F. = Oil fuel
- L.O. = Lubricating oil
- W.B. = Water ballast
- V = Ventilators
- F.P. = Fore-peak
- W.B.T. = Water ballast tank

KEY:

1. Hatch to engineers store
2. Door to engine casing
3. Door to accommodation
4. Fish loading hatches
5. Hatch to net store
6. Door to factory
7. Door to engine room escape
8. Goalpost mast
9. "A" Frame mast
10. Funnels port and starboard
11. Main mast







SECTION 2
Particulars of *Gaul*

2.1 GENERAL

To aid the interpretation of the underwater survey data, this section contains a detailed description of *Gaul*'s layout. It is taken from the shipyard's 'As Fitted General Arrangement' drawing and is complemented by contemporary photographs of *Gaul*'s sister ships *Arab* and *Kurd*. Reference is made to specific design features such as bobbin rails and weathertight doors and these are explained in the Glossary of Terminology.

A copy of the contemporary booklet, "*Trawl Fishing*", published by the British Trawlers' Federation Limited is in **Annex 3**. It contains a description of factory trawling, and a general overview of the fishing industry of *Gaul*'s era.

2.2 *GAUL'S* LAYOUT

In common with the majority of purpose-built stern trawlers of her time, *Gaul*'s predominant characteristics were a forward accommodation block, high freeboard at the bow, a lower freeboard at the stern and a long aft deck culminating in a steep ramp that cut down through the centre of the transom to the waterline.

The trawl deck and the main deck ran the full length of the vessel. The forecastle deck ran from the stem to the aft bulkhead of the accommodation block and then continued either side of the trawl deck. The weather deck was formed by the forecastle deck forward and the trawl deck aft.

The vessel was sub-divided by six transverse watertight bulkheads. The forepeak bulkhead extended to the underside of the trawl deck, the others to the main deck. Watertight compartments formed by these bulkheads were from forward: the forepeak tank (water ballast); oil fuel deep tank; fish hold; meal hold; engine room; oil fuel deep tanks port and starboard; shaft tunnel centre; and the liver oil tank. There was a double bottom extending from the aft end of the forward oil fuel deep tank to the aft end of the engine room. This was divided into water ballast and oil fuel tanks.

2.2.1 Forecastle deck layout

Forward of the accommodation block were the weathertight hatches to store No 7, the fish unloading trunk, the accommodation escape; the weathertight door to the accommodation block; and the ventilator to the refrigeration machinery space.

The wooden (non-weathertight) doors to the port and starboard wings of the accommodation block gave access to the vessel's boats and the liferafts on the next deck up. The "C" class boat was stowed just forward of the port funnel. The inflatable boat was stowed in a similar location on the starboard side.

Immediately inboard of the port funnel was a large weathertight deck hatch into the engine room casing. This gave access for the removal of small items of equipment and machinery.

2.2.2 Bridge deck layout

A labelled plan of the bridge deck layout is shown (**Figure 1**). There were no weathertight deck hatches on this deck. Wooden (non-weathertight) doors were fitted at each bridge wing, with a third positioned to the aft bulkhead of the bridge offset to starboard. The liferaft stowage racks were immediately aft of the bridge wings. The bridge layout included a control console offset to starboard (**Figures 2 to 4**), and separate chart and radio rooms.

2.2.3 Trawl deck (weather deck) layout

A labelled plan of the trawl deck (weather deck) layout is shown in **Figure 5**. The superstructure ran down both sides for about half its length (**Figures 6 and 7**). The port wing of the superstructure contained the engine casing, the store for the CO_2 bottles to the engine room fire extinguishing system and a net store. The starboard wing contained the engine room ventilator trunk, the engine room escape and the companionway down to the factory. The remainder of the deck was bounded by 1m high bulwarks.

The aft end of the trawl deck between the bobbin rails was closed by a pair of hydraulically operated gates (**Figure 8**). Each gate fitted into a recess in the bobbin rail when fully opened for shooting or recovering the trawl.

Weathertight doors and hatches on the starboard side of the trawl deck were, from aft to forward: the net store hatch (**Figure 6**); the aft facing door to the emergency escape from the engine room (**Figure 9**); the aft facing door to the companionway to the factory deck (**Figure 10**); the hatch to the fish meal hold's trunk.

Either side of the centre-line and just forward of the top of the stern ramp, were the pair of fish loading hatches (**Figure 11**). Each was about 4 m^2 in area and weighed about 0.9 tonne with hinges aft. When shut they were flush with the trawl deck. They were operated hydraulically or, in the event of a power failure, manually. The controls were located on the outboard face of the port bobbin rail adjacent to the hatches. Each hatch could be locked closed by three clips which were turned manually using a socket tool applied from either above or below. There were also manually inserted locking pins to prevent the hatches from dropping down once they were open (**Figure 11**).

Important weathertight doors and hatches on the port side of the trawl deck were from aft to forward: the hatch to the engineers' store; the forward facing door to the engine room casing; the hatch over the fish meal hold's second trunk; and the weathertight door leading to the accommodation block (**Figure 7**).

In the bulwarks there were 13 freeing ports to starboard and 10 to port. Each was 0.91m in length by 0.23m in height and fitted with vertical safety bars (**Figure 5**). They drained water off the trawl deck to safeguard the vessel's stability.

A "goalpost" mast spanned the extreme aft end of the trawl deck. It held the blocks leading the trawl warps over the stern of the vessel (**Figures 6 and 8**). Forward of this, and in line with the fish loading hatches, the "A" frame mast spanned the deck (**Figure 6**). The cod-end was emptied into the fish loading hatches by suspending it from the "A" frame (**Annex 3**).

On each side of the deck, just aft of the superstructure, was a rack holding two or three spare trawl doors (**Figure 5**). There was a recess in the outboard face of each bulwark, immediately aft of the "A" frame, to store the working pelagic trawl doors. (These were not carried by *Gaul* on her last trip). The working pair of demersal trawl doors hung against the transom on either side of the stern ramp (**Figure 8**).

Twin, 560mm high, bobbin rails extended from the trawl winch to the transom, and split the deck lengthways into three strips. The bobbin rails had three functions: to store spare bobbins which were attached in pairs to the rails (**Figure 7**); to prevent the catch of fish from spilling onto the side decks; to reduce the effect on stability of large quantities of water on deck.

The net arena, a large steel trough used for storing the working trawl, was on the centre-line and just aft of the trawl winch (**Figure 7**). When the working trawl was stored, its bobbins were arranged around the outside perimeter of the arena (**Figure 5 and Annex 3**).

2.2.4 Main deck (aft) layout

The fish filleting and freezing factory took up most of the space aft of the crew accommodation (aft of frame 58). Fish were dropped into the aft end of the factory through a chute underneath the fish loading hatches. The factory was divided by a 0.6m high transverse coaming on frame 45. The fish filleting plant was aft, and wet from the 47 tonne/hour of water used in the cleaning and filleting process. Gratings, 0.15m above the deck, covered the area (**Figure 12**). Two Turo slush pumps, each of 91 tonne/hour capacity, prevented an accumulation of water in the factory. Control buttons for the pumps were on the forward bulkhead of the factory, with another set in the engine room. The electric motors driving the pumps were on either side, at the rear of the factory. They were vulnerable to failure if more than 0.6m of water was on the deck.

The factory could also be drained through six suctions using the main bilge pumping system. The suctions were arranged with three on each side. Two were immediately forward of the coaming on frame 45 and two immediately aft. The other two were right aft.

Plate freezers occupied the forward end of the factory. Here fish fillets were frozen in blocks and boxed in cardboard cartons. The boxed fillets were stored in the fish hold. An insulated, three piece, plug hatch sealed the fish hold from the factory. It was retained solely by its own weight, was non-weathertight and probably buoyant. A recess in the forward bulkhead, at frame 58, bounded the hatch opening on three sides. The opening was about 1.3 m square and its aft side was flush with the deck.

Four ducts provided natural ventilation to the factory. Each led to a louvred outlet in the superstructure either side of the trawl deck. Two ventilators were forward and two were aft, arranged two per side. A vertically hinged steel door was fitted to each outlet louvre. The upper quarter of each door formed a horizontally hinged flap (**Figure 10**). This allowed the door to be closed without cutting off all ventilation. It was common practice in this class of vessel to close the doors on the aft louvres leaving the flaps down, and to fully open the doors on the forward ones.

The two gas-tight doors to the engine room casing, in the port aft corner of the factory, had sill heights of 0.64 m. The forward door was the usual route to the engine room.

The weathertight door to the liver oil plant had a sill height of 0.64m. The remaining spaces in this area were linked by doorways in a circuit back to the engine room casing. The sill heights of the intervening doors were 0.15m and the doors were non-weathertight.

Waste products from filleting were handled in two ways. Fish carcasses went into the hopper that fed the fish meal plant in the engine room directly below the factory. Offal was discharged overboard through two chutes in the vessel's starboard side about 1.5m above the design waterline. Each chute was 0.46m by 0.53m in size and fitted with counterbalanced flaps to prevent water sloshing back through them. These were effective to about 90° of heel. Watertight covers were also attached to the chutes.

2.3 PROPULSION AND ELECTRICAL POWER

Gaul was propelled by a 16 cylinder English Electric Type 16 RK3M diesel engine of 1939 kW output at 750 rpm, driving a single 4-blade cp propeller via a reduction gearbox.

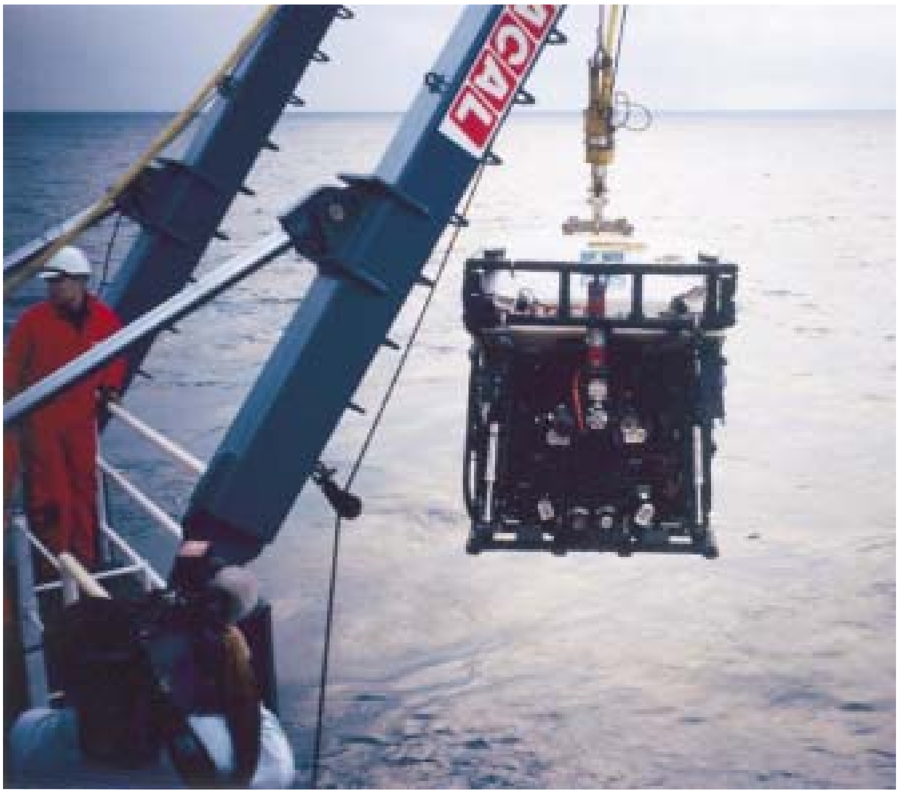
Electrical power was supplied by a shaft generator and two diesel generators. On passage, the electrical load could be met by the shaft generator alone. In an emergency the shaft generator could also be used as an electric motor to provide propulsive power in place of the main engine. In this mode it could drive the vessel at a maximum speed of about 3 knots.

2.4 LIFESAVING APPARATUS

Gaul was equipped with six liferafts. When she left the builder's yard in 1972 these were fitted with Hydrostatic Release Units (HRUs). There were four lifebuoys and lifejackets for every member of the crew. The accident occurred long before Emergency Position Indicating Radio Beacons (EPIRB) were carried on board merchant ships and fishing vessels.

Figure D: **Mansal 18 in Kristiansand, Norway**

Figure E: **Launching an ROV from Mansal 18**



SECTION 3
Data Collection

The underwater survey of the wreck

3.1 GENERAL

Preparations for the survey included drawing up a detailed specification of the objectives. This was presented to the *Gaul* Families Association for comment and was, so far as it was possible, amended to accommodate the families' particular requirements.

The most difficult problem was gauging the extent of fishing nets covering the wreck and working out how best to handle them.

At the particular request of the families three of their representatives were embarked on the survey vessel to monitor progress. A large compartment, equipped with three video monitors linked directly to the ROV control room, was provided for the exclusive use of the families' representatives. From here they could maintain a continuous observation on the ROV operations as they took place.

The families also requested that a television team should embark to film events. In view of the avowed aim to make the entire survey as open as possible, and to remove any suspicion of a 'cover up', this request was granted even though there was a risk that 'instant' assessments of any findings might be made before a detailed analysis could be undertaken. It was decided that the benefits of allowing a television crew to film this particular survey would outweigh the disadvantages.

The survey was carried out over three days beginning 10 August 1998, from the dynamically positioned cable laying vessel *Mansal 18* (**Figure D**). Weather conditions were ideal. Three ROVs were embarked, with full on-site repair capability (**Figures E and 13**). A side scan sonar was also carried. The prime contractors were Dronik Consultants Ltd and Southampton Oceanography Centre (SOC). The team from SOC were equipped with computers for enhancing and producing large scale plots from the video and sonar recordings.

A wreck was located using side scan sonar in the position given to MAIB by Mr Fenton and Anglia Television. Its sonar image was of good quality and showed a vessel with all the main characteristics of *Gaul* (**Figure14**).

A side scan sonar reconnaissance of the seabed was also carried out in the area of the wreck (**Figures 15 and 16**) before the ROV was deployed and gave a reasonably clear picture of the net coverage.

The first task for the ROV was to circumnavigate the wreck from a range of 50m to locate and identify any hazards to its navigation (**Figure 17**). While conducting this manoeuvre one of the ROVs became trapped by a trawl net off the starboard aft corner of the wreck. The second ROV was launched to cut it free. This was the only occasion when two ROVs were used simultaneously.

