Report on the technical inquiry into the

BUGALED BREIZH

Bureau d'enquêtes sur les évènements de mer

Technical report
on the investigation
of the

Capsize and foundering

of the trawler

BUGALED BREIZH

on 15th January

South of Lizard Point

(with the loss of 5 lives)

Bureau d'enquêtes sur les évènements de mer

Warning

This report has been drawn up according to the provisions of Clause III of Act No.20023-3 passed by the French government on 3rd January 2002 relating notably to technical and administrative investigations after accidents at sea and the decree of enforcement No. 2004-85 of 26th January 2004 relating to technical investigations after marine casualties and terrestrial accidents or incidents, and in compliance with the "Code for the Investigation of Marine Casualties and Accidents" laid out in Resolutions A.849(20) and A.884(21) adopted by the International Maritime Organization (IMO) on 27/11/97 and 25/11/99.

It sets out the conclusions reached by the investigators of the *BEA*mer on the circumstances and causes of the accident under investigation.

In compliance with the above mentioned provisions, the analysis of this incident has not been carried out in order to determine or apportion criminal responsibility nor to assess individual or collective liability. **Its sole purpose is to identify relevant safety issues and thereby prevent similar accidents in the future.** As a consequence**,** the use of this report for other purposes could therefore lead to erroneous interpretations.

CONTENTS

APPENDICES

Glossary of abbreviations

A1	:	In the GMDSS, a sea area within range of a shore-based VHF DSC coast station
A2	:	In the GMDSS, a sea area within range of a shore-based MF DSC Coast station
A3	:	In the GMDSS, a sea area covered by at least one geostationary INMARSAT satellite
A4	:	In the GMDSS, a sea area outside areas A1, A2 or A3
AIS	:	Automatic Identification System
ANFR	:	National Agency for frequencies (*Agence Nationale des Fréquences*)
AOR-E	:	Atlantic Ocean Region – East (INMARSAT)
AOR-W	:	Atlantic Ocean Region – West (INMARSAT)
***BEA*mer**	:	French maritime accident investigation Bureau
CES	:	Coast Earth Station (INMARSAT)
COSPAS-SARSAT	:	International Organization using a network of satellites for situations of distress (*SARSAT : search and rescue satellite-aided tracking system*)
CROSS	:	Regional Centre for Surveillance and Rescue Operations (*Centre Régional Opérationnel de Surveillance et de Sauvetage*)
DSC	:	Digital Selective Calling
EPIRB	:	Emergency Position Indicating Radio Beacon (COSPAS-SARSAT)
GOC	:	General Operator's Certificate in radiocommunications
GPS	:	Global Positioning System (Satellite navigation system developed by the United States)
IMO	:	International Maritime Organization
INMARSAT	:	International Organization using geostationary telecommunications satellites
IOR	:	Indian Ocean Region (INMARSAT)
kW	:	kilowatt
kΩ	:	kiloohm

LUT	:	Local User Terminal (COSPAS-SARSAT): receiving station for distress messages
MCA	:	Maritime and Coastguard Agency (British state agency responsible for search and rescue operations, the safety of navigation and ships and anti-pollution measures)
MCC	:	Mission Coordination Centre (COSPAS-SARSAT) : centre for processing distress messages and liaison between the COSPAS-SARSAT system and the MRCCs
MDV	:	Mine disposal vehicle (remote-controlled underwater naval vehicle equipped with a camera)
MF	:	Medium frequency radiomagnetic waves
MMSI	:	Maritime Mobile Service Identity : in the GMDSS, a vessel's identification number
MPa	:	Megapascal
MRCC	:	Maritime Search and Rescue Coordination Centre
ms	:	Millisecond
N	:	Newton
PCM	:	Licence to operate small engines (*Permis de Conduire les Moteurs*)
ROV	:	Remotely Operated Vehicle (remote-controlled underwater camera)
MSI	:	Maritime Safety Information (includes navigation warnings, notice of exercises and weather bulletins)
SHOM	:	French hydrographic service (*Service Hydrographique et Océanographique de la Marine)*
GMDSS	:	Global Maritime Distress and Safety System
SRR	:	Search and Rescue Region
TSS	:	Traffic Separation Scheme
UTC	:	Universal Time Coordinated
VHF	:	Very High Frequency
Ω	:	Ohm

FOREWORD

As there were no survivors or eyewitness reports of the sinking, the *BEA*mer investigators, with a view to helping the reader better understand this report, wish to explain how they came to their conclusions.

Their approach was first to gather as much information/ to make as many material observations as possible and then to compare it/them with the various conceivable hypotheses.

The initial observations were carried out by undersea diving. A preliminary series of dives was effected by a French Navy self-propelled mine disposal vehicle (MDV) three days after the accident. This was followed by a second series carried out by divers and a ROV prior to refloating the vessel in July 2004. The *BEA*mer investigators were able to examine the video footage made on these two occasions and were thus able to make a number of crucial observations of the wreck and the trawl rig *in situ*.

From July 2004 on the wreck and the trawl rig were examined in great detail. It was deemed necessary to complete the observations made by several series of tests and analyses : these included metallurgical analysis of the hull and the warps as well as theoretical calculations on the stability and the structure.

The first chapters of the report are the result of documentary research on the vessel, her manning and operation at the time of the accident; they relate how the search and rescue operations were carried out and include testimony from people who knew the vessel or were involved in these operations.

Chapter 6, called "Observations and tests on the vessl" describes what was observed. It also details the tests and analyses commissioned on the vessel and her trawl rig as well as the theoretical studies carried out on her stability and structure and the way it was deformed.

Chapter 7 "Analysis of the hypotheses" deals with the various hypotheses likely to be taken into consideration by the *BEA*mer in the search for an explanation of the possible causes of the sinking. Each hypothesis was examined taking into account the observations and studies developed in Chapter 6. The aim of this chapter is therefore to attempt to explain **how** the sinking occurred.

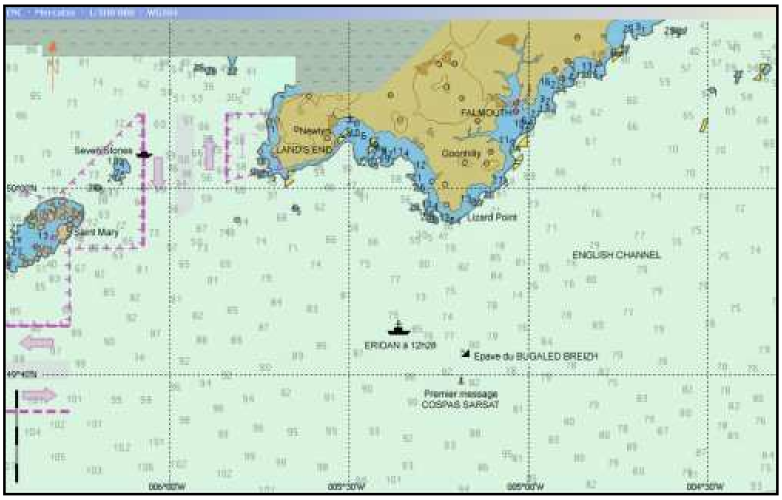
Chapter 8 entitled "Determining and commenting on the causes of the accident" goes beyond the hypotheses and seeks to establish the decisive, incidental or underlying factors which may have contributed to the accident. It too uses the results obtained in Chapter 6, analysing and commenting on the causal elements in compliance with "Code for the Investigation of Marine Casualties and Accidents". The aim of this chapter is to try to establish **why** the accident happened.