In the later ROV dives, to save time in changing from manipulator held camera to hydraulic hammer, different ROVs were used. One did not have its depth gauge correctly calibrated and photographs taken by this ROV show depths which are about 20m too shallow. The correct depth to the seabed is about 280m.

Underwater visibility was limited by plankton and also restricted from time to time by large numbers of fish.

The survey was carried out using video cameras mounted on a Racal Sealion ROV (**Figure 13**). The ROV equipment fit was varied to suit the requirements of each dive. To smash portholes it was fitted with a hydraulic hammer; to look inside compartments, a miniature video camera was mounted on one manipulator arm; and to cut trawl nets, one manipulator arm was fitted with shears.

The plan was to inspect the wreck for damage, check the state of each of the weathertight doors and hatches, and obtain as near 100% video coverage of the visible wreck as possible. It also included the intention to look inside a number of compartments for human remains.

A further objective was to see if there was any physical connection between the wreck and the cable lying on the seabed that was discovered by Mr Fenton during his expedition the previous year.

The overall objective was to collect evidence to determine the cause of the sinking.

Because it was possible to establish the general locality of the nets in the initial survey, it was decided that the best way of managing the problem was to manoeuvre around the nets rather than make any attempt to cut or secure them. Apart from the initial snagging, this policy proved to be successful.

The operation ran continuously over the three days and about 45 hours of video evidence was gathered.

The survey aims were achieved.

3.2 WRECK ORIENTATION AND ACCESSIBILITY

The wreck was confirmed to be lying in position 72° 04'N 25° 05'E at a depth of about 280m.

It was heeled about 35° to starboard and lay, approximately, level fore and aft. Its heading was north-east. The bow was buried in sediment to a depth of 1.7m; the stern was clear. The large angle of heel gave easy access to the port side of the hull but restricted it to the starboard side which was buried in sediment to about 0.3m below the trawl deck amidships (**Figure 18**). Access to the port side was relatively unobstructed but many trawl nets had caught on the starboard side. In places these hung like curtains and prevented the ROV from approaching the hull too closely.

The restricted underwater visibility meant that many video frames showed an area less than 2 metres square. To assist in the subsequent analysis larger images have been produced by making digital copies of the individual frames and joining them together in a mosaic using computer software. The selected frames have been laid onto scaled drawings to ensure that the resultant mosaic was dimensionally accurate. A number of mosaics are reproduced in this report and will be referred to frequently. Where the ROV's camera was able to maintain the subject at a constant perspective much useful data was obtained.

This was the first time that the MAIB had taken such extensive video photographs of a wreck interior. It was done by strapping a mini video camera to the end of the manipulator arm of the ROV. The extent to which the camera could be inserted into the interior was limited by the length of the manipulator arm to about 1 metre. On one occasion, in order to view the control console on the bridge, the camera was fitted to the end of an extension piece held in the manipulator's jaws. The orientation of the camera, once inserted into a space, was however constrained by the limited movement and rotation of the manipulator jaws. This method was impracticable when inserting the camera through portholes.

3.3 DETAILED FINDINGS

3.3.1 Port side (from forward to aft) (Figure 19)

The side plating at the bows forward of bulkhead 92 and below the trawl deck was badly crushed. It was worst near the lower edge of the anchor box where the plating had torn open over a length of about 2m (**Figure F**). The tear was forward of the bulkhead on frame 92 and below the trawl deck, about 2.7m above the design waterline. Apart from one other tear, about 0.2m long at the level of the main deck on bulkhead 92, the plating was intact but grossly deformed. Between bulkheads 92 and 79 the deformation in the plating was below the main deck. Aft of frame 79 the plating, which was visible to just below the level of the bilge keel, appeared undamaged.

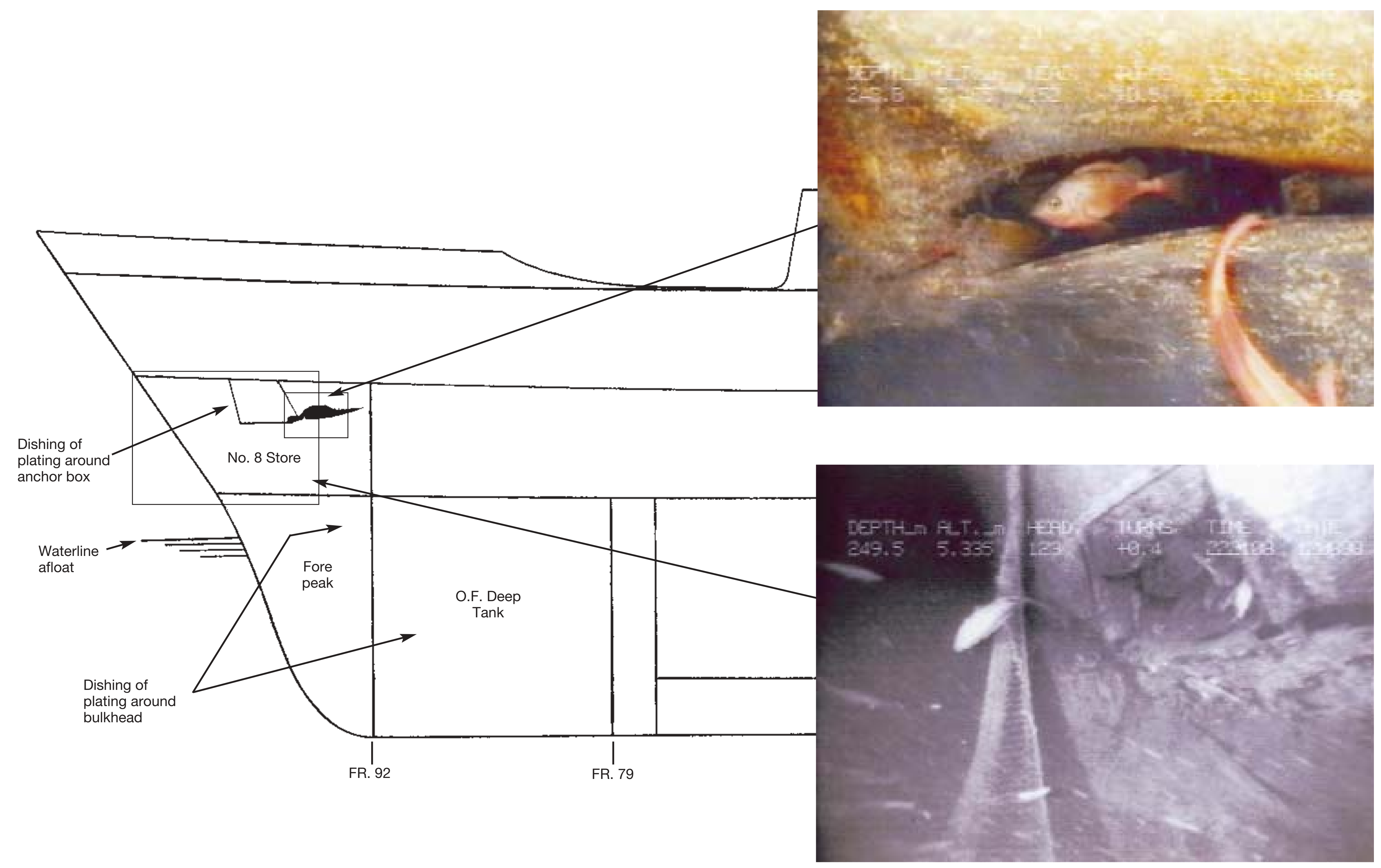
The guard-rails between the stem bulwark and the front of the superstructure had been destroyed.

The anchor was in its box.

An uninflated liferaft container marked "Beaufort" was on the seabed close to the port bow (**Figure 20**). It was the same make as *Gaul*'s and was assessed to be one of hers.

The bilge keel was visible and generally undamaged. Sea water intake grilles were visible below the bilge keel.

Figure F: **Damage to plating of port bow**



Guard-rails to the bridge top were twisted and had been torn loose in places.

The glass to the port bridge windows was unbroken and all the bridge windows were closed.

Five of the 16 portholes on the port side could not be examined closely, but the glass in the remainder was unbroken. Only the unsecured deadlight to No 3 four-crew cabin was down and was hanging away from the glass.

An oval-shaped wooden trawl door hung from the bridge deck guard-rails with its warp running diagonally down the side and over the aft end of the bilge keel.

The side shell pilot's door was closed.

The liferaft containers were missing.

A wall of net prevented access to the lower part of the hull aft of the bilge keel. An area of rust between frames 21 and 27, just aft of the bilge keel, revealed two minor dents in the hull plating. This apart, the plating appeared undamaged, including those areas over the fresh water, fuel oil and liver oil tanks.

The freeing ports were clear. The pelagic door storage recess was empty. (The doors were not carried on *Gaul*'s last trip.)

The outboard plating on the port funnel was indented over most of its height (**Figure 21**). A three dimensional computer model of the observed damage has been produced.

3.3.2 Starboard side (from forward to aft) (Figure 18)

As with the port side, the side plating of the starboard hull was grossly deformed below the trawl deck and forward of frame 79 to the stem. The deformation was worst near the lower edge of the anchor box and across bulkhead 92. Unlike the port side, the plating was not torn open, but minor splits radiated out from the corners of the anchor box.

The anchor was in its box.

A string of trawl bobbins were tight in by the forefoot. These were identified by Skippers Suddaby and Petty as a type not used on *Gaul*. The warp from the bobbins cut diagonally aft across the wreck's side and disappeared into the tangle of nets caught on the starboard aft corner of the bridge.

Of the 18 portholes in this area, 10 had their glass unbroken. Because they could not be examined closely the condition of the remainder is unknown. The deadlight to the forward porthole of the crew's mess was secured down, the aft one was also down but unsecured, as was the deadlight to the second engineer's cabin. The deadlight over the porthole to the factory manager's cabin was up. The others could not be examined closely enough to see the deadlights.

The glass to the portholes of Nos 8 and 9 four-crew cabins was intact and there was no visible deformation in the surrounding hull plating. The portholes were less than a metre above the sediment. The ship's bell and the remains of the DF aerial were found lying on the seabed nearby.

Parts of the starboard side were heavily shrouded in nets which prevented close photography. A cod-end hung from the starboard bridge wing and obscured all but the most forward bridge side window which was unbroken and closed.

The side shell pilot's door was closed.

The starboard side was buried in sediment up to about 0.3m below the third freeing port from forward. The outlets from the offal and duff chutes and the galley waste chute were buried under the sediment.

The freeing ports were too close to the seabed to be examined.

The liferaft stowage racks looked empty, but the view was partly obscured by a trawl net. The top section of the main mast was also lying in this area.

The starboard funnel was completely encased in trawl net with headline floats rising above it. The outboard face of the funnel appeared undamaged. Trawl nets hung from the 'A' frame.

The sediment dropped away sharply at the stern so that the steerable Kort nozzle was visible. The seabed was littered with discarded nets and bobbins in the vicinity of the Kort nozzle.

3.3.3 Transom

The transom was undamaged and the goalpost mast was in place (**Figure 22**). The port corner was covered in several layers of net but a trawl door of the type used by *Gaul* was visible under the netting. The door was in the usual stowage location for the working port trawl door. The starboard corner of the transom was clear of net and no trawl door was present. The block, which would have led the trawl warp over the starboard side, was not seen.

The steerable Kort nozzle and the propeller were sighted and appeared undamaged (**Figures 23 and 24**). Kort Propulsion Ltd was consulted for its interpretation of the video evidence. It advised that the nozzle showed between 10° and 15° of port helm, the propeller was in ahead pitch (based on the shipyard's drawings showing a left handed propeller), and while they could not make an accurate assessment of the degree of ahead pitch, they judged that the propeller was pitched to absorb between 50% and 75% power.

3.3.4 Forecastle deck (forward) – (Figure 25)

The deck structure appeared undamaged. All three weathertight hatches were secured down; none were deformed. All air pipes and ventilators were in place and appeared undamaged.

3.3.5 Deckhouse front – (Figure 26)

The structure was undamaged. The weathertight door to the accommodation was secured closed. The glass to both portholes was unbroken, and the deadlight to the radio workshop was up. The spare anchor was stowed in its brackets.

3.3.6 Deckhouse top

Although the structure was undamaged all standing equipment such as aerials had gone. The deckhouse top was littered with debris from adjacent areas. One of the bridge front windows, complete with frame, was lying on it. The three ventilators in front of the bridge were undamaged.

3.3.7 Bridge front – (Figure 27)

The structure was intact apart from the missing window (fourth from port) which was lying on the deckhouse top in front of the bridge. The middle section of the bridge front, which was constructed of aluminium alloy, was very badly corroded and on the point of collapse.

The builder's plaque was in place but the ship's bell was missing: it was later recovered from the seabed. Both lifebuoy stowage boxes were missing.

3.3.8 Bridge top

Access was restricted by nets hanging from the main mast. The main mast was standing but the section above the cross-beam had been displaced and was found near the inflatable boat stowage position on the starboard side. All other standing equipment on the bridge top had been destroyed or was missing. The searchlight was hanging over the front edge and the port side navigation light box had been destroyed displacing the lamp which was recovered. The guard-rails were badly buckled and were missing in several places.

3.3.9 Bridge interior

The bridge was remarkably well preserved with most of the equipment and fittings in their original positions. This preservation was a common feature in all the interior spaces inspected.

The port bridge wing door was missing and not found; the starboard bridge wing door was closed and its glass unbroken.

The port side of the control console was viewed but could not be inspected close-to. The fire alarm panel, the panels immediately below it, the radar scope and Elac echo sounder were discernible. The rubber socket which would have held the VHF telephone handset was empty. The watchkeeper's chair was not seen and the autopilot control was missing (**Figure 28**). A deckhead lining panel had fallen over the console and obscured the view into the port forward corner. The view to starboard was restricted to the echo sounder and instruments in the forward corner (**Figure 29**). The propeller pitch control lever could not be reached.

The rudder angle indicator, binnacle compass periscope and voice pipe were all in place in the deckhead. The ship's wheel was sighted; its pedestal was on the point of collapse.

Across the front of the bridge the floor mats were heaped to starboard and the handrails from below the bridge front windows had fallen onto the floor. Radiators were in place, as were the voice pipes. The cover to the port voice pipe was open; the trumpet at the end of the starboard voice pipe was missing. The binocular box was empty.

The twin doors to the flag locker were wide open.

The steering tiller on the port bridge wing was to port and the gyro compass repeater was in place (**Figure 30**). The steering control changeover lever was also in place. This control station was used for bringing *Gaul* alongside when docking.