Finally, Chapter 9 naturally leads the investigators to consider what lessons can be learned to prevent similar casualties in the future and to make recommendations to this end, which is the purpose of the technical investigation.

This report thus stems from a totally independent analysis based on observations, made in as unbiased a way as possible, of the concrete evidence available to the *BEA*mer at this time. This analysis goes no further than the objectives of the technical inquiry and therefore contains no elements which could be used to apportion liabilty – which is the rôle of the judicial inquiry.

Should any hitherto unknown or uncollated evidence come to light at a later date, it will obviously be fully assessed and if necessary the present report will be amended or a complement published.

1 CIRCUMSTANCES



On 15th January 2004 the trawler *BUGALED BREIZH,* out of Le Guilvinec, was engaged in fishing operations south of Lizard Point (Cornwall). The weather conditions were what could be expected in the area at that time of year : a southwesterly gale was blowing, visibility was good but reduced in rain.

Another trawler out of Le Guilvinec, the *ERIDAN,* was fishing in the same area. The two vessels were in the habit of working the same waters and called each other frequently on VHF radio.

The *BUGALED BREIZH* called the *ERIDAN* twice to say that she was capsizing and to give her position, contact was then lost and the vessel went down with loss of all hands; the *ERIDAN* raised the alarm.

MRCC FALMOUTH deployed numerous aerial and maritime rescue resources. Of the five crew members of the *BUGALED BREIZH,* two bodies were found on the same day, a third body was found in the wreck when it was refloated.

Three days after the sinking, the wreck of the *BUGALED BREIZH* was located (see appendix D1) and filmed by the camera of an MDV from a French minesweeper; she was subsequently refloated by court order in July 2004.

2 BACKGROUND

2.1 Operational management

The *BUGALED BREIZH* was a 24 metre stern trawler, operated as a bottom trawler.

Since her inauguration in 1987 she had always belonged to the same skipper-owner who, because he had been on extended sick-leave since 2003, had turned over command to another skipper.

There had been no major transformations to the vessel with the exception of an engine retrofit in 1999.

She was fitted out for deep sea fishing (which meant that she was away from her operating port for a period of more than 96 hours) and was registered in the port of Le Guilvinec. She operated in the west Channel and the southern part of the Irish Sea; each fishing trip would last 14 days, the catch would be sold on the 15th and this would be followed by three days shore leave.

When fishing, the vessel would usually make six tows per twenty four hour period, each tow lasting for three hours during the day and four hours at night. According to the conditions, the rhythm could be increased to shooting the trawl seven or eight times per twenty four hour period.

At the time of the accident, she was fishing mainly for squid.

2.2 Traffic conditions in the area (see chart appendix D.2)

Merchant traffic in this sector is heavy as, in its western part, the routes of ships sailing between the North Atlantic and the Channel/North Sea cross those of ships sailing between the northern and southern parts of the Celtic Sea.

Three traffic separation schemes (TSS) have been adopted by the International Maritime Organization (IMO) : "off Land's End, between Seven Stones and Longships", "west of the Scilly Isles " and "south of the Scilly Isles ". Even if they are only recommended these navigation routes constitute the normal shipping lanes for merchant vessels. Laden tankers over 10 000 gross tonnage should not use the TSS " off Land's End, between Seven Stones and Longships" in restricted visibility or adverse weather conditions.

The IMO-adopted ship reporting system MAREP is applied, on a voluntary basis, east of a line from Bishop Rock to the southeast of the Scilly Isles to the southwest Ushant light buoy and therefore includes the "off Land's End, between Seven Stones and Longships", as well as "south of the Scilly Isles" TSSs. All merchant vessels having a gross tonnage equal to or over 300 are recommended to participate in the MAREP scheme.

It is mandatory for any vessel not under command, or restricted in her ability to manœuvre or having sustained damage, to report. The same obligation exists for laden tankers of over 10 000 gross tonnage using the "off Land's End, between Seven Stones and Longships" TSS.

All MAREP messages are transmitted to MRCC FALMOUTH (*Falmouth Coastguard*) (see paragraph 2.4 above).

The TSS's and, *a fortiori*, the shipwreck area are not covered by coastal radar stations.

2.3 Navy exercises

The waters to the south of Lizard Point are shown on nautical charts and in the sailing instructions as exercise areas. These exercises may be carried out during the day or at night and may involve surface vessels, submarines and aircraft (see charts appendix D.3).

Advance warning is given of exercises involving submarines and messages are broadcast while they are taking place by means of *SUBFACTS-South Coast* messages, transmitted according to the procedures described in the following paragraph (2.4) by the *Flag Officer Sea Training*, who is the officer in charge of ships training at Plymouth/Devonport. These messages are broadcast by MRCC FALMOUTH at the same time as other maritime safety information.

Moreover, a code of practice dealing with the conduct of submarines on exercise and fishing vessels has been published by the Royal Navy and the fishing industry. The guide is entitled "*Submarine operations and fishing vessels : the Code of Practice"* and is applicable to all British and foreign submarines wishing to carry out diving operations in British exercise areas under British operational control. The guide sets out, amongst other procedures, the minimum distances to be observed between submarines and vessels likely to be engaged in fishing and the procedures to be followed to achieve them, it also details the communications and radio watch procedures which must be adhered to by submarines and fishing vessels as well as the action to be taken in the event of an incident involving a fishing vessel. For the captain of a submarine involved in a collision with a fishing vessel or her gear, it is specified that the safety of life over-rides all other considerations; he must fire white and yellow smokes to indicate his presence and position relative to the fishing vessel, come slowly up to periscope depth and establish VHF contact to assess the situation and give assistance.

2.4 Search and Rescue and the Global Maritime Distress and Safety System (GMDSS)

The accident occurred 15 miles south of Lizard Point, in international waters, in the British search and rescue region (SRR) and more precisely, in the *South Western Region* which is covered by MRCC FALMOUTH (see chart appendix D.4).

The area is defined as A1 + A2 in the Global Maritime Distress and Safety System (GMDSS). The area falls under the responsibility of MRCC FALMOUTH which therefore gives VHF and MF coverage, keeps watch on the distress and safety frequencies and broadcasts martime safety information (MSI) for the area (see chart appendix D.5).

Very High Frequencies (VHF) :

As well as the Falmouth site, MRCC FALMOUTH keeps a 24 hour watch on six remote sites for channel 70 (DSC, digital selective calling) as well as a 24 hour watch on channel 16 (radiotelephony) in four remote radio sites. The stations covering the accident area are those of Saint Mary's in the Isles of Scilly, Land's End, Lizard and Falmouth. As well as distress messages MAREP messages can also be received. The sites at Saint Mary's, Land's End and Falmouth are equipped with radio direction finding equipment enabling the positions of calling vessels to be fixed.

Medium Frequencies (MF) :

A 24 hour watch is kept on 2187.5 kHz (DSC) at Falmouth; watch is not kept on 2182 kHz.

Broadcasting of maritime safety information (MSI)

Maritime safety information comprises, successively, weather forecasts, gale warnings, storm warnings, navigational warnings and SUBFACTS/GUNFACTS warnings. Thay are broadcast by radiotelephony on VHF and MF frequencies and via the NAVTEX system. The area in which the accident took place is DELTA zone for navigational warnings, area PLYMOUTH for British weather bulletins and area USHANT (OUESSANT) for French weather bulletins (see charts appendix D.6).

Broadcasts on MF and VHF frequencies are preceeded by an initial announcement on 2182 kHz (telephony) and 2187.5 kHz (DSC) and on channels 16 (telephony) and 70 (DSC) respectively.

MRCC FALMOUTH broadcasts coastal warnings on MF (2226 kHz) and coastal and local warnings on VHF on channels 23 (Saint Mary's and Falmouth) and 86 (Lizard) at the following times (UTC) : 0140, 0540, 0940, 1340, 1740 and 2140. SUBFACTS/GUNFACTS messages will follow these, if military exercises are scheduled.

Gale warnings are transmitted as soon as they are received and in the same conditions and at the same times as the navigational warnings above. The same applies to the weather bulletins for the inshore coastal areas up to 12 miles offshore, which are only broadcast on VHF; bulletins giving the general synopsis and 24 hour forecasts are broadcast on VHF and MF at the 0940 and 2140 broadcasts; three day forecasts are only broadcast on MF at 0950 and 2150 between 1st October and 31st March.

MRCC FALMOUTH co-ordinates the NAVTEX transmissions from NITON radio station (located in the south of the Isle of Wight). This station uses three message headers for its international NAVTEX system messages which are transmitted on 518 kHz, in English :

- [S] : transmission of navigational warnings at 0300, 0700, 1100, 1500, 1900 and 2300.
- [K] : transmission of navigational warnings at 0140, 0540, 0940, 1340, 1740 and 2140.
- [E] : transmission of weather bulletins : gale warnings are transmitted as soon as they are received then at 0040, 0440, 0840, 1240, 1640 and 2040; the general synopsis, 24 hour forecast and 24 hour outlook are transmitted at 0840 and 2040; the further outlook and 3/4 day forecasts are sent at 0040.

NITON also broadcasts maritime safety information for national NAVTEX services on 490 kHz :

[A] : transmission of inshore navigational warnings (AVURNAV) in French from Cherbourg;

- [I] : transmission in English of navigational warnings at 0120, 0520, 0920, 1320, 1720 and 2120; gale warnings as soon as they are received and at 0520 and 1720; weather bulletins for the southeast, south and southwest coasts of Great Britain with 24 hour forecasts and the outlook for the following 24 hours at 0520 and 1720;
- [T] : transmission of gale warnings (BMS – Bulletin météo spécial) in French for USHANT (OUESSANT) and other areas : as soon as they are received and at 0310, 0710, 1110, 1510, 1910 and 2310; 24 hours forecasts are available at 0710 and 1910.

CROSS CORSEN (MRCC CORSEN) also broadcasts weather bulletins for offshore areas in French on MF at 0815 and 2015 as well as inshore bulletins on VHF. Special weather bulletins (BMS) or gale warnings for offshore areas are broadcast as soon as they are received on MF and then every hour at three minutes past the hour.

Weather information is also transmitted by facsimile from the Northwood centre. In addition, weather forecasts are also broadcast by radio : on BBC – radio 4 on their Plymouth transmitter and BBC – Radio Wales; Radio France offers the Inter-Service-Mer bulletin on France-Inter and France Bleue. METEO FRANCE also transmits weather charts by fax (NAVIFAX service).

✓ INMARSAT satellite system

The INMARSAT system is an international maritime radiocommunications system operating a number of geostationary satellites. Besides its radiocomuunications functions, it is used for distress, urgency and safety communications. The services and techniques it uses are classified in "standards"; standards A, B and C are integrated in the GMDSS

Whenever a ship sends out a distress message, it is automatically transmitted to an MRCC, either directly or via an associated coast earth receiving station (CES).

The western Channel is covered by the AOR-W, AOR-E and IOR satellites.

On board 2nd category fishing vessels, the MF transceiver equipped with DSC, which was necessary to comply with GMDSS requirements, could be replaced by an INMARSAT C station up to 1st February 2003 (see Chapter 2.5 below). On board, standard C means a compact piece of equipment, fitted with an omnidirectional antenna enabling fax and telex messages to be received and transmitted as well as permitting low rate transmission of data to shore-based computers. Distress messages can be addressed to an MRCC chosen by the operator or sent in pre-formatted form by pushing a button. This type of message will contain information about the ship's identity and position, if the INMARSAT C station is coupled to a GPS receiver.

In the United Kingdom the GOONHILLY coast earth station deals with standard C communications from the AOR-E, AOR-W and IOR satellites; distress messages are relayed to MRCC FALMOUTH for British ships, wherever they are, and for foreign ships in the SAR area under British responsibility (British SRR).

In the same way, in France, standard C distress messages received by the AUSSAGUEL centre from the AOR-E and IOR stellites are relayed to CROSS GRIS-NEZ (MRCC GRIS-NEZ) for French ships, wherever they are, and for foreign ships in the SAR area under French responsibility (French SRR).

✓ COSPAS-SARSAT satellite distress system

In this system, the messages transmitted by the emergency position indicating radio beacons (EPIRBs) are picked up by low-altitude polar orbiting satellites and geostationary satellites. They are relayed to shore receiving stations called LUTs (Local User Terminal) and then processed by mission coordination centres (MCCs).

The messages are coded and include information about the flag state and the MMSI number which enables the identity of the vessel carrying the EPIRB to be known. When they are received by a satellite on a low-altitude polar orbit, the difference in speed between the satellite and the EPIRB enables the latter's position to be calculated.

After they are processed, the messages are forwarded by the MCCs to their associated MRCCs : MRCC FALMOUTH is associated with the British MCC (UKMCC), CROSS GRIS-NEZ to the French MCC (FMCC).

Because of the trajectories of the satellites on polar orbits, the MCCs are interconnected in geographic strips which are oriented north-south along which the messages circulate; Europe and Africa make up the central area with the French MCC (FMCC) being the nodal point linking it to the other areas (see appendix E.7).

The English Channel is covered by a number of LUTs, linked, for the case under investigation, to the French (FMCC), British (UKMCC) and Norwegian (NMCC) MCCs.

Emergency position indicating radio beacons transmit coded messages on 406.025 MHz, in the form of 0.5 second long pulses which are transmitted every 50 seconds; they also transmit a continuous signal on 121.5 MHz; although this signal is transmitted at low power, it can be picked up by COSPAS-SARSAT satellites; it helps the rescue resources to home in on the beacon.