The bridge front radar was in place but the cathode ray tube had imploded (**Figure 31**).

3.3.10 Forecastle deck (aft)

The inflatable boat was missing and its davit was pointing directly outboard.

The class "C" lifeboat was missing and the lifeboat davit was in its stowed position.

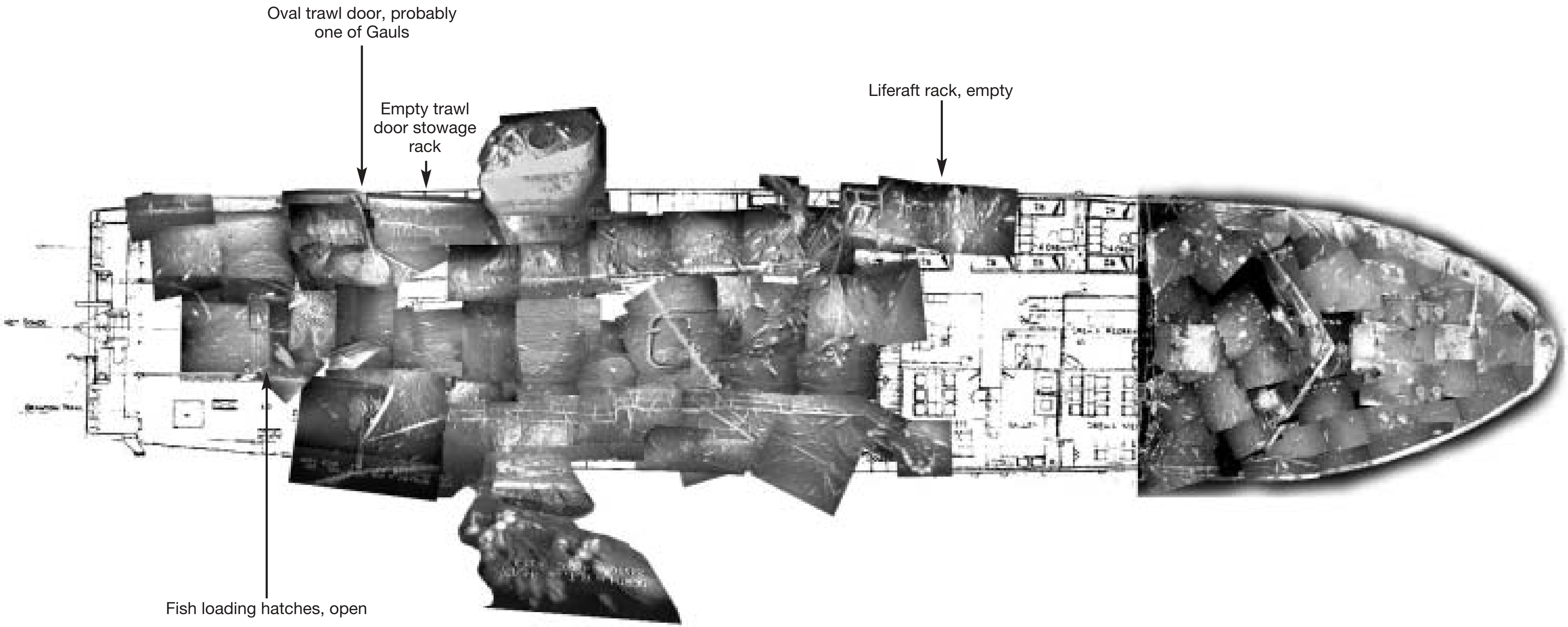
The door on the port wing of the accommodation was open and falling off its hinges; the starboard door was closed.

The inboard faces of both the port and starboard funnels appeared undamaged. The cover to the access hatch on the aft face of the port funnel was open (**Figure 32**).

The inboard guard-rails down both sides were in place but parts were badly bent (**Figure G**).

The machinery removal hatch, inboard of the port funnel, was down but unsecured.

Figure G: **Plan view of trawl deck and forecastle deck**



Southampton Oceanography Centre

Note: 1) Nets prevented photography over the aft starboard corner of the trawl deck

3.3.11 Trawl deck (aft) – (Figure G)

The presence of nets and wires made ROV access to the trawl deck particularly hazardous and video coverage was conducted at relatively long range with varying perspectives.

The deck structure appeared undamaged and all major items of fitted equipment were in place.

The port fish loading hatch was fully open, the starboard side one was slightly less so. Both hatches appeared undamaged, as did their securing clips (**Figure 33**). All the securing clips, bar one, were in the open position.

Neither of the hatch locking pins was in place (**Figure 34**).

The chute beneath the hatches was empty. The hatch control panel was in place on the port bobbin rail and was covered by a layer of sediment.

Both halves of the gate at the top of the stern ramp were fully open and recessed in the bobbin rails (**Figures G and 35**).

The hatch to the engineers' store was down and undamaged; that to the net store was inaccessible.

To port, the spare trawl door stowage rack was empty (**Figure 36**). A wooden oval trawl door was caught underneath the forward barrier to the 5 tonne back-haul winch (**Figure G**). The folding door over the engine room exhaust ventilator was ajar. The weathertight doors to the engine casing and CO_2 compartment were secured closed. The top flap of the aft ventilator to the factory was open and the after door to the net store was hanging open. The forward ventilator to the factory and the weathertight door to the accommodation were inaccessible. The band brake on the 5 ton back-haul winch was on and its control lever was in neutral.

To starboard, the spare trawl door stowage rack was empty (**Figure 37**). The weathertight door to the emergency engine room escape was open and appeared undamaged (**Figure H**). The weathertight door to the factory companionway was also open (**Figure I**). It was undamaged but appeared to have been secured open by its door hook. The doorway opening was two-thirds full of trawl net. The top flap of the aft ventilator to the factory was open. The forward ventilator to the factory was inaccessible.

One pair of spare bobbins, attached to the port bobbin rail, was seen. Two more bobbins were seen, partly underneath netting, on the starboard inside of the net arena (**Figure 38**). These appeared to be connected to others in a string which led over the starboard coaming of the net arena, into the mass of nets filling the space between the starboard coaming of the net arena and the vessel's starboard side (**Figure 37**).

On the port side, trawl net was rising from the net arena to the level of the forecastle deck (aft). Almost the entire aft face of the accommodation and bridge was hidden under a shroud of nets rising from the net arena and hanging from the main mast.

Figure H: **Door to engine room emergency escape**

Note: 1) Door is wide open.
2) The two securing clips visible in the photpgraph are in the open position.

Figure I: **Door to factory from trawl deck**

Note: 1) Door is wide open.
2) Doorway is two-thirds full of fishing net

3.3.12 The 'A' frame – (Figure 39)

Both the port and starboard trawl warps passed through the tension meter blocks on the 'A' frame mast. The mast's aft port stay was parted and hung forward close by the starboard leg of the mast. A cod-end net was draped over a loop of wire which led to the block half way up the inside of the starboard leg. The wire which led from the block at the top of the mast and was used for raising the cod-end above the fish loading hatches, also hung near the starboard leg. The end of the wire could not be viewed closely but appeared to have parted.

3.4 THE SEARCH FOR HUMAN REMAINS

At the special request of the *Gaul* Families Association a search for human remains was a key objective. Some research was done in parallel with the survey preparations to determine whether physical remains were likely to be present after 24 years but the findings were inconclusive. Expert opinion varied from predicting that nothing would be found after such a long time to guarded optimism that there might be something.

The preparation and search for human remains ran continuously for about 24 hours. During this time the interiors of nine compartments were examined: the bridge; the cabins of the factory manager; the second engineer; the radio officer; the second officer; and the mate; and Nos 1, 2 and 3 four-man crew cabins. Portholes to five of the cabins were broken by hydraulic hammer to enable the miniature video camera to gain access. Three of the cabins were viewed through the collapsed partition bulkheads between adjoining cabins.

Every effort was made to gain access to the radio room, crew's mess and galley but in the event, it could not be done. All attempts to break the glass to the radio room window failed; the deadlights were down over the portholes to the crew's mess, and nets prevented the ROV from getting to the galley portholes. The deadlights were also down over the portholes to the second engineer's cabin, and No 3 four-man crew cabin. However these were viewed from adjacent cabins as the partition bulkheads had burst open.

The cabins were in a state of chaos. Although fixed items of furniture were in place, loose gear was scattered everywhere. Non-structural partition bulkheads had collapsed forwards into adjoining cabins (**Figure 40**). The forward bulkhead of the chart room had bulged forward without breaking the glass that formed its upper half. The mattress in one cabin had been thrust forwards and was found curled up against the bunk end panel. In No 2 four-man cabin the fire extinguisher was missing from its bracket, but one was seen to be still in place in No 1 four-man cabin. The three desk drawers in the mate's cabin were fully extended to starboard (**Figure 41**).

Sightings of what were thought to be possible human remains were made in three cabins: Nos 1 and 2 four-man crew cabins, and the radio officer's cabin.

The search was terminated when the *Gaul* Families representatives on board were satisfied that every reasonable effort had been made to find evidence of human remains.

The objects discovered in some of the cabins had certain characteristics which resembled parts of a body and were video photographed.

3.5 SEABED CABLES

There were a number of cables lying on the seabed around *Gaul*. One cable in particular had attracted interest following a suggestion in the "Dispatches" television documentary that it might have been a military cable associated with underwater listening devices to track Russian submarines.

The main reason for the interest was its apparent alignment with the island of Söröya, which was believed to be the site of a monitoring station for military subsea cables. This theory attracted greater credibility once it was found there were no mapped commercial submarine cables in the area of the wreck.

The cable shown in the "Dispatches" programme was located during the MAIB survey and followed. It was taut and ran in a fairly straight line on an alignment very similar to the "Dispatches" report. Unfortunately, the "Dispatches" underwater video provided no clues as to where the cable was in relation to the wreck.

The MAIB's ROV examined the cable closely and found it had the "stranded" appearance of a wire rope (**Figure 42**). It was followed to the wreck and was found to pass forward of the bow and beneath the rake of the stem. It was not physically connected to *Gaul* in any way.

The MAIB found many other cables on the seabed in the vicinity of the wreck, and some of these were caught on it. None appeared to be linked to the loss of *Gaul*, and none seemed anything other than the wire rope used in trawl gear. Although the "mystery" cable was larger than others observed in the immediate vicinity it did not appear to have the characteristics of an underwater communications cable and was not connected to *Gaul*.

There was no evidence to indicate it had contributed to the loss of *Gaul*.

3.6 MODEL EXPERIMENTS

Part of the data collection process involved conducting model experiments in a hydrodynamics testing tank.

MAIB's model experiments were designed to test the theory that *Gaul* had sunk from downflooding through open weathertight doors and hatches after her trawl deck had been swamped by large breaking waves. It was important to establish whether a large wave could fill the trawl deck with several hundred tonne of water, pour through the open fish loading hatches, the open door to the factory deck and the open door to the engine room escape, and sink the vessel. BMT devised and managed the experiments which were carried out in eight days between 19 December 1998 and 11 January 1999 at BMT/DERA's Hydrodynamic Test Centre at Haslar, Hampshire. The former skipper and mate of *Gaul* attended the last two days of the experiments.

Before construction of the model could begin, its scale had to be calculated based on the wave height which could be generated in the test tank. This was derived from the wave height that *Gaul* might have encountered on the day she disappeared. BMT engaged Dr N Hogben, an expert in ocean waves, to advise on the modelling of the severe wave conditions likely to have been present on North Cape Bank on 8 February 1974. He confirmed that the tendency for waves to form groups was a well-known feature of the real sea and that the phenomena was characterised by a sequence of relatively high crests separated by areas of relative calm. Enhanced Jonswap wave spectra were devised to produce the wave grouping effect required. It was also determined that the highest wave which could have been expected to occur 3 hours into the storm was about 18.3m (60 feet) and this set the scale for the model size. The steepness of the waves was chosen to produce breaking waves.

A one to forty-six scale model was constructed to match the largest breaking waves which could be generated at the BMT/DERA Hydrodynamic Test Centre. It was equipped with radio control and instrumentation for measuring and recording roll angles, and was ballasted to the same displacement as used in the 1975 model tests. Its centre of gravity was found by assuming that *Gaul* had, as usual, consumed fuel from the forward tanks first. The measured roll period of the model corresponded to 10 seconds full size.

Experiment runs were carried out with the model in beam, stern quartering, and bow quartering waves. The model was both lightly tethered in position and free to manoeuvre under radio control. Most runs were carried out in irregular parallel crested waves. In two calm water runs, the factory was progressively filled with water until the model sank by the stern.

The irregular wave patterns generated for the experiments contained groups of breaking waves representing the worst conditions that prevailed on the North Cape Bank when *Gaul* was lost.

BMT also set out to establish whether the fish loading hatches could have been lifted by a build up of air pressure in the factory as the vessel sank.

The results of the experiments did not support the theory being tested. *Gaul* was shown to be an extremely seaworthy vessel and would not have succumbed to waves breaking onto her trawl deck. She was also shown to be directionally stable in following seas and did not broach when surfing. In head seas her sea keeping performance was excellent.

The experiments revealed however, that a group of very large breaking waves, 16m (52 feet) or higher on her beam, could roll her to 90° (a "knock-down"), and a 22m (72 feet) high wave could completely invert her. This was an unexpected development.

The sinking experiments showed that flooding the factory with about 350 tonne of water immersed the sill to the engine room escape door. It was also found that once this inflow of water had started, downflooding caused the model to sink rapidly and steeply by the stern.

Calculations showed that the fish loading hatches could not have been opened by the pressure of trapped air in the factory as the vessel sank. It was also found that rolling in a heavy sea state did not cause sufficient acceleration to throw the hatches open.

BMT's executive summary report on the model experiments is at **Annex 4**.

3.7 ADDITIONAL DATA

The 13 volumes of the transcriptions taken at the FI were examined by inspectors and provided evidence of particular significance following the discovery of the wreck.

Of equal value were the construction drawings for *Gaul*. Early in the investigation the MAIB were fortunate to obtain about 1000 micro film copies of the construction drawings for *Ranger Castor* and her three sister vessels. These had been saved from the vessel's builders, Brooke Marine Ltd, by its sister company FBM Ltd which still operates on the Isle of Wight.

3.8 GAS POCK MARKS

The side scan sonar also revealed that the seabed around the wreck was scarred by small craters, thought to be the vents to pockets of natural gas. A few were examined visually by the ROV and none showed any signs of current activity **(Figure 16)**. There is no evidence to show they had anything to do with the cause of the accident.

SECTION 4
Analysis

4.1 GENERAL

Using the data obtained in the survey and supported where appropriate by model experiments and evidence produced at the original FI, the MAIB set out to determine the most likely cause of *Gaul*'s loss. Inspectors retained an open mind throughout the investigation and had to change their views several times as analysis of the evidence ruled out certain possible causes of her loss.

Inspectors referred frequently to the vessel's construction drawings.

Many of the still photographs taken from the underwater survey video recordings were built into mosaics and superimposed on ship's drawings of the same scale. These enabled detailed analysis to be made of large areas of the hull, superstructure and equipment including the nets. This technique was developed during the DETR sponsored investigation into the loss of another vessel, the mv *Derbyshire*.

Inspectors began by considering what evidence there was to support the theories discussed with the *Gaul* Families representatives while the survey was being planned. These can be summarised as: structural failure; damage in a collision; sinking as the result of an explosion or fire; foundering as a result of heavy weather damage; or a capsize.

Conducting an investigation so long after the event was not easy. There were no witnesses and there was no voyage data recorder to be recovered. Internal access to the vessel was very limited and much external damage had been caused by the trawls of other fishing vessels. This activity may have removed, or even destroyed, important evidence. The investigation was further complicated by the presence of so many trawl nets that obscured or prevented close photography of large areas of the trawl deck and the starboard side. Nonetheless, the wreck was still in remarkably good condition and most of the weathertight doors and hatches could be seen.

It was unlikely that the photographic evidence would provide all the answers as it would be confined, in the main, to a look at the exterior of the vessel as it would have been when she sank. From experience the MAIB has found that an underwater survey of a wreck will provide sufficient information on which to form a valid judgment as to why it sank.

4.2 BOW DAMAGE

Detailed examination of the hull revealed that there was only one area where it had been damaged; at the bow and on both sides of the stem. The inspectors started their analysis by concentrating on this feature. They carefully examined the deformed and torn hull plating.

The most significant feature was that the bow damage occurred on both sides of the hull but had hardly affected the stem (**Figure 43**). The port side plating of No 8 store was badly torn forward of the bulkhead on frame 92 and immediately below the anchor box (**Figure F**). The plating to the forepeak ballast tank and the forward oil fuel deep tank was badly distorted but not torn.

The two most likely explanations for the damage were collision and the effects of water pressure.

4.2.1 Collision?

Damage caused by collision with another object is usually confined to one side of a vessel or, when head-on, the actual stem. The damage is normally characterised by evident signs of an impact and, often, by an indentation in the shape of the object with which contact was made. None of these indicators were present.

Had there been a head-on collision, the stem would have been severely damaged and set back over much of its length. This had not occurred; the damage was slight and over a very short length.

Had the damage occurred while *Gaul* was on the surface, any flooding would have been contained by the bulkhead at frame 92. It would not have seriously endangered her and there would have been ample time to put out a distress call. Had the damage caused the bulkhead at frame 92 to pull away from the side plating in places, the flooding would have still been relatively easy to contain. The damage was conspicuously above the waterline and flooding would only have occurred when the vessel buried her bow into the seas. In these circumstances the rate of flooding could have been reduced considerably by turning the vessel down sea and there would, once again, have been ample opportunity for those on board to report what had happened.

The investigation concludes that the damage to the bow was not caused by a collision, nor by any other event that occurred on the surface.

4.2.2 Water pressure?

The alternative explanation for the damage, water pressure, was examined.

The very high pressures to which watertight objects are subjected when underwater are well known. Submersibles operating at great depths have to be manufactured from material such as titanium to withstand these. What is not so well known is that pressures at even modest depths are significant and capable of exerting immense forces on any structure that remains watertight. Once flooding has taken place the pressure on both sides of any hull plating will have equalised and the situation does not arise.

The ice-strengthened bow plating on *Gaul* was designed to withstand about 16 tonne/m^2. The water pressure at the seabed, where the wreck of *Gaul* was lying, is about 280 tonne/m^2 which is almost twenty times the design strength of the bow structure. It is little wonder that the bow plating collapsed as she sank rapidly.

The characteristics of water pressure crushing damage are well known and have been seen in other marine accident investigations. The distorted bow plating of the wreck presented the classic characteristics of damage caused by external pressures on the hull after the ship had left the surface. The most recent example of water pressure crushing damage occurred when the Hull trawler *Galatea* sank in only 100m of water on 5 January 1999. Video footage of the wreck revealed bow damage that was almost identical to that observed in *Gaul*.

If, as will be argued, the hull was undamaged when *Gaul* sank, water could have entered the forepeak ballast tank and the forward oil fuel deep tank, through, and only through, their air pipes. If the skipper of *Gaul* had followed the usual practice of using fuel from the forward deep tank first, it would have been virtually empty by 8 February. The forepeak ballast tank was also probably dry to give the vessel a heavy stern trim for towing. If the open tops of the air pipes were still above water in the moments just before *Gaul* began her final plunge to the seabed, conditions would have been right for the tanks to collapse under external water pressure. Similar conditions applied to No 8 store. It was unventilated and sealed from the rest of the vessel by a deck hatch.

There was no other sign of water pressure crushing damage on the hull. This indicates that *Gaul* settled by the stern and, in so doing, allowed the after tanks to flood through their air pipes before she finally sank. While this process was taking place the tops of the air pipes on the forecastle remained above water. When she finally sank, the empty forward tanks began to flood through their air pipes, but as the rate of descent was so fast, some air remained in them. When *Gaul* reached crushing depths, the external water pressure was so great that it destroyed the tank boundaries. This imbalance between the external sea water pressure, and the internal air pressure in the bow spaces, was so great that it caused the destruction observed on both sides of the ice-strengthened bow at a depth of between 30m and 40m.

The MAIB is in no doubt that the bow damage was caused by water pressure as *Gaul* sank. It was not responsible for the vessel's loss.

This view was shared by Professor Colin MacFarlane of Strathclyde University who independently assessed the damage for the *Gaul* families.

4.3 DISCOUNTED THEORIES

4.3.1 MAIB inspectors considered whether *Gaul* was lost by fire, explosion, hostile act or structural failure. A careful search was made to find evidence to support any of these scenarios. None was seen.

There was no evidence at all of any damage having been caused by fire, gunfire, any form of projectile, or ordnance impact, either above, or below, the waterline. Furthermore, there was no indication of any structural failure that might have caused *Gaul* to sink from flooding.

4.3.2 One theory advanced for *Gaul*'s sudden disappearance was that she had foundered following a heavy list caused by internal flooding (**Annexes 1 & 2**). It was argued that a list had been caused by flooding of the factory from the water supply to the fish processing machinery. This might have been possible had the water supply been left running for several hours after the last haul had been processed.

The FI was told that *Gaul*'s factory had flooded at least once during her previous trip because the drain pumps had choked (**Section 1.5**) during fish processing. It was suggested that if something similar had occurred at the time fish processing stopped, it would have gone unnoticed. Had the water supplies to both the processing machinery and washing-down hoses been left on, then the factory would, so the argument goes, have flooded. The evidence of *Gaul*'s previous chief engineer confirmed that the water supplies were frequently left running once fish processing had stopped.

Notwithstanding these theories the MAIB concludes that factory flooding had not occurred for three reasons:

1. When *Gaul* was seen by the mate of *Swanella* lying beam on to the seas, no processing had taken place in the factory for about 9 hours. While this would have been time enough for a dangerous quantity of water to accumulate in the factory there was no evidence whatsoever to suggest she was listing.

2. *Gaul* was seen lying beam on to the seas. She would have been rolling heavily and this would have caused a large volume of water in the factory to slosh violently from side to side. It would not have escaped notice for long.

3. After processing stopped, the factory should have been visited on several occasions by various members of the crew. Engineers walked through the factory to the engine room at least every 4 hours when the watch changed. It was the established practice for the deck watch on duty to go through the factory to check for fire and flooding every 1 or 2 hours. Since at least 12 hours had elapsed between *Gaul*'s last radio message which reported she was laying and mending, and the completion of the last processing run (assuming that it finished about 2300 on 7 February), it is thought inconceivable that any flooding to the factory would have gone unnoticed and not been dealt with.

4.4 THE POSSIBILITY OF HIDDEN DAMAGE

The investigation looked for any sign of damage obscured by the sediment covering a large area of the starboard side. Had it existed it could have led to flooding. It would have been substantial and would have revealed itself in the deformed plating of adjacent parts of the hull. There was no such sign. Had there been, some explanation would be necessary.

Had a collision occurred, the resultant damage would have been evident somewhere on the visible hull, probably up to the bulwarks.

It is inconceivable that there was any inherent weakness in the hull plating. *Gaul* was a relatively new vessel and built in excess of the strength and construction requirements of the Lloyd's Register of Shipping classification society. The good condition of the hull seen in the underwater survey strengthens this judgment, as does the longevity of *Gaul*'s three sister vessels.

Nor could she have run aground or struck an uncharted rock, the nearest land was about 60 miles away. Any rock on the North Cape Bank capable of being struck by a ship would, without question, have been discovered many years previously and properly charted.

The investigation concludes that there was no hidden damage which would have led to flooding.

If, despite all these indications to the contrary, some underwater damage had occurred, an analysis was made to determine the effect on the vessel and the likely reaction of those on board. This found that unless there had been a catastrophic failure (for which there is conspicuously no evidence), *Gaul*'s watertight bulkheads would have contained the flooding sufficiently long for an appropriate distress message to be sent.

Evidence produced to the FI revealed that a distress call transmitted on the VHF located on the control console could be made very quickly by simply lifting the handset and speaking. If *Gaul* was sinking from flooding through a hole in the hull there should have been ample time for some form of distress message to be transmitted.

The MAIB is confident that *Gaul* did not founder as a result of flooding caused by some unknown underwater damage.

4.5 FUNNEL DAMAGE

The survey revealed that the outboard plating on the port funnel was indented over most of its height (**Figure 21**). The damage had all the appearance of being caused by excess pressure.

Had the damage to the port funnel been caused by crushing due to water pressure, both inboard and outboard plating would have been similarly affected. Because the funnel would have flooded freely as the vessel sank, the conditions for pressure crushing did not exist.

The only explanation for the indentation was wave impact.

Evidence presented to the FI revealed the presence of very large breaking waves in the area of North Cape Bank on 8 February 1974. As already stated this was reassessed by BMT in preparation for the model tests. This found that waves as high as 18.3m could have been present that day (**Annex 4**).

Since *Gaul* spent her last hours in extremely rough seas, the wreck was expected to show signs of wave impact damage. The funnels, as the lightest and most easily deformed part of *Gaul*'s external structure, were particularly vulnerable. In most conditions they would have been high enough to avoid wave damage, but in the very high sea states apparent that day, this height would have afforded little protection. The situation would have been aggravated had *Gaul* been lying beam to, or nearly beam to, the sea.

The damage to the funnel is entirely consistent with wave damage. *Gaul* was either hit hard by very large waves of funnel height, or smaller waves had struck as she sank.

Of the two scenarios the former is the more likely. The evident indentation was far more likely to have occurred when the vessel was in a more or less upright position, whereas with a heavy list to starboard the funnel sloped away from direct wave impact, and the greater exposure of the hull would have provided an element of protection from breaking waves.

MAIB's model experiments showed that if *Gaul* was beam to sea, very large breaking waves could reach and impact on the funnel. The starboard funnel was undamaged which points to waves impacting on the port side.

Everything indicates that *Gaul* was hit on her port beam by very large breaking waves.

4.6 FLOODING THROUGH OPEN WEATHERTIGHT HATCHES AND DOORS

There is indisputable evidence that some weathertight doors and hatches were wide open when *Gaul* sank. Weathertight doors and hatches are designed to remain firmly closed in the roughest weather and, to be effective, are strongly built and heavy. Four were found open in *Gaul*. They were; the factory companionway door, the door to the engine room escape and the two fish loading hatches. In addition, the engine room machinery removal hatch by the port funnel was closed but unsecured and the access hatch in the aft face of the port funnel was also found open which indicated it had not been secured.

The factory companionway door, the door to the engine room escape, and the fish loading hatches could, and should, have been secured. The survey could not reveal why or how these doors and hatches were opened, but the inescapable reality is that they were all open when *Gaul* foundered and could have caused rapid flooding.

4.6.1 Factory companionway door

Photographs revealed that this doorway was choked with trawl net. This could only have occurred as water poured through the open doorway (**Figure I**) dragging the net with it.

A photograph taken on *Arab* (**Figure 10**) shows the position of the door hook. This corresponds precisely to the position of the "hook" seen on the underwater survey. It is concluded that the door had been secured open.

In rough weather this door should have been closed. Evidence presented at the FI established that on one vessel of this class the door was often kept open. The testimony of Mr Scott, a ship surveyor with the Department of Trade, confirmed that the door to the factory on *Kurd* could not be closed. It had been open for so long that the securing clips could not be turned due to overpainting and rust. One clip had stuck in such a position that it hit the door frame when the door was pulled to and prevented it from being closed.

It is not known what arrangements were in force for closing of doors and hatches in *Gaul* during her final voyage. The duty watch would have checked the factory for fire or flooding every couple of hours and would, without question, have closed the door had it been letting in water. Unless the trawl deck was completely flooded with water up to the height of the bobbin rails, it was unlikely that much would find its way through this well sheltered door with its high sill. If the vessel was dodging head to the weather, even greater protection would have been provided.

MAIB's model experiments showed that even in the most severe wave conditions, a negligible quantity of water would have found its way through the open doorway. This would have been easily contained by the Turo slush pumps which were run continuously in *Gaul*. In all probability, this door was open at all times on the basis that little or no water ever came through it.

4.6.2 Engine room escape door

The underwater survey showed that the door to the engine room escape was undamaged (**Figure H**).

There are two possible explanations: it had either been opened to provide additional ventilation to the engine room; or it had been released by someone trying to escape. The MAIB found no evidence to indicate that the door was normally kept open for additional ventilation in *Gaul* or any other vessel of the class. It was positioned at the top of a vertical ladder and would have been inconvenient to open and close in bad weather. The investigation believed this door was normally kept shut and was so in the bad weather encountered on 8 February.

The only explanation to account for it being found open was that someone had released it in an attempt to escape from the engine room.

4.6.3 The two fish loading hatches

The underwater survey showed that the hatches and their securing clips were undamaged. All but one of the securing clips were found turned to the "unlocked" position which suggests that the hatches had either been opened by the crew, or by some unknown mechanism after they had been closed but not secured. In the latter event the only means of keeping them shut was their own weight holding them down.