2.5 Relevant regulations

The *BUGALED BREIZH*, which was brought into service in 1986, was examined by the Regional Safety Committee of Britanny (Rennes), in compliance with the provisions of Act N° 84-810 of 30th August 1984 concerning "the preservation of human life at sea, the habitability on board vessels and pollution prevention" and the technical sections appended to the Order of 27th December 1984 "fixing the technical rules and procedures applying to vessels and their equipment for the preservation of human life at sea, the habitability on board vessels and pollution prevention". This Order was replaced by that of 23rd November 1987 "concerning the safety of vessels", to which the same technical sections were appended.

The relevant sections are section 211 "on intact stability and damage stability", section 226 "concerning fishing vessels having an overall length equal to or more than 12 metres and less than 24 metres" and section 216 "concerning radiocommunications".

Sections 219 and 226 are described below in order to explain and clarify the recommendations they make.

Radiocommunications

Maritime radiocommunications underwent substantial changes during the vessel's lifetime with the setting up of the Global Maritime Distress and Safety System (GMDSS). As a consequence equipment on board existing ships and shore-based telecommunications installations had to be modified, while, at the same time, ensuring complete compatibility between the old system and the new, even during the transition period.

What these changes led to as far as shore-based radioelectric installations are concerned has been described in paragraph 2.4 above.

The new section 219 "concerning radiocommunications", which replaced the former section 216 describes the operating principles of the GMDSS, specifies what radioelectric equipment must be carried according to ship type, year of construction and area of operation as well as the technical specifications of the equipment. On account of the fact that the changes were sometimes difficult to put into application, it has been modified several times, notably for fishing vessels in certain areas.

The area in which the *BUGALED BREIZH* operated is a sea area defined as A1 + A2, that is within radiotelephone coverage of VHF and MF coast stations (see Chart appendix D.5).

Until 1st February 2003, taking into account the vessel's length, date of construction and area of operation, she was required to be equipped with :

- a VHF radiotelephone transceiver without DSC
- a handheld GMDSS VHF radiotelephone transceiver,
- an MF radiotelephone transceiver without DSC combined with a watchkeeping receiver on 2182 kHz or an Inmarsat C ship earth station,
- a NAVTEX receiver (an exemption could be granted for as long as there were no broadcasts in French),
- A deck-mounted COSPAS-SARSAT 406 MHz EPIRB

At this stage the compliance of vessels with GMDSS requirements was incomplete, to say the least, and compatibility between on-board equipment and coast stations was dependent, to a very large extent, on keeping services which the GMDSS had made obselete, operational. In particular, aural watchkeeping on the distress and safety frequencies – 156.8 MHz (channel 16 VHF) and 2182 kHz (MF) – was maintained as digital selective calling (DSC) was progressively introduced on 156.525 MHz (channel 70 VHF) and 2187.5 kHz (MF).

Implementation of the GMDSS was thus phased in through successive recommendations from the IMO's Maritime Safety Committee and the decisions of a number of coastal states, including France.

After 1st February 2003, VHF (at least one) and MF transceivers had to be equipped with digital selective calling on existing fishing vessels, NAVTEX receivers became mandatory as did radar transponders, finally making on board equipment compatible with shore-based installations. A further six month exemption prolonged the transition period pushing the equipment deadline date back to 1st August 2003.

Built under survey

The vessel's freeboard and stability were examined and verified by a recognized classification society who issued the initial freeboard certificate for (fishing) vessels of more than 12 metres.

The recognized classification society has to inspect the structure and scantlings of fishing vessels of more than 12 metres to ensure they correspond to the requirements of their own rules. To this end a number of drawings are submitted and the conformity of the scantlings and construction with the drawings is checked.

The points checked are the solidity and method of construction of the hull, the closed superstuctures, the deckhouses, the wheelhouse, the engine casing, the companionways and other elements providing rigidity as well as equipment for watertight integrity. All these elements must enable the vessel to withstand all foreseeable conditions of service for which she is designed.

Before issuing the initial freeboard certificate, the recognized classification society which has carried out all these checks must follow the tests and trials alongside and at sea required by its rules.

These provisions are part of Article 226-2.02 of section 226 entitled "solidity and method of construction of the hull".

3 THE VESSEL

3.1 Particulars (see appendix B.1)

The *BUGALED BREIZH* is a 24 metre stern trawler with a steel hull and aluminium superstructures. She was built in 1987 at Pont-Lorois (BELZ, Morbihan) by the Chantiers de Bretagne Sud.

Her main characteristics are as follows :

- **length overall : 23.85 m ;**
- **length between perpendiculars : 20.30 m ;**
- **breadth : 6.60 m ;**
- **moulded depth : 3.54 m ;**

- summer draught : 2.750 m ;
- summer freeboard : 513 mm ;
- gross tonnage : 103.93 ;
- light displacement : 134.8 tonnes;
- engine make : MGO V 12 M 4 ;
- engine retrofit in 1999 : ABC type 6 DXC-750 A ;
- power : 478 kW ;
- service speed : 11 knots ;
- volume of fish hold : 90.00 m^3 ;
- fuel capacity : 35.00 m^3 ;
- fresh water capacity : 8.00 m^3 ;
- port of registry : Le Guilvinec;
- registration number : GV 642421 J ;
- call sign : F.H.J.H. ;
- MMSI number : 228295000 ;
- Navigation category : second ;
- GMDSS areas : A1 + A2 ;
- Type of fishing : deep water ;
- commissioned : 25 May 1987.

3.2 Stability / freeboard

The *BUGALED BREIZH* was designed as a fishing vessel operating as a bottom stern trawler. The initial stability documents were drawn up using those of an almost identical trawler, the *RAVEL.* The difference between the two vessels lay in the fact that the latter was equipped with an ABC engine weighing nine tonnes while the engine of the *BUGALED BREIZH*, during her trials, was an MGO V 12 M 4 engine which weighed five tonnes less. To compensate for the difference in weight between the two engines, 4 tonnes of scrap steel were incorporated in the keel as extra ballast. The stability test carried out on 19th May 1987, in good conditions, showed a difference of one tonne compared to the preliminary calculations and a lowering of the centre of gravity, corresponding to the difference in weight of the two engines and the installation of the extra ballast.

The stability documents were approved by the Regional Director of the Maritime Administration (Affaires Maritimes) for south Brittany on 21st October 1987.

The initial freeboard certificate was issued by the Bureau Veritas, then renewed annually by the Le Guilvinec office of the Ship Safety Centre in Concarneau.

3.3 Transformations

The vessel underwent an engine retrofit during a major careening operation in 1999; the original MGO V12 M 4 engine of 478 kW was replaced by an ABC 6 DXC – 750 A engine developing the same power.

The Ship Safety Centre in Concarneau was informed of the project by a letter dated 23rd September 1998 and gave its approval on 06th October 1998. A letter dated 15th June 1999 from the Ship Safety Centre reminded the owner of the effect of the engine retrofit on the weight of the vessel and the COPREMA carried out a study which concluded that it was necessary to remove four tonnes of ballast. After the engine retrofit, the stability characteristics of the *BUGALED BREIZH* were thus almost identical to those of the *RAVEL*, which had, moreover been approved by the Regional Safety Committee for Brittany.

No other transformations were made to the vessel.

3.4 Surveys and certification

Inspection of the annual survey reports showed that the vessel had been regularly maintained and kept in a generally satisfactory condition since being brought into service.