The locking pins used to prevent the open hatches falling down were not in place. Since these were probably not used every time the hatches were used no conclusions can be drawn as to whether or not the crew had deliberately opened them (**Figure 11**).

The investigation initially examined the circumstances under which the hatches might have been opened by the crew. A number of possibilities were considered; they had either been inadvertently left open after the last haul of fish or had been opened later to remove, or store, a damaged net. It is also possible that *Gaul* might just have hauled, and the hatches had been opened to receive the fish from the cod-end.

The first possibility was discounted because of the length of time (at least 12 hours) which had elapsed between the cessation of fishing and the accident. During this time one of the watchkeeping officers on the bridge would without question have noticed the open hatches. The trawl deck was clearly visible from the bridge.

Of the remaining possibilities, it was felt that to deliberately open the hatches in the high sea states prevailing at the time of *Gaul*'s loss was inconceivable.

The investigation looked very carefully for any evidence that *Gaul* had, against all rational likelihood, been fishing in such bad weather. As her port trawl door was found hanging in its normal stowage place on the transom, this possibility has been rejected. It is assessed that the missing starboard door had been pulled away by the gear of another trawler.

Notwithstanding this assumption, a further examination was made to establish whether *Gaul* had, despite the evidence to the contrary, been engaged in handling a cod-end or other nets in the vicinity of the hatches.

A cod-end appeared to be hanging from the 'A' frame. Had this been one of *Gaul*'s it would have been a good indication that she had been fishing and was emptying the cod-end, or was lowering a damaged net through the hatches. The former scenario could also have explained why the gates were open at the top of the stern ramp.

A careful re-analysis of the video data showed that the cod-end was draped over a tied-off wire and was not connected to the wire which would have been used to lift it over the hatches. The end of that parted wire was found hanging loose (**Figure 39**). Although the net was similar in construction to those used in *Gaul* it has been assessed that it was a net belonging to another trawler.

If this interpretation was correct, there was no evidence to suggest that the fish loading hatches had been opened for loading fish, or storing a damaged net in the fish chute.

It is further concluded that the stern ramp gates were probably not shut when *Gaul* stopped fishing. This was not unusual as they were often left open until the time when she left the fishing grounds to return home.

If the crew had not opened the hatches, then something else did.

Four situations were considered. The first focused on the possibility that pressurised air trapped in the factory had lifted them: the second was whether they could have "jumped" open as the vessel pitched violently in waves; the third and fourth possibilities were that they had fallen open if *Gaul* had gone beyond the vertical as she sank stern first, or rolled beyond 90° during a knock-down. Whatever caused them to open, the simple fact remained that once they had done so, a non-return valve in the hydraulic operating system prevented them closing again.

At this juncture the reason for the two fish loading hatches being open remained unresolved. The only firm conclusion drawn by the MAIB inspectors was that they had not been opened by the crew. Four possibilities had been identified and would have to be investigated further (**Section 4.9**).

4.7 ANALYSIS SUMMARY

At this stage of the investigation, the MAIB had found that *Gaul* had not sunk from flooding following hull damage, that the port funnel showed signs of wave impact and in all probability the weathertight door to the factory had been open prior to the sequence of events that led to her loss. It had also been assessed that it was most unlikely that *Gaul* was fishing or the fish loading hatches had been opened by the crew.

An explanation still had to be found to explain why she had sunk. It was therefore decided to conduct model experiments in simulated sea conditions designed to replicate those prevailing on the 8 February 1974. In particular the MAIB wanted to test the theory that *Gaul* could have been lost due to downflooding through the open weathertight doors and hatches.

Model experimentation is an established and accepted means for evaluating the performance of vessels in a variety of sea conditions and has, over many years, been used successfully by ship designers, researchers and naval architects.

4.8 MODEL EXPERIMENTS IN VERY LARGE BREAKING WAVES

The experiments confirmed that *Gaul* was an exceptionally seaworthy vessel. They also revealed the awesome power of the sea. Unexpectedly, the experiments showed that *Gaul* could have capsized in seconds if caught beam on to the seas by a group of very large breaking waves. The investigation believed that this "knock-down" was the key to *Gaul*'s sudden disappearance. It also fitted with the wave impact damage found on the outboard face of the port funnel.

This possibility that *Gaul* had been "taken by a big wave on the beam" had first been suggested to the MAIB by Skippers Suddaby and Petty. When this was first put forward, the MAIB thought it highly unlikely because of *Gaul*'s large range of stability in excess of 90° (**Annex 2**). The results of the model experiments led to a reassessment.

The evidence available on the sea conditions indicated that breaking waves of a height sufficient to deliver a knock-down could have been encountered by *Gaul* on the 8 February 1974.

The investigation then looked for any evidence from the underwater survey to show that *Gaul* might have been knocked-down.

4.9 THE EVIDENCE FOR A KNOCK-DOWN

There is ample evidence to show that *Gaul* had heeled very heavily to starboard at some point. There were several indicators; the bobbins for the working trawl that should have been arrayed around both sides of the net arena (**Figure 5**), had moved to starboard – some were inside the net arena itself (**Figure 38**). All the spare trawl doors were missing from their racks and the wreck was listing about 35° to starboard.

For the bobbins to move from the port side of the arena to the starboard side would have necessitated them 'jumping' over the 0.6m high arena coaming. Each bobbin weighed about 92kg in air but only a few kilograms in water. They were threaded onto a wire foot-rope with lancasters between them. The result was a heavy assembly. Its location at the forward end of the trawl deck sheltered it from any waves. The MAIB believes that waves were not responsible for sweeping the gear over the coamings but that a heel of more than 90° to starboard caused them to shift to their final resting place (**Figure 44**).

The spare trawl doors, normally housed in racks just aft of the superstructure, weighed about 1 tonne each. They were secured to the racks to prevent movement and, although it is not known exactly how this was done, the arrangements would have been sufficient for all normal operating conditions. The survey revealed the racks to be empty and it is thought unlikely that the restraint would have prevented them from falling out of the racks once *Gaul* had rolled to beyond 90°. Another possible explanation was that they had been caught in the gear of other fishing vessels towing over *Gaul*. Because they were stowed below bulwark height and were well protected by the superstructure, funnels and the 'A' frame, this is extremely unlikely.

The oval trawl door lying on the port side of the trawl deck and near the back-haul winch was probably one of *Gaul*'s (**Figure G**). It had almost certainly fallen out of the port rack but had remained attached to it.

The wreck was found lying 35° to starboard on a relatively flat seabed. Had she been upright when she 'landed', it could be expected that she would have come to rest at an angle of no greater than about 20°. *Gaul*'s heavier list to starboard indicates she arrived on the seabed canted in that direction. This would have been caused by internal weights having moved to starboard at some time before she came to rest. The only materials capable of such movement were loose gear and cargo which would have shifted following a substantial heel to starboard.

There was also the unexplained mystery of how the the fish loading hatches had managed to open despite their weight. As already discussed, four possibilities existed: they had either opened because pressurised air trapped in the factory had lifted them as *Gaul* sank; or they had "jumped" open as the vessel pitched violently in waves before *Gaul* sank. Alternatively they could have fallen open if, in sinking stern first, *Gaul* had achieved a stern down angle exceeding 90°, or if she rolled beyond 90° during a knock-down (**Figure 45**).

The first possibility could not be substantiated by calculation, and was in any case, impossible if *Gaul* had sunk by the stern.

The second possibility had been brought to the attention of the MAIB by two experienced freezer trawler skippers. One remembered the "ramp lid" (fish loading hatch) on a 39m long fresh fish stern trawler lifting a couple of inches before dropping closed, as the vessel pitched when dodging head to wind in heavy seas. The other recalled a similar experience. Unfortunately, there is no way of relating these experiences to *Gaul*, to assess the likelihood of it happening onboard her. There is no evidence that it was known either on *Gaul* or her sister ships and her former skipper had not experienced it.

If the hatches had begun to open as the vessel dodged to windward, the non-return valve in the hydraulic system would have prevented them closing. A situation could be envisaged where the hatches gradually worked themselves open with the pitching of the vessel, but it is unlikely they could have opened far without one of the bridge watchkeepers noticing it and taking appropriate action to shut them.

Provided the vessel kept dodging to windward the trawl deck would remain dry as it was well protected from water spray by the high superstructure. Consequently, little water would enter the factory by way of the partially open hatches unless the vessel turned beam on, or stern on to the seas. In that event the flooding would probably have been detected by the duty watch or engineers walking through the factory.

The MAIB believes the possibility that the hatches "jumped" open due to the vessel's pitching motion was remote and would not, in itself, have led to the loss of *Gaul*.

The third possibility was that *Gaul* had gone beyond the vertical as she sank stern first and the hatches fell open. The inspectors looked for evidence that this had occurred. While there was evidence *Gaul* had sunk steeply by the stern, none indicated that her bow had passed the vertical, and the positions of the floor mats on the bridge indicated that it had not. The mats were heaped to starboard in front of the control console. If *Gaul* had passed beyond the vertical they should have fallen over it.

The fourth explanation, that *Gaul* had rolled beyond 90° and the hatches had simply fallen open because they had not been secured down, was then examined in detail.

This is thought the most likely sequence of events to account for the heavy hatches opening of their own accord. They are unlikely to have opened very far but enough to destroy watertight integrity on the trawl deck and allow substantial quantities of water to pour in.

The investigation concludes that there was evidence from the underwater survey that *Gaul* had indeed rolled beyond 90°, and that this was consistent with a knock-down scenario.

The investigation then turned its attention to how, or why, *Gaul* might have been caught beam on to the weather and in a state whereby she could be knocked down. The starting point was to reconstruct her movements on the day she was lost.

4.10 RECONSTRUCTION OF GAUL'S LAST MOVEMENTS (FIGURE J)

Gaul was last seen between 0900 and 0930 on 8 February when lying stopped beam on to the sea within 1 mile of *Swanella*. On the basis of evidence submitted to the FI, and the very telling remark by *Swanella*'s mate that he was 'at the top of the bank', the MAIB assesses that both vessels were somewhere in the vicinity of 72° 25'N 25° 00'E.

When *Gaul*'s mate spoke to his opposite number in *Swanella* at the time of this encounter, he concluded his conversation with the words, "...we're going to dodge more into land." This suggests that *Gaul* intended heading towards the land once she was under way again.

In the same VHF exchange it transpired that *Gaul* was waiting for the 1030 skippers' schedule to find out what other fishing vessels were catching on the Malangan fishing grounds.

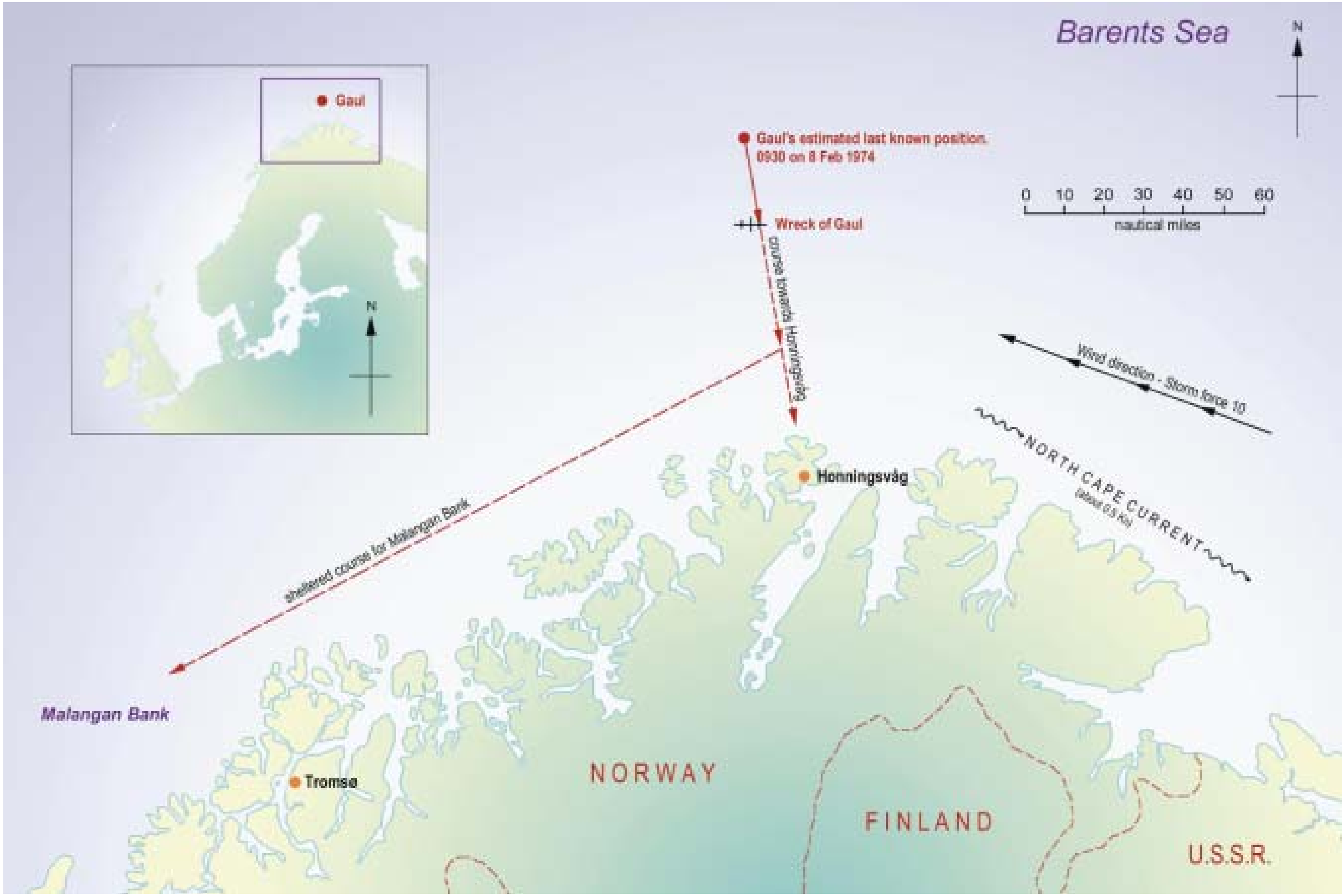
The Malangan grounds (Malangsgunnen) lay some 180 miles to the south-west and not far to seaward of Tromsø. Given the prevailing weather, these grounds would have been in the lee of the Norwegian mainland and in more sheltered water. A decision to make for Malangan where the fleet was still fishing, would have been sensible, logical and seamanlike. To head straight for the Malangan Bank would have meant that *Gaul* would be making way with the weather on her beam. Given the conditions, experienced fishermen would have avoided heading in such a direction in the open sea.

The sensible alternative would have been to seek more sheltered water as early as possible and could explain why she was intending to "dodge more into land". The nearest land lay some 55 miles to the south in the direction of the port of Honingsvaag and, in the opinion of MAIB, this is what *Gaul* did. The deduction that she was making directly towards land and shelter is strengthened by the report of the mate in the trawler *Somerset Maugham*. He had heard "Pete", who he took to be *Gaul*'s skipper Pete Nellist, talking on the VHF radio, saying that he was heading for Honingsvaag. If the previously calculated position was anywhere near accurate, this would have involved making good a course of about 170° which would have put the weather about five points (about 55°) on the port bow.

This information on *Gaul*'s last known position and likely movements was deduced from the transcriptions of the FI. When those testimonies were taken in 1974, the position of the wreck was unknown. In that context the data appeared tenuous and unconvincing. However, when this same information is plotted on a chart that now shows the wreck of the *Gaul*, it is a revelation. The wreck lies directly on the track from *Gaul*'s last estimated position to Honingsvaag, and about 20 miles along it.

The investigation concludes that just before she was lost *Gaul* was very likely making good a course of 170° towards the land. This probably meant her actual course was to port of this, putting the weather 4 to 5 points on the port bow.

Figure J: **A reconstruction of Gaul's last movements**



It is not known at what time *Gaul* turned towards the land. When she was last seen she was heading approximately WNW (292°), or downwind. It is assumed that the skipper was trying to reduce both pitching and rolling while the crew completed essential tasks. Nor is it known at what speed she would have proceeded when she started making way. In the prevailing conditions it is unlikely that she would have proceeded very fast. It is thought that she might have been making about 5 knots which is consistent with the estimate of propeller pitch from the underwater survey. If she had started to make way shortly after she was last seen at about 0930, and on the assumption that she had made good a speed of about 5 knots, she would have been in the position where she was eventually found at about 1330.

This estimate of her last course and speed does not however, explain how she came to be beam on to the sea.

4.11 BEAM ON TO SEAS

For the knock-down to have occurred, *Gaul* would have had to be nearly beam on to the sea when the breaking wave caught her. The MAIB remained convinced that seamen with the experience of those embarked in *Gaul* would not have allowed the vessel to be in this position unless it was absolutely essential.

4.11.1 One possibility fully explored by the FI was that *Gaul* was turning from stern on to the seas to bow on (or vice versa), and was caught in the middle of her turn by some large waves. It was common practice for freezer trawlers riding out bad weather to dodge to windward and then turn onto a reciprocal course. They would then run before the sea back to the fishing ground where they would turn again and repeat the process. The FI recommended that skippers should avoid this potentially dangerous practice during bad weather.

Each turn would have been carried out as quickly as possible to minimise the time the vessel was exposed to beam seas. The steering would have been under the control of the helmsman, probably using the tiller attached to the autopilot, and more power would have been applied to accelerate the vessel through the turn. If *Gaul* had been turning at the end of a leg, the helm would have been hard over (about 35°) and the propeller at about 75% ahead power.

The underwater survey showed that *Gaul*'s steerable Kort nozzle was positioned between 10° and 15° to port, and the propeller pitch was estimated as between 50% and 75% ahead power. It is most unlikely that these settings would have been used had *Gaul* been turning at the end of a leg.

The wreck was found several miles to the south of where she was last seen and, although there are many unknowns in coming to a conclusion as to why she was further south, the balance of probability would suggest that she was more likely to be making headway to the south rather than laying and dodging and turning at the end of a leg.

4.11.2 Another possibility, fully examined by the FI, was that *Gaul* had broached when running before the sea. The MAIB's experiments showed that the model was directionally very stable and remained on track even when surfing down the face of a breaking wave. In some runs, despite attempts to steer her into a broach, it could not be done.

MAIB concludes it was most unlikely that *Gaul* broached in the prevailing wave conditions.

4.11.3 It is also feasible that *Gaul* stopped to carry out further repairs; she had already done so once on the morning of 8 February. She had not reported the nature of that problem to anyone which suggests it was containable. It is possible this repair work may not have been completed satisfactorily or there may have been a recurrence to cause *Gaul* to stop again and drift. Had she done so she would have lain beam to sea. Freezer trawler skippers would not normally choose to lay their vessel beam to heavy seas, if for no other reason than to make working conditions tolerable for those on board. In certain circumstances it cannot be avoided, particularly when main engine power is lost or the steering gear motor has to be stopped for repair.

There is no evidence from the underwater video to indicate that *Gaul* had stopped for essential repairs. Had the steerable Kort nozzle been found amidships or the propeller at zero pitch then such an eventuality was possible. The vessel could have lost all propulsive and electrical power, in which case the nozzle and propeller settings would reflect their state when power was lost. Both propulsive and electrical power would have been lost if the main engine had stopped and the electrical power was provided by the shaft generator.

The investigation believes that such a coincidence of events including a "black-out" just before meeting a group very large breaking waves, was very remote.

4.11.4 Any one of these three interpretations for *Gaul* being beam to sea was possible but, in the opinion of the inspectors, the most likely explanation lay elsewhere.

It has already been assessed that following her last sighting by *Swanella*, *Gaul* turned from running down sea to head towards the land. It is highly likely she was heading in the direction of Honingsvaag where she could expect to find more sheltered water. She would have been making headway to the south as best she could with the weather broad on her port bow. She was well capable of confronting the heavy seas which would have combined to push the ship's head to starboard. The tendency to turn off the wind and sea would have been countered by applying port wheel but conditions on that occasion were extremely severe. It is known that other trawlers in the area were facing very heavy seas on 8 February and that *Swanella,* for instance, was knocked off course sometime between 1100 and 1130.

Skippers Suddaby and Petty suggested to the MAIB that some combination of wind and sea could have pushed *Gaul*'s head around before the watchkeeper could take effective action and said that such an event was very possible. The mate of *Swanella* testified that a group of very large breaking waves appeared suddenly and almost caught his vessel by surprise. A steep 17m (56 feet) high wave could, for example, have a speed in excess of 30 knots. Given the poor visibility prevailing at times that day, it is possible the watchkeeper would not have seen the onset of a large breaking wave in time to do much about it.

Gaul had a heavy stern trim due to using fuel from the forward tanks and having little cargo in the fish hold. The windage from her high bow and exaggerated by the stern trim, was not balanced by an equally large area aft. This imbalance would have made her very susceptible to weather-induced forces acting on the port bow to cause her to turn rapidly to starboard if struck by large waves.

If a combination of wind and waves had forced her to swing to starboard at the precise moment a sequence of very heavy waves hit her port side, she would have found herself in the one state where this stable and seaworthy vessel was vulnerable; beam to, or nearly beam to, the heavy seas.

The angle of the steerable Kort nozzle and the estimated pitch of the propeller blades fit this scenario. As *Gaul*'s bow fell off to starboard, port helm would have been applied. Whether this was done by the autopilot or the officer on watch there is no means of knowing, but both would have counteracted the vessel's swing to starboard by applying port helm.

Because it was missing, it was not possible to sight the position of the autopilot control lever on the bridge control console and see whether the autopilot was engaged when *Gaul* foundered. Had it been so, it would have been set to limit the maximum nozzle angle of about 15°. If more helm was required then the watchkeeping officer would take control, but in this particular event it is unlikely he had sufficient time to do so.

If the autopilot was disengaged and the vessel was in tiller control, the setting of the tiller by the bridge windows, at hard to port, could be important. Unfortunately, there is no way of knowing whether it was in use or whether it had simply been pushed to that position for convenience when not in use, which, as the photograph of *Kurd* shows (**Figure 2**), may have been the usual practice.

The MAIB concludes that while *Gaul* headed south towards Honingsvaag with the weather 4 to 5 points on her port bow, she encountered a combination of severe wind and seas that forced her bow to starboard. Once beam to sea she was knocked-down to an angle exceeding 90° by a group of very large breaking waves. The model experiments show that it took less than 7 seconds for this to occur.

This was the factor that probably triggered the sequence of events that led to *Gaul* sinking.

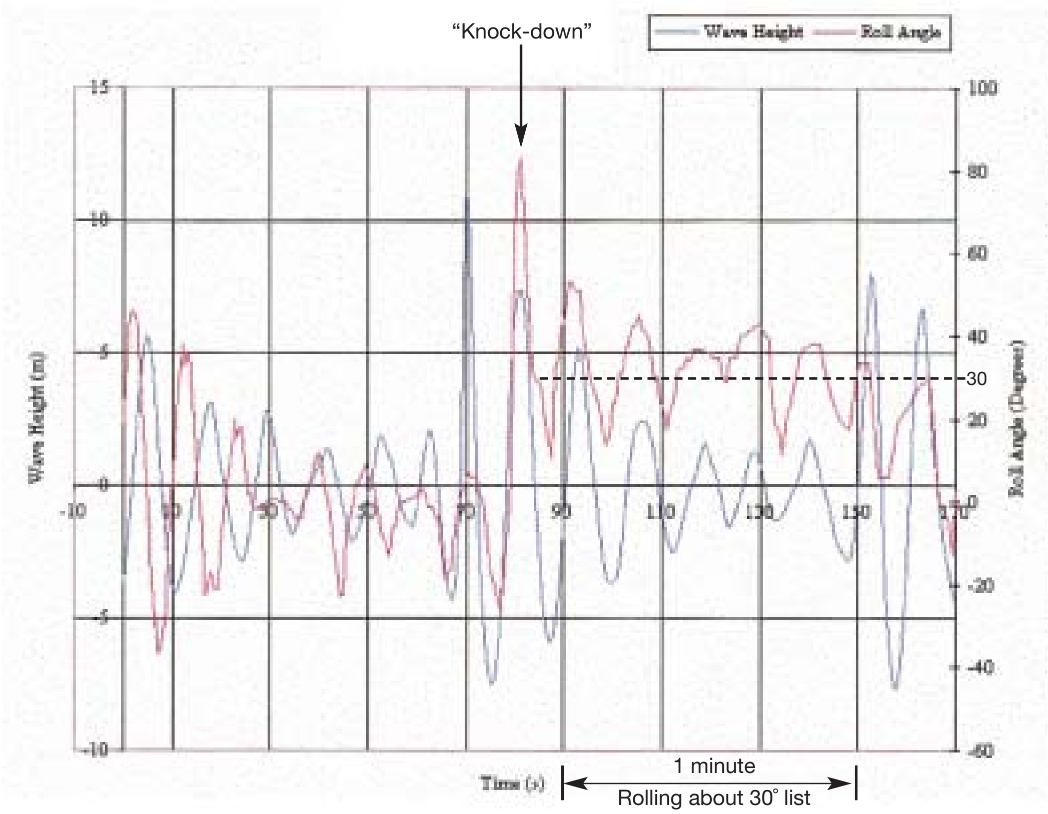
4.12 THE KNOCK-DOWN

A knock-down to just over 90° would have been a traumatic experience for all on board. In such circumstances there would have been no opportunity to transmit a distress call.

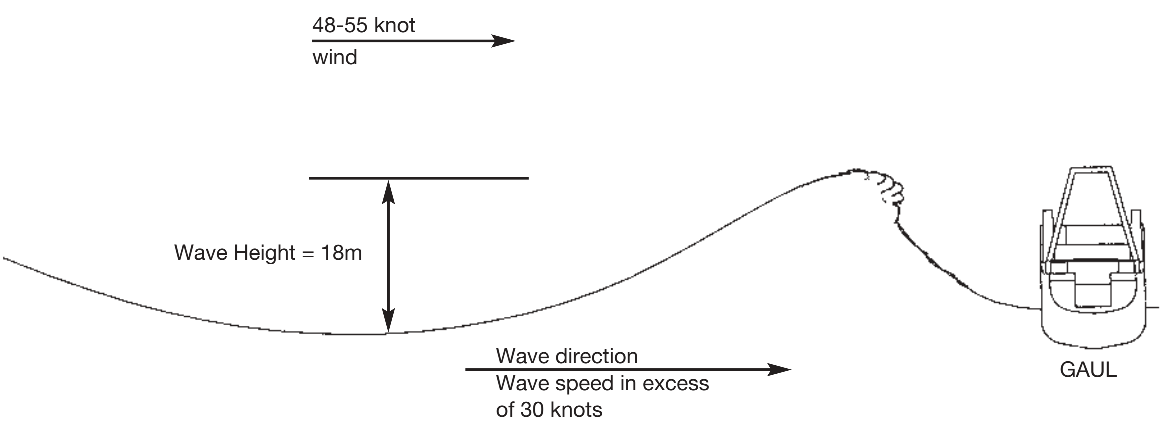
It also would have caused the fish loading hatches to begin opening under their own weight. Because of *Gaul*'s inherent stability she would have recovered to a list of much less than 90° in seconds, and this would have stopped the hatches from opening fully. Nonetheless, they would have opened sufficiently to cause the substantial amount of water caught within the trawl deck to start flooding the factory.

On the assumption that such a traumatic event took place there would have been other factors to consider such as *Gaul*'s ability to recover from it, and the implications for equipment, systems and, of course, the crew.

Figure K: **Measured roll angles and wave heights**



A trace of the wave heights and the roll motion of the GAUL model for Run 28, during which a *knock down* occurred. The height of the first steep wave of the wave group was 18m from crest to trough. This wave became a breaking wave and was responsible for the *knock down*. The wave trace represents the wave profile at the model’s mean position at the start of the run.



Approx: scale 1:500

Gaul had a large range of stability (**Annex 2, Figures 10 and 11**) and appeared capable of surviving a knock-down. Calculations carried out during the earlier NMI study showed that, provided the hull and forecastle remained watertight, *Gaul* could return to the upright from an angle of heel of about 87°. This angle of vanishing stability increased to about 120° if the superstructure and funnels were included.

In practice the vessel would not remain watertight with all weathertight doors and hatches shut and secured. Water would inevitably gain access through ventilators and air pipes but would take time to do so. Model experiments showed that during a knock-down, the factory would have flooded with approximately 40 tonne of water entering through the open fish loading hatches, companionway door and ventilators. At the same time it is estimated that approximately 15 tonne would pour into the engine room through the ventilators in the starboard funnel. Because her range of stability would remain well in excess of 90° (**Annex 2, Figures 18 and 23**), she would, despite this flooding, have recovered from a knock-down.