A hull plating thickness check was carried out in 1999.

The last careening was carried out in July 2003; the hull valves were checked during this operation.

The last annual survey was carried out on 12th November 2003 by the Le Guilvinec office of the Concarneau Ship Safety Centre.

Tests were conducted on the water level alarms. A recommendation was made to fit a water level alarm in the crew's quarters.

The vessel's navigation licence (roughly equivalent to the UK Fishing Vessel Certificate) and national freeboard certificate were renewed until 11th November 2004.

The vessel was built under Bureau Veritas survey so that stability and freeboard documents could be presented to the Regional Safety Committee before she was brought into service. The vessel was not subsequently classed with a classification society.

3.5 Fishing gear (see appendix B.2)

3.5.1 Winches and drums

The *BUGALED BREIZH* was fitted with two winches on the freeboard deck abaft the work room. The winches were hydraulically driven but were not of the self-tensioning type. The drums were connected and disconnected by the movement of a hydraulically operated claw-type clutch. The brake consisted of a circular band and was tightened by a hydraulilc ram; a hand wheel made it possible to use the brake manually and to take up any play due to wear. The tension on the warps was measured mechanically and there was a warp tension indicator in the wheelhouse with an alarm which was set off if a four tonne limit was exceeded; there was no warp tension recording equipment nor was there any means of decreasing the tension. A warp guide was used to ensure that the warps spool on to the drums correctly.

The vessel was equipped with two net drums, located on the upper deck, above the winches and abaft the superstuctures, for stowing the trawl nets.

There was also a supplementary drum on the main deck, forward of the work room which was used to stow a spare trawl net or when repairs were being carried out on the trawl nets.

The net drums were hydraulically operated.

The hydraulic power unit for the winches and net drums was in the engine room. The controls for the winches and net drums as well as for the clutches and brakes of the warp drums were grouped together on a control panel in the after part of the wheelhouse. The winches could be controlled locally by means of hand-held control boxes around the winches themselves.

The winches and the after deck were not visible from the winch control panel in the wheelhouse.

3.5.2 Trawl rig

The warps, of the Super Cordon Rouge type, were produced by TREFILEUROP. They had a nominal diameter of 22 mm and a nominal strength of 27.8 tonnes. They were made up of 6 strands twisted around a fibre core with a right hand lay. The strands consisted of 3 layers of wire wound spirally around a wire core with a left hand lay. The wires used had previously been galvanised.

The warps had a length of around 1200 metres.

The usual practice in Le Guilvinec is to replace the worn ends of the warps and to leave the new part on the winch side; the old and new parts are joined together by two splices. On each of the warps, 600 metres had been renewed in November 2003; the new part of these warps was therefore wound on the winch drums at the time of the accident.

By means of swivels and connectors each warp was connected :

- to the top of the trawl net, via the upper bridle which was 81 metres long and 16 mm in diameter, and was followed by 2 metres of 13 mm chain connecting it to the upper wing of the trawl net, on the one hand;
- and to an otter board via the lower leg of the fork which was 12 metres long and had a diameter of 22 mm, on the other hand. The otter board pulled the lower wing of the trawl net by means of two chain backstrops which were connected to the lower bridle, which was 65 metres long and 22 mm in diameter, by means of a swivel and which, in turn, was connected to the three way connection[1] by means of a groundchain about 10 metres in length.

Each otter board was made of wood, was rectangular in shape, had a length of 2.5 metres and weighed about 800 kilos. Their lower edges were fitted with metal shoes, giving protection as the boards slid vertically along the seabed. Each board had a two-armed bracket on its outer surface, to which the warp connecting it to the vessel was fastened and two attachment brackets, on its inner surface, for attaching the two backstrops by which the otter board was connected to the lower bridle of the trawl net.

The two otter boards were used to hold the mouth of the trawl net open; during fishing operations they were about fifty metres apart.

During fishing operations the trawl net had a horizontal opening of 18 metres and a vertical opening of 4 metres.

1 The expression three way connection, as used in this report, designates the place where the groundchain is shackled to the footrope and wingline by means of a butterfly spreader. It translates the French "pignon" for which no satisfactory English equivalent was found.

3.6 Life saving appliances

In compliance with regulations, the *BUGALED BREIZH* was equipped with two 8 person Class 1 liferafts, located on either side of the upper deck abaft the wheelhouse. They had been serviced on 7th May 2003.

She was also equipped with six immersion suits which had been verified on 3rd January 2003.

The *BEA*mer investigators observed that the immersion suits were stowed in the crew's quarters which would have made them difficult to use in the event of an emergency due to the steepness of the access ladder.

3.7 Radio equipment

The vessel was equipped with :

- 2 SAILOR RT 144 C VHF transceivers;
- 1 KENWOOD VHF transceiver;
- 1 SKANTI MF transceiver;
- 1 2182 kHz watchkeeping receiver;
- 1 hand-held VHF transceiver;
- 1 406 MHz KANNAD emergency position indicating radio beacon, located on the aft bulkhead of the wheelhouse;
- 1 FURUNO FAX 208 marine facsimile receiver;
- 1 POLARIS VHF/RDF;
- 1 INMARSAT C station
- 1 EMSAT terminal.

The radionavigation equipment comprised a RAYTHEON radar set, a KODEN radar set, an MLR FX 312 GPS receiver, an MLR FX 412 PRO DGPS receiver and a BEN MARINE log.

The vessel was fitted with a dual frequency FCV 291 sounder, the transducers of which were located on the starboard side. The transducer shoe, on the port side, belonged to the original paper sounder which had been removed.

Regarding GMDSS-stipulated equipment, which became mandatory on 1st August 2003 (see paragraph 2.5), the MF/HF transceiver of the *BUGALED BREIZH* was fitted with digital selective calling on MF and a hand-held GMDSS compliant VHF set was added to the vessel's equipment. However, the vessel was not fitted with a NAVTEX receiver nor did she have digital selective calling on one VHF set.

After the annual survey held on 12th November 2003 :

- the installation of MF/HF equipment with digital selective calling was noted,
- A directive was issued requiring the radio equipment to be brought into conformity with GMDSS requirements.

The last inspection by an inspector from the ANFR (Agence Nationale des Fréquences – National Frequency Agency) was made on 8th November 2002.

3.8 Bilge pumping system and alarms

The bilge pumping system comprised five drain wells, in the forepeak tank, the fish hold, the forward and after parts of the engine room and the crew's quarters. The corresponding valves were located on a manifold in the forward part of the engine room.

A drain duct ran from the steering gear room abaft the engine room, under the crew's quarters. A cut-off valve, located to starboard of the reduction gear in the engine room, was fitted with a stem-mounted handwheel.

The fish hold and the forward and after drain wells in the engine room were fitted with float switch water level alarms. The alarm console was in the starboard after part of the wheelhouse. There were two warning lights, one for the engine room and the other for the fish hold; there was a sound alarm below the console which could be switched off.

4 THE CREW

4.1 Crew Composition and certification

The vessel was operated for deep water fishing and her manning requirements had been set at five persons.

The crew comprised a skipper, a chief engineer, a second engineer and two deckhands.

As the skipper/owner had been on sick leave since July 2003, the skipper's role devolved upon a licensed Fishing Captain who had sailed on the *BUGALED BREIZH* since April 2000, alternately as Chief Officer and skipper.

The Chief engineer who held a Motorman's certificate of competency for fishing vessels had sailed on the *BUGALED BREIZH* in this capacity since 1997.

The second engineer who held a certificate of competency had sailed on the *BUGALED.BREIZH* since 1998 and had alternated in the role of Chief engineer and Second engineer since 2000.

One of the deckhands, who was licensed to operate small engines on fishing vessels, had sailed on the *BUGALED BREIZH* since 2002 while the other, who held a (fishing) certificate of competency and a mate's fishing certificate, had been with the vessel for about a year.

All the crew members were experienced fishermen and had enjoyed great stability of employment in their previous vessels before joining the *BUGALED BREIZH.*

4.2 Medical fitness

All the crew members were fit for navigation with no restrictions. Only one of the deckhands was not up to date with his annual medical examination.

5 SEQUENCE OF EVENTS (all times are in UTC)

The sequence of events was established using the notes and SITREPs from MRCC FALMOUTH, the COSPAS-SARSAT messages received by MRCC FALMOUTH and the CROSS GRIS-NEZ, the operational reports from CULDROSE air base and the statements made by the fishing vessels who participated in the search and rescue operation.

Wednesday 7th January 2004

- The *BUGALED BREIZH* and the *ERIDAN* left the port of Loctudy for a two week fishing trip south of Cornwall.

Sunday 11th January 2004

- **2100,** the *BUGALED BREIZH* and the *ERIDAN* put into the port of NEWLYN to shelter from the bad weather. The *ERIDAN* moored alongside the *BUGALED BREIZH.*

Tuesday 13th January 2004

- **1900,** the two vessels left the harbour. It would take them two and a half hours to reach their fishing area; the skipper of the *BUGALED BREIZH* indicated that he would be fishing a little further to the south east.

Thursday 15th January 2004

- **1030,** the *ERIDAN* hauled her trawl in position 49°15,9' N, 005°14,9' W.

- **1100,** the two vessel called each other on VHF : the *BUGALED BREIZH* reported that she had hauled her trawl at 1030 and would be making her next tow towards the southeast. The *ERIDAN* could see the *BUGALED BREIZH* visually and on her radar three to four miles southsouthwest of her own position. The two vessels recommenced fishing operations for a tow which should have lasted three to three and a quarter hours. According to the *ERIDAN*, the wind was then southwesterly force 4 to 5 with a 2 to 3 metre swell, visibility was 4 to 5 miles and the current was setting eastsoutheast.

- **1225,** the *BUGALED BREIZH* called the *ERIDAN* on a private P2 VHF channel and repeated three or four times "We're capsizing, come quickly, we're capsizing, come quickly". The skipper of the *BUGALED BREIZH* gave his position as 49°42'N, 005°10'W but did not explain what was happening. The skipper of the *ERIDAN* called the skipper of the *BUGALED BREIZH* and told him to launch his inflatable liferafts. He left the wheelhouse and went to call his crew so that they could haul the fishing gear. When he came back, there was a further VHF contact which quickly became inaudible then stopped. According to him, no more than one and a half minutes to two minutes had elapsed between the two calls. The skipper proceeded to the position indicated by the skipper of the *BUGALED BREIZH.* He did not notice any background noise during the exchanges except during the final one when there was a sort of crackling sound which got louder until the contact was broken.

- **1236,** the *ERIDAN* transmitted a Mayday relay distress message by INMARSAT C and contacted the CROSS GRIS-NEZ by radiotelephony via the IRIDIUM satellite system to inform them of the incident. Conditions in the area were wind, southwest 25 to 30 knots, rain, visibility 2 to 3 miles.

- **1238,** MRCC FALMOUTH received a distress message from a 406 Mhz COSPAS-SARSAT emergency position indicating radio beacon from MMSI N° 228295000, the triangulated position with 84% accuracy was 49°39.4 4'N 005°11.21'W.

- **1240,** the CROSS GRIS-NEZ informed MRCC FALMOUTH of the accident. The latter called MMSI N° 228295000 using digital selective ca lling on VHF and MF.

- **1245,** the *ERIDAN* called MRCC FALMOUTH to give them the last position reported by the *BUGALED BREIZH* and the number of persons on board; she would be on the scene in 20 minutes.

- **1246,** MRCC FALMOUTH placed a helicopter on standby at the CULDROSE base.

- **1248,** the CROSS GRIS-NEZ called MRCC FALMOUTH to confirm the information they had received from the *ERIDAN*.

- From **1250** on, MRCC FALMOUTH broadcast MAYDAY messages.

- **1250,** the Dutch submarine *DOLFIJN* reported that she was 8 miles to the south and proceeding to the distress position, estimated time of arrival on scene 1400 hours.

- **1259,** helicopter R193 took off, estimated time of arrival on scene 1315 hours. The all weather LIZARD lifeboat was tasked.

- **1304,** the CROSS GRIS-NEZ informed MRCC FALMOUTH that the French trawler *ALYA* was eight miles away and proceeding to the scene.

- **1305,** MRCC FALMOUTH received a COSPAS-SARSAT distress alert identified as coming from beacon N° 228295000 giving the position 49°42.12'N, 005°10.49'W (99% accuracy).

- **1306,** *HMS TYNE* reported gusts of 50 knots from the southwest, sea state 4-5 and decreasing visibility. The last position indicated by the 406 Mhz beacon was given to helicopter R193.

- **1308,** the submarine *DOLFJIN* gave her estimated time of arrival on scene as 1345 hours; the merchant vessels *SILVER DAWN* and *AUTO TRANSPORTER* reported and proceeded to the area.

- **1314,** the *AUTO TRANSPORTER* would arrive on scene in 22 minutes. Helicopter R 193 picked up a signal on 121.5 Mhz.
- **1316,** helicopter R 193 spotted a liferaft and saw a fishing vessel in the accident area; it was the *ERIDAN*.
- **1325,** the CROSS GRIS-NEZ informed MRCC FALMOUTH that the *BUGALED BREIZH* had two liferafts.
- **1328,** helicopter R 193 investigated the liferaft : there was no-one on board. The diver punctured the raft with a knife so that it would sink.
- **1334,** vessel *SILVER DAWN* proceeding, would arrive on scene in 18 minutes.
- **1343,** helicopter R 193 picked up one body.
- **1347,** PENLEE lifeboat proceeding.
- **1357,** helicopter R 193 recovered a second body.
- About **1400** the skipper of the *ERIDAN* sighted a submarine.
- **1411,** the *ERIDAN* recovered the COSPAS-SARSAT beacon and a life buoy. The CROSS GRIS-NEZ transmitted this information to MRCC FALMOUTH.
- **1425,** *HMS TYNE* was designated On Scene Commander (OSC) by MRCC FALMOUTH.
- **1426,** helicopter R193 landed at CULDROSE and unloaded the bodies.
- **1427,** helicopter R 169 arrived on scene.
- **1454,** helicopter R 193 arrived back on scene.
- **1501,** weather conditions on scene were : wind, southwest force 7-8, visibility 1 mile, rough sea.
- **1508,** the CROSS GRIS-NEZ reported that the French trawler *HERMINE* had picked up an empty life raft from the *BUGALED BREIZH*.