Given these findings and the discovery that the engine room escape door was open, the investigation concludes that *Gaul* survived the knock-down and was able to recover to some degree.

Gaul would have taken less than 7 seconds to roll to 90° and probably slightly beyond but, crucially, her recovery would have taken considerably longer (**Figure K**). The model experiments showed that *Gaul*, in ideal conditions (ie unencumbered by a shift of loose gear and cargo and with clear freeing ports) could have recovered to about 30° list within 10 seconds, but would then have continued to roll 10° either side of this mean list for a further minute before slowly returning closer to the upright.

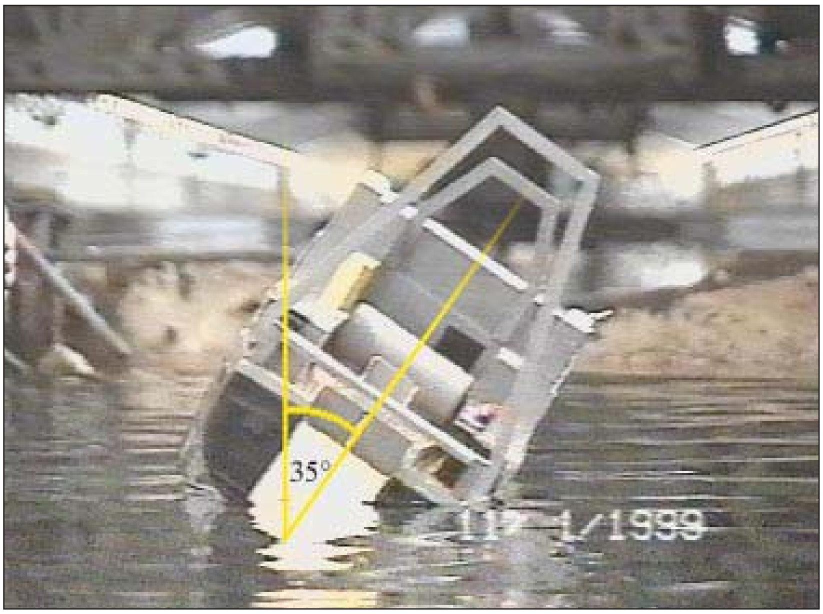
Immediately after the knock-down the model could not return to less than 30° because of the weight of free water swamping the weather deck. This water would gradually drain through the freeing ports. On the model these freeing ports were completely clear and 100% effective but, in practice, much of the loose gear and netting on the trawl deck would have collected against the starboard bulwarks and obstructed free drainage. What effect this might have had cannot be quantified, but it would have prolonged the recovery period.

The recovery would have been further delayed by the effects of loose gear and cargo shifting to starboard, and exacerbated by the storm force winds on the beam. Many items previously thought to have been well secured would have broken loose.

The 19.5 tonne of fish cargo was only 5.5 % of the capacity of the fish hold. It would have covered the floor of the fish hold with one complete layer of cartons and part of a second. The hold was equipped with removable pound board partitions to prevent the cartons moving but these were often not fitted until the cargo was several layers deep. In the worst case, and assuming the pound boards had not been fitted, a shift of the whole cargo across to starboard would have had a negligible effect on *Gaul*'s stability. It might have increased the list by, perhaps, 2° to 3°.

Dried fish meal has the constituency of a coarse dry powder. In *Gaul* it was stored in a hold that spanned the full width of the vessel and could be divided into three sections by two removable plywood bulkheads. It was normal to fit panels of the bulkheads up to the meal's surface and add more panels as the quantity of meal increased. Periodically the meal would be trimmed manually. In the knock-down it would have slid to starboard, overcome the plywood bulkheads and increased the list by a further 3° to 4°.

Figure L: **Model experiments, showing the significance of the angle of list**



At 35° list

1. Bulwarks around trawl deck (aft) submerged.
2. Ventilator to net store submerged, (not on model).

At 45° list

1. Door to engine room escape completely submerged.
2. Door to factory deck completely submerged.
3. Outboard edge of starboard fish loading hatch submerged.

At 55° list

1. Lower edge of engine room ventilation ducts in starbaord funnel immersed.

The bulk of loose gear would have been in store rooms or on the trawl deck. Loose gear in all the store rooms could not have fallen further than the 1.5m to 2m width of the compartment during the knock-down.

Although the shift of individual items of "moveable" objects appears to have only a minor effect on the list of the vessel, their cumulative effect could have been substantial. If it is assumed that all "moveable" items shifted 2m to starboard, the list would have increased to at least 40° if the beam wind effect is also included. At this angle the sills to the engine room escape and factory deck doors would have been almost continuously immersed and sea water would be flooding freely through the fish loading hatches into the factory (**Figure L**). Once this process had started, nothing could have saved *Gaul* and she would have sunk through progressive downflooding in, probably, less than 10 minutes.

A judgment has been made that following the limited and short-lived recovery from the knock-down, and while *Gaul* was listing heavily to starboard, someone attempted to leave the engine room by the emergency escape. By then some, or all, of the machinery had probably cut-out. Water had almost certainly flooded into the engine room from the ventilators in the starboard funnel and from the flooded factory on the next deck above. To anyone in the engine room escape to the upper decks was their only hope. The low, or starboard side exit would have been much easier to reach than the main access in the casing on the high, port side.

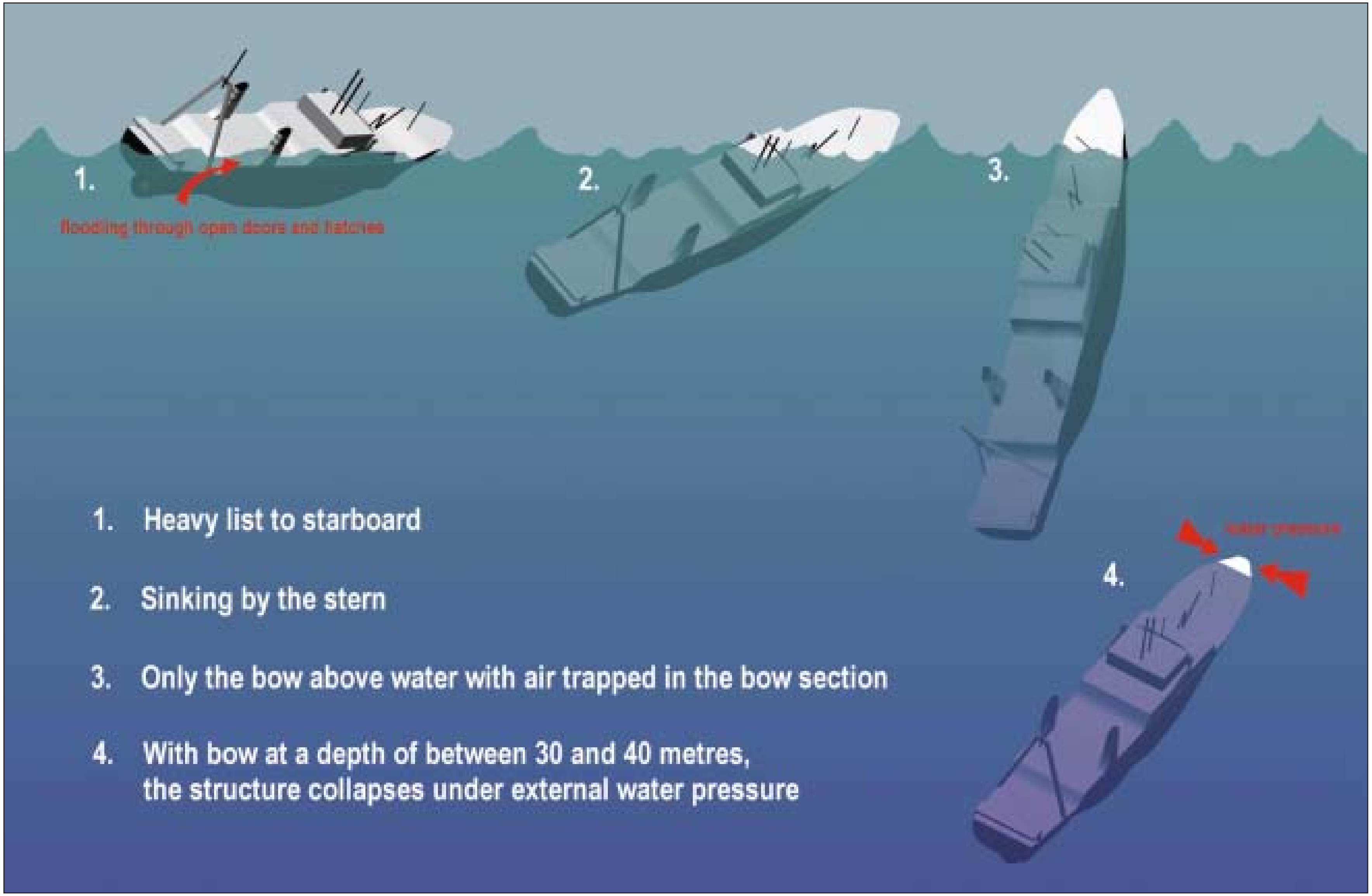
There is no way of establishing how those on board would have reacted to the appalling predicament they were facing with water flooding into an already disabled vessel. Whatever happened it would have been far beyond anything that any of them had ever experienced before.

The crew of *Gaul* would have been confronted by an overwhelmingly difficult situation. The investigation has no means of judging the traumatic impact but it must be assumed that many would have been injured in the knock-down, perhaps seriously. Movement on board would have been extremely difficult, particularly with the list to starboard, the heavy rolling and in near darkness.

When the Baltic ferry *Estonia* foundered with the loss of 852 lives in the Baltic in September 1994 it was found that when the list had reached between 45° and 50° movement around the ship became virtually impossible. Anecdotal evidence from the Royal Navy's school for damage control indicates that once a list has reached about 25°, a ship's company's effectiveness drops dramatically. This is not only due to the list, but because loose gear falls into passageways and stairwells causing continual obstructions.

In this impossible situation, even if by the remotest chance some form of electrical power remained, it is entirely understandable why no distress call was transmitted.

Figure M: **Gaul Sinking**



4.13 THE SINKING

Once continuous downflooding to the interior of the vessel had started, sinking was inevitable. *Gaul* probably began to sink within minutes of the initial knock-down and she would have completely submerged within 10 minutes.

Model experiments have shown that she settled by the stern. They also showed that in her final moments she slid stern first below the surface at a very steep angle (**Annex 4 page 7**).

The MAIB concludes that water downflooded through the emergency escape to the engine room, the open fish loading hatches, and the door to the factory deck. Water pouring through the open factory door carried a mass of trawl nets with it.

Flooding spread forward along the factory deck and down into the fish hold through the open hatch. The plug hatch to the fish hold was most likely to have been displaced in the knock-down. The immersion of the starboard ventilation trunks to the factory and engine room would have added to the rate of flooding. The fish meal hold would have flooded through its interconnections with the factory and the meal plant in the engine room. As the hull trimmed steeply by the stern, flooding spread up the stairwells into the accommodation and bridge, and finally the forepart of the vessel. Floodwater and air pressure would have combined to force internal partitions forward.

With the vessel now sliding below the waves at a very steep stern down angle, the fish loading hatches fell fully open. As the *Gaul* started its descent to the seabed, spaces in the forward part of the vessel retained trapped air at atmospheric pressure (**Figure M**). The boundaries to these spaces were crushed by the increasing water pressure as she sank more deeply. This probably occurred at a depth of between 30m and 40m.

Model experiments have shown that if *Gaul* sank from downflooding through openings on the trawl deck, the foredeck (where the air pipes to the forward tanks emerged) would have been the last part of the vessel to submerge. This would produce the precise conditions for the side shell structure either side of the bow to collapse under water pressure.

The damage observed on the bow of the wreck, and the forward displacement of the partition bulkheads in the cabins and bridge, are all consistent with this scenario.

Gaul was on a southerly heading at the time when she was knocked-down but the wreck was discovered pointing north-east. Whatever the heading of the vessel when on the surface, the random nature of the forces acting on the vessel as she left the surface stern first and sank 280m makes any possible connection between the two headings tenuous, unpredictable and unrepeatable. No significance can be placed on the wreck's heading.

Any diesel oil escaping from the wreck would have dispersed rapidly in the high sea states. It would not have formed a slick and the chances of sighting any oil would have been remote.

Gaul finally came to rest on the seabed at an angle of 35° from upright and, apart from snagging the occasional trawl over the intervening years, remained undisturbed and undiscovered until 1997.

4.14 LIFESAVING APPLIANCES

Because the davit was stowed it was clear from the underwater survey that the "C" class boat on the port side had not been launched. In all probability the boat itself had been washed away during the knock-down.

The inflatable boat was also missing on the starboard side. It too is believed to have been washed away. The davit, which was free to swing once its lashings had failed or been released, was found swung out to starboard due to the list.

The circumstances under which *Gaul* foundered left the crew little time to find and don lifejackets, or abandon ship in an organised manner. Attempts to launch the port liferafts would have been futile because of the heavy list to starboard, whilst launching them to starboard would have been impossible in such high sea states.

When *Gaul* was built, the carriage of liferafts on fishing vessels was a comparatively new practice and the use of "float free" hydrostatic release units even more so. They were not then mandatory but *Gaul* was fitted with them when she left the builder's yard.

One four-man liferaft container was found on the seabed close to the port bow. No others were seen, and none was found during or after the search for *Gaul*. Consequently, the investigation had insufficient information to draw any conclusions about what happened to them. In the MAIB's experience it is not uncommon to find uninflated liferaft containers near, or on, a wreck. It usually indicates that the container was carried down with the sinking vessel to such a depth that it lost its buoyancy. Had some liferafts inflated on the surface as she sank, the storm force winds would probably have carried them away very rapidly and possibly out of the search area.

The MAIB concludes that it was very unlikely that any of the lifesaving appliances could have been used when *Gaul* sank.

4.15 SCUTTLING

This analysis would not be complete without making some comment about the theory that *Gaul* was scuttled deliberately. Despite the impossibility of proving that sea cocks or other internal flooding means had not been opened deliberately, at no stage of this investigation did MAIB obtain any supported evidence to indicate that *Gaul* was deliberately sunk.