- **1541,** the *ANGLIAN PRINCESS* reported that she was proceeding to the area and would arrive in 20 minutes.

- **1630,** weather conditions were : wind, west by south 35 – 40 knots, sea state 6, wave height 5 metres, visibility 5 miles.

- **1650,** helicopters R 193 and R 169 left the area as darkness was falling.

- **1715,** search and rescue operations by nautical resources were called off. All those who had taken part in the SAR operation were stood down and given permission to proceed.

- **1740,** *HMS TYNE* left the area.

- **1743,** the CROSS GRIS-NEZ informed MRCC FALMOUTH that the *ERIDAN* would be staying in the area with the other French fishing vessels.

- **1900,** the CROSS GRIS-NEZ gave the fishing vessels liberty to proceed.

Friday 16th January 2004

- Helicopters R 193 and S 08 as well as the Breguet Atlantic A 405 flew over the accident area.

- The *BEA*mer decided to open an administrative and technical inquiry. (see appendix A)

- The *BEA*mer asked the Préfet Maritime to have an underwater inspection of the wreck carried out.

Saturday 17th January 2004

- The mine sweeper *ANDROMÈDE* set sail from Brest at 1800 hours. A *BEA*mer investigator, a senior police officer, the owner of the *BUGALED BREIZH* and the President of the Guilvinec local Sea Fisheries Committee were on board.

Sunday 18th January 2004

- The mine sweeper *ANDROMÈDE* located the wreck of the *BUGALED BREIZH* and made four inspections by means of a self-propelled mine disposal vehicle, which everyone on board was able to witness.

Thursday 22nd January 2004

- The Regional Director of the Maritime Administration for Brittany instructed the Ship Safety Centre in Concarneau to inform all member and associated-member countries of the Paris Memorandum of Understanding of the position and date of the wreck so that they could look for merchant vessels showing signs of having been in a collision. The information transited via the SIRENAC computer network of the Paris Memorandum of Understanding.

- At the same time, the CROSS GRIS-NEZ was asked to draw up a list of ships which had transited the Straits of Dover and could have been in the accident area when the accident happened.

Friday 9th July 2004

- After an underwater survey of the site had been carried out, the wreck was refloated by the vessel *DISCOVERY* of the company STOLT OFFSHORE who had been entrusted with the task by the judicial authorities within the framework of the inquiry which had been instigated on 23rd January 2004.

Tuesday 13th July 2004

- Upon arrival in Brest the wreck was lifted ashore and placed in the Naval Base.

6 OBSERVATIONS AND TESTS CARRIED OUT ON THE VESSEL

The *BUGALED BREIZH* foundered and sank with the loss of all hands during daytime.

The last person to see her was the skipper of the *ERIDAN*, who also received the last VHF calls from the *BUGALED BREIZH* indicating that she was capsizing, when he was about four or five miles away from her.

The minehunter *ANDROMEDE* carried out an inspection of the wreck three days after her sinking by means of a self-propelled mine disposal vehicle (MDV). It was only possible to examine the starboard side of the hull and deadworks as the wreck was lying on her port side with about forty degrees of list. It was also possible to examine the main components of the trawl rig. Even though this examination was not totally complete, it was nevertheless invaluable because it gave vital information about the conditon of the trawl rig only a short time after the accident.

The *BUGALED BREIZH* was refloated in July 2004 and it was possible to make a complete inspection of the wreck. Before lifting operations commenced, the STOLT team undertook a survey of the area and underwater video footage was shot by ROVs and divers. Although they are very detailed, these images are nonetheless very difficult to interpret as the wreck, the trawl gear and the sea bed had undergone changes after the sinking.

Apart from the statements made by the skipper of the *ERIDAN*, who was the last person to see and hear from the *BUGALED.BREIZH,* only the observations made of the ship herself and of her trawl gear were likely to shed any light on the causes of the accident. To complete these observations, a great number of in-depth studies and tests were carried out so that the various conceivable hypotheses could be confirmed or refuted.

The aim of the present chapter is to describe the observations made of the ship and her trawl gear, as well as the studies which made it possible to broaden the scope of our deductive processes. The ensuing hypotheses are analysed in Chapter 7.

6.1 The statement made by the skipper of the *ERIDAN*

The skipper of the *ERIDAN* spoke with the skipper of the *BUGALED BREIZH* on VHF shortly before eleven o'clock. The latter had hauled his trawl and was intending to make his next "tow" towards the southeast from eleven o'clock for about three to three and a quarter hours. At that time the current was setting eastsoutheast.

Both vessels recommenced fishing operations at about eleven o'clock.

At 1225 the *BUGALED BREIZH* called on VHF to say that they were capsizing.

During the afternoon of the 15th January 2004, the *ERIDAN,* the first vessel to arrive on scene, located, by echo sounder, an object which could have been the wreck, in position latitude 49°42.401'N longitude 005°10.370'W.

The following passage is taken from the sea protest of the skipper of the *ERIDAN* and concerns the moments immediately preceeding the foundering of the *BUGALED BREIZH* (times given are UTC +1).

"On 15th January 2004, at 1130, I hauled the trawl after the 31/2 hour morning tow in position 49°15'900N 005°14'850W, I could see the BUGALED BREIZH in my binoculars 3 or 4 miles further to southsouthwest of me. He hauled his gear at the same time. We spoke on VHF just before 1200. There was nothing to report, he told me he was going to make his next tow to the southeast, the wind was then southwest force 4 to 5 with a 2 to 3 metre swell, I reckoned the visibility was about 4 or 5 miles. I began fishing again at 1200 for a 3 to 31/4 hour tow, so did the BUGALED BREIZH. I shot the trawl and made course westsouthwest, the current was then setting eastsoutheast.

At 1325 the BUGALED BREIZH called me on VHF and said "we're capsizing, come quickly, we're capsizing, get a move on", three or four times. I asked him what was happening, but he kept on repeating the same thing. I asked him for his position which he said was 49°12'N 005°10'W (Note from the BEAmer: the latitude was 49°42'N). His voice wasn't the same as usual. I told him to launch his liferafts, that we were coming to his assistance. I rushed down to the crew's quarters to warn the lads and said "We've got to haul the gear straightaway, the BUGALED has capsized". I went back up to the wheelhouse and immediately contacted the BUGALED BREIZH on VHF, he answered that he was capsizing, the VHF was crackling more and more and I lost radio contact. My mate came into the wheelhouse, I was still holding the VHF set but couldn't hear anything more from the BUGALED BREIZH. It was barely more than a minute after I'd received the first call from the BUGALED BREIZH."