It is inconceivable that *Gaul* was seized and scuttled during a storm force 10 or that she made sheltered waters and was returned to the fishing grounds to be scuttled without being observed. If it is assumed that *Gaul* had reached sheltered waters she would have made radio contact with other vessels and met the skippers' schedule at 1630 on the 8 February. Because she made no calls after 1109 it is deduced that she did not survive to reach sheltered waters but sank on passage within 20 miles of her last known position.

MAIB concludes that scuttling was not the cause of her sinking.

4.16 HUMAN REMAINS

A high percentage of the survey time was spent trying to establish whether there were any signs of human remains. Some objects seen in three cabins had certain characteristics that could have been remains and were photographed.

The pictures were carefully enhanced following the survey and subjected to searching examination by a consultant pathologist and the *Gaul* Families own expert. They both concluded that the objects were not human remains.

The MAIB concludes, with regret, that the survey failed to reveal any sign of human remains.

4.17 AFTERWORD

There were no survivors of this tragic accident and there were no witnesses. Voyage data recorders did not exist in 1974 and even now are not carried by fishing vessels or the majority of merchant ships. Nobody will ever know the precise circumstances about what occurred on board *Gaul* on or about, 8 February 1974.

The evidence from the wreck is now recorded in 45 hours of video tape that has been examined in great detail. The MAIB presents both the actual evidence, and its deductions, for the consideration of the anticipated re-opened Formal Investigation.

During the course of the investigation every detail has been examined and many theories about the causes of her loss have had to be discounted because the evidence has failed to support them. The chain of events outlined in this report is the only one that has withstood the inspectors' intense scrutiny (**Figure 46**).

SECTION 5
Conclusions

5.1 FINDINGS

5.1.1 New and important evidence

The underwater survey and model experiments have revealed new and important evidence that was not available to the FI in 1974.

1. The wreck was in one piece in position 72° 04.1'N 25° 05.3'E. [3.2]

2. There was no evidence of fire damage or explosion. [4.3.1]

3. There was nothing to indicate that *Gaul* had sunk because her hull had been holed. [4.4]

4. There was a tear due to water pressure crushing damage in the side plating above the waterline at the bows. [4.2.2]

5. All weathertight doors and hatches on the forecastle deck were closed and secured. [3.3.4]

6. The weathertight door to the engine room casing (port side of the trawl deck) was closed and secured. [3.3.11]

7. The weathertight door to the engine room escape (starboard side of the trawl deck) was open, and undamaged. [3.3.11]

8. The weathertight door to the factory (starboard side of the trawl deck) was secured open and undamaged. [3.3.11]

9. The opening to the factory doorway was two thirds full of net. [3.3.11]

10. The two fish loading hatches (aft centre of the trawl deck) were fully open and undamaged. The locking pins were not in place. [3.3.11]

11. The port trawl door was found hanging on the transom in its usual storage position. [3.3.3]

12. The steerable Kort nozzle was at 10° to 15° to port. [3.3.3]

13. The propeller pitch was estimated to be set to absorb about 50% to 75% ahead power. [3.3.3]

14. Partition bulkheads between the cabins, and the forward bulkhead to the chart room, had burst forwards. [3.4]

15. A general absence of water pressure crushing damage to the hull, hatches and doors. [3.3.1 & 3.3.2]

16. Bridge windows and portholes were unbroken.[3.1, 3.3.2 & 3.3.7]

17. The outboard face of the port funnel was indented over most of its height. [3.3.1]

18. The stern ramp gates were open. [3.3.11]

19. The spare trawl doors were missing from their racks on the trawl deck, and the fishing gear appeared to have fallen to the starboard side of the net arena. [3.3.11]

20. Model experiments showed that *Gaul* could have been "knocked-down" if hit on the beam by a breaking wave higher than about 16m (52 feet). [3.6]

5.1.2 INVESTIGATION FINDINGS

Findings of the underwater survey

1. *Gaul* sank in position 72° 04'N 25° 05'E. [3.2]

2. The wreck was in one piece and heeled about 35° to starboard. [3.2]

3. The bow was buried to about 1.7m in sediment, the stern was clear down to the bottom of the Kort nozzle. [3.2]

4. Trawl nets obscured the forward end of the trawl deck, the aft face of the bridge, and the aft starboard corner of the trawl deck. [3.3.11]

5. The port side of the hull was visible down to the bilge keel. [3.3.1]

6. A large portion of the starboard side was buried in sediment. The sediment was within 0.3m of the trawl deck amidships. [3.3.2]

7. There was a tear in the side plating above the waterline at the bow due to water pressure crushing damage. [4.2]

8. All weathertight doors and hatches on the forecastle deck were closed and secured. [3.3.4]

9. The weathertight door to the engine room casing (port side of the trawl deck) was closed and secured. [3.3.11]

10. The weathertight door to the accommodation block (forward end of the trawl deck) was inaccessible. [3.3.11]

11. The weathertight door to the engine room escape (starboard side of the trawl deck) was open and undamaged. [3.3.11]

12. The weathertight door to the factory (starboard side of the trawl deck) was secured open, and undamaged. [3.3.11]

13. The opening to the factory doorway was two thirds full of net, which had been carried into this position as the vessel filled with water on the surface. [3.3.11]

14. The outboard face of the port funnel was heavily indented over most of its height. [3.3.1]

15. The two fish loading hatches (aft centre of the trawl deck) were fully open and undamaged. All but one of the securing clips were in the open position. [3.3.11]

16. The locking pins to the fish loading hatches were not in place. [3.3.11]

17. The net store hatch (aft starboard corner of trawl deck) was inaccessible. [3.3.11]

18. The port trawl door was found hanging on the transom in its usual storage position. [3.3.3]

19. The starboard trawl door was missing. [3.3.3]

20. There was a general absence of water pressure crushing damage to the hull, hatches and doors. [3.3.1 & 3.3.2]

21. The bridge windows and portholes were unbroken. [3.1, 3.3.2 & 3.3.7]

22. Bulkheads between cabins, and the forward bulkhead to the chart room, had burst forwards. [3.4]

23. The autopilot control was missing from the control console. [3.3.9]

24. The spare trawl doors were missing from their racks on the trawl deck, and the fishing gear appeared to have fallen to the starboard side of the net arena. [3.3.11]

25. The aft (and inner) of the double doors to the net store was hanging open. [3.3.11]

26. The steerable Kort nozzle was between 10° and 15° to port. [3.3.3]

27. The controllable pitch propeller is estimated to be set to absorb between 50% and 75% ahead power. [3.3.3]

28. The davit for the "C" class boat was stowed. [3.3.10]

29. As far as could be seen all the liferaft containers were missing from the stowage racks. [3.3.2]

30. One of *Gaul*'s four-man liferaft containers lay on the seabed off the port bow. [4.14]

31. The "C" class boat and the inflatable boat were missing. [3.3.10]

32. The gates at the head of the stern ramp were fully open. [3.3.11]

33. There was no evidence that a seabed cable had contributed to the loss of *Gaul*. [3.5]

Findings of the model experiments

34. The highest wave which could have been expected in the area of North Cape Bank on 8 February 1974 was 18.3m. [3.6]

35. Waves groups would have been likely. [3.6]

36. *Gaul* could have been "knocked-down" if hit on the beam by a breaking wave higher than about 16m (52 feet). [3.6]

37. *Gaul* probably retained sufficient stability to have recovered from the "knock-down". [4.12]

38. The mean roll angle following a particular "knock-down" was 30° to starboard without the effect of wind and cargo shift. The time taken for the vessel to return to the upright would be well over a minute with clear freeing ports. [4.12]

39. It is unlikely that a sufficient air pressure could be generated to open the fish hatches during the sinking of the vessel if the air in the factory deck was able to exhaust through vents. [4.9] Also, since the vessel sank steeply by the stern the possibility of any trapped air under the fish loading hatches would have been remote.

40. The vessel sank very steeply by the stern after downflooding through open doors and hatches on the trawl deck. [4.13]

MAIB's findings

41. The damage to the bow was the result of water pressure, after the vessel had sunk to between 30m and 40m, crushing empty tanks and a sealed compartment. [4.2]

42. There was no evidence of fire or explosion damage. [4.3]

43. There was nothing to indicate that *Gaul* had sunk because her hull had been holed. [4.4]

44. The investigation failed to find any positive signs of human remains. [4.16]

45. *Gaul* did not sink as the result of scuttling. [4.15]

46. There was no evidence to connect *Gaul* with intelligence gathering. [1.6]

47. *Gaul* was last seen in position 72° 25'N 25°E at about 0930 on 8 February 1974 by the mate of *Swanella*. [1.8.1]

48. Shortly after she was last seen *Gaul* started heading in the direction of Honningsvaag, on a course of 170°. [4.10]

49. She was probably making about 5 knots with the weather about 5 points (55°) on her port bow. [4.10]

50. Some combination of wind and waves forced her bow around to starboard, placing her roughly beam on to the seas. [4.11.4]

51. Port rudder was applied to bring her head back round to port, but before it took effect......... [4.11.4]

52. ..... she was hit by a group of very large breaking waves, at least one being in excess of 16m (52feet) high. As a result her port funnel was indented and *Gaul* was "knocked-down" just beyond 90°. [4.5, 4.11.4, & 4.12]

53. The fish loading hatches fell partly open. [4.12]

54. The spare trawl doors fell out of their racks. [4.9]

55. The "C" class boat and the inflatable boat were washed away. [4.14]

56. Loose gear and cargo shifted to starboard. [4.12]

57. *Gaul* recovered from the "knock-down", listed at least 40° to starboard, and rolled heavily about this angle. [4.12]

58. Loose gear on the trawl deck fell against the starboard bulwarks obstructing the freeing ports. [4.12]

59. All propulsive and electrical power was lost. [4.12]

60. It is entirely understandable that no distress message was transmitted.[4.12]

61. Somebody attempted to leave the engine room through the escape door. [4.12]

62. Continuous downflooding through the fish loading hatches, the door to the factory and the door to the engine room escape caused *Gaul* to sink very steeply by the stern, probably in less than 10 minutes. [4.13]

63. No lifesaving appliances could be launched before she sank. [4.14]

64. As she sank very steeply by the stern the fish loading hatches fell fully open, and water flooding through the superstructure burst partition bulkheads forwards. [4.13]

5.2 CAUSE

5.2.1 General

The finding of the FI in 1974 was "that *Gaul* capsized and foundered due to being overwhelmed by a succession of heavy seas". The MAIB's investigation has arrived at a very similar conclusion, and submits this for consideration by the assessors of the anticipated re-opened FI.

5.2.2 The immediate cause of the accident

Gaul was heading with the seas broad on her port bow when her bow was pushed to starboard and a group of very large breaking waves impacted on her port beam, rolling her just beyond 90° to starboard. This action caused the fish loading hatches to fall partially open. She recovered, to list at least 40° to starboard but this was sufficient to allow downflooding through the open weathertight hatches and doors on the trawl deck. She probably sank in less than 10 minutes.

5.2.3 Contributory factors

The chain of events which caused the loss of *Gaul*, with all hands, was precipitated by three fundamental factors:

i. She came beam onto a group of very large breaking waves.

ii Her fish loading hatches had not been locked down.

iii The weathertight door to the factory was open.

An accident factors tree is at **Figure 46**.

SECTION 6
Recommendations

The Chief Inspector of Marine Accidents recommends that:

The Secretary of State for Environment, Transport and the Regions re-opens the Formal Investigation into the loss of fv *Gaul* to examine the new and important evidence that the MAIB's underwater survey and model experiments have produced.

Glossary of Terminology

automatic pilot – a device which will steer a ship at a fixed heading

bobbin – steel buoyant sphere on foot rope of trawl

bobbin rail – an upright barrier running the length of the trawl deck on both sides to which the spare bobbins are attached

broach – an uncontrollable turn across the front of a wave when in a following sea

bulwark – an upright protective barrier around the perimeter of the weather deck

class “C” lifeboat – a small rigid open boat with a transom stern for general and emergency use

Classification Society – an independent authority charged with setting standards of seaworthiness build, maintenance and upkeep of seagoing vessels

coaming – an upright barrier

cod-end – the end of the trawl net which collects the fish, sometimes known as the bag

danleno bobbin – large bobbin at either end of the foot rope

davit – a light crane on a ship’s side for lowering and lifting a lifeboat

deadlight – a steel plate fitted over a porthole to protect it

demersal – bottom feeding (eg cod)

derrick – a crane consisting of a large beam, the foot of which rests at the base of a mast or post

dodging – hove to (head to seas, holding position)

dynamic positioning – computer controlled arrangement of propellers which allows a vessel to remain precisely over one spot on the seabed

fine on her bow – the relative position of an object, when another ship is a few degrees to one side of the ship’s head (bow)

foot rope	–	the wire rope across the bottom of the mouth of the trawl net
frame	–	a transverse structural member, sequentially numbered from aft to forward
freeboard	–	the height of the weather deck above the waterline
freeing port	–	a large drain hole in the bulwarks
goal post mast	–	a mast in the shape of a football goalpost
hatch locking pins	–	removable pins which could be inserted through holes in the bobbin rails to stop the open fish loading hatches closing
hydrodynamic	–	behaviour of a fluid in motion
hydrostatic	–	behaviour of a fluid not in motion
implode	–	to collapse inwards
Jonswap Spectrum	–	used to describe the component frequencies and wave heights in a given sea state
knock-down	–	a wave impact causing a sudden violent roll to at least 90°
Kort nozzle	–	a duct surrounding the ship's propeller which improves thrust
Lancasters	–	heavy metal collars around the foot rope to which the trawl net is attached
lay and dodge	–	to alternate between laying and dodging
laying	–	not under power
list	–	to lean over, or tilt, to one side
net arena	–	the steel enclosure on the trawl deck used for storing the working trawl net when not in use
pelagic	–	surface feeding (eg herring)
plug hatch	–	a hatch which fits into an opening
pulled away	–	lost to the force of the sea

range of intact stability	– the range of heel angles over which the fully closed-up vessel will retain positive stability
shot her trawl	– lowered her trawl into the water to begin fishing
side scan sonar	– a device which uses sound waves to produce a side view of objects on the seabed
sill	– an upright barrier across the lower edge of a doorway to prevent the ingress of water
slush pumps	– pumps capable of dealing with water containing parts of fish
stay	– a wire supporting a mast
transom	– the flat surface forming the aft end of a ship
transverse	– across the vessel from side to side
trawl door	– a large steel or wooden board used as one of a pair to keep the mouth of the trawl open
Voyage data recorders	– an electronic “black box” for recording important information on a ship’s operation for use in the event of an accident
weather deck	– a deck exposed to the elements
weathertight	– capable of being sealed to exclude water