This statement shows that the sea conditions were difficult but not exceptionally so. Moreover the two skippers had been sheltering in NEWLYN waiting for a gale to abate before putting out to sea again. It shows the surprise and incomprehension of the skipper of the *BUGALED BREIZH* when confronted with a sudden, apparently inexplicable event. The interval between the two VHF contacts corresponds to the time it took the skipper of the *ERIDAN* to go from the wheelhouse to the crew's quarters to call the crew who were resting at the time, and back. Taking into account the layout and size of the *ERIDAN* this would have taken between a minute and a half to two minutes at most. It is impossible to know whether the skipper of the *BUGALED BREIZH* tried to explain the situation on VHF during this time or whether he called his crew to abandon their vessel.

6.2 Survey of the vessel's structure

Deformation of the fish hold

Damage to the vessel's structure can be divided into three areas :

- ✓ The vessel's stern was severely damaged. Referring to the underwater video footage shot by the MDV from the *ANDROMEDE* in January 2004, a certain amount of damage is visible but it is relatively limited in extent : the stern frame sole is slightly deformed, the rudder blade is jammed in the rudder trunk, the propeller nozzle is slightly deformed. There is no comparison with what was observed when the vessel was refloated : the stern frame sole was severely deformed, and the rudder blade, propeller nozzle and blades were also seen to be greatly deformed. This was no doubt due to the fact that, during the first attempt at refloating the *BUGALED BREIZH* on 29th June 2004, she fell on to her stern from a height of 10 metres.

Moreover, comparing the condition of the wreck on the January 2004 video with the underwater images taken by STOLT enables us to explain why the starboard leg of the stern gantry, which was intact in January, is twisted over the wreck. The images taken by STOLT show a trawl net hanging vertically above the stern gantry which therefore must have been snagged by another trawler. We shall not discuss further the damage to the vessel's stern which has no bearing on the accident.

- ✓ In way of the forward part of the engine, on the port side shell plating a diamond-shaped breach was observed in way of the port echo sounder transducer mounting. Forward of this breach, there was a vertical crack in the shell plating which had also been pierced. The port side shell plating was severely rusted; this was due to the fact that the vessel had lain on her port side for six months and the plating had suffered from rubbing on the sea bed and from chemical reactions with the sediments. This made it more difficult to analyse the areas where breaks had occurred.

- ✓ In that part of the hull situated forward of the midships perpendicular, which corresponded to the bulkhead separating the engine spaces from the fish hold, the frames and shell plating were severely buckled, symetrically on both sides of the hull, in way of the fish hold and the double bottom below it, as were the main and upper decks, the keel and the forward bulkhead of the engine casing.

6.2.1 Damage to the port side of the engine room
(see appendix E.1 and photographs in appendix F.1)

A visual inspection of the hull established that the side shell was damaged in three places on the port side forward of the engine spaces around the echo sounder mounting :

- ✓ The plating had been torn open and pushed inwards; this breach corresponded to the position of the port echo sounder;
- ✓ There was a vertical crack in the shell plating in way of frame 18 forward of the torn sounder location, together with a secondary vertical crack parallel to it a few centimetres further forward and a horizontal crack above it;
- ✓ There was a further vertical crack with perforation of the shell plating over a few millimetres in way of frame 19.

A metallurgical analysis was made of all the damage and included :

- ✓ A morphological analysis of the deteriorations with the aim of determining :
  - how the deteriorations were brought about;
  - what sort of stress was applied;
  - in what direction the cracks were propagated;
  - the site (or sites) where the cracks started.
- ✓ tests to detect any traces of paint from outside sources;
- ✓ The metallurgical characteristics of the welded assemblies and the base materials.

This analysis was subsequently completed by a further analysis of the breach in order to determine the relationship between the fatigue crack surfaces and the breach as a whole.

A third stage comprised the metallurgical analysis of the area around the base of the starboard echo sounder, largely symmetrical to the area of the breach and cracks on the port side, in order to determine whether this part of the structure was also affected by cracks or showed fatigue crack starting points. Another of its aims was to assess how much tractive force needed to be applied to break the sounder's cable conduit. Detection tests of paint from outside sources and determining the physical and chemical properies of the material and welds were not carried out, as the area had remained intact in the accident.

All of these metallurgical analyses were then studied in order to to quantify what forces were required to create the breach and to attempt to determine what had caused it.

The breach in way of the port echo sounder (see photographs in appendix F.1)

When intact, the transducer of the port echo sounder was located in the frame spacing between frames 17 and 18, around level 2H. The transducer shoe was a 30 cm long doubling plate made of 8 mm steel, like the hull plating, and had the shape of an elongated hexagon along the vessel's longtudinal axis. It was welded directly to the outside surface of the shell plating. A hole was drilled in the centre of this polygon to allow the passage of the transducer cable. The gland installation comprised a circular flange welded around its periphery to the outside surface of the shell plating and threaded in its centre. The cable conduit, which was threaded on its outside surface, was screwed into the gland stuffing tube and held in place by a weld; it was completed by a screwed 90° elbow coupling, another screwed coupling and a simple conduit carrying the cable upwards towards the upper part of the engine spaces.

The port echo sounder was installed during the vessel's trial period. Although it was no longer in use, the shoe protecting its transducer had been left in place.

The rent in the shell plating formed a diamond shape, 300 mm long and 180 mm high. The shell plating was torn along its upper edge following the weld of the sounder transducer shoe; in the bottom part of the breach, the tear diverges from this weld; the part of the plate which remained attached to the side shell and around which the torn part rotated, is horizontal and 200 mm long.

The sounder transducer shoe was seen to be missing. The underwater video sequences shot by STOLT just after the wreck was brought upright were examined and gave the impression that the transducer shoe was still in position when they were made. A number of images were captured; by comparing them to photographs of the wreck, it was possible to conclude that the shoe was no longer in position before the refloating operation began. It was not found in the area around the wreck, but it must be said that no specific search was made for it.

The cable conduit broke in way of the screwed coupling located just after the 90° elbow.

The metallurgical analysis of the breach in way of the sounder shoe revealed that the break had been initiated by progressive cracking induced by fatigue. Cracks and micro-cracks, which started on the inner surface of the shell plating, appeared at the two ends of the diamond-shaped breach and in a small area at the top of the tear.

The tear was caused by a sudden brutal overload which sheared the plating starting from the areas which had already been weakened by the fatigue cracks, that is, the points of the diamond. The tear was the result of a force being applied upwards and towards the after part of the diamond and led to the brutal tearing being propagated in those directions. The breach in the side shell and the bending inward of its edges into the engine spaces occurred when the fatigue cracking met that produced by the brutal overload.

The ratio of the length of the break due to fatigue and the total length of the tear was estimated to be between 19.6% and 33.5%

Areas where the metal had been crushed inwards were observed on the upper edge of the breach, which could indicate a metal to metal contact.

The metallurgical properties of the shell plating corresponded to those of normal strength hull structural steel of type S 235 according to the AFNOR standard NF EN 10025. No traces were found of paint from outside sources nor were there any signs of metal to metal contact. The welds assembling the strakes were found to be of satisfactory quality and did not contribute to the breaking process.

Inspection of the weld fixing the sounder shoe to the hull showed that it was practically equivalent to its having been glued in place.

Analysis of the cable conduit showed that it broke at the end of the threaded part of the second coupling, in a particularly sensitive area due to its geometry. The breaking of the cable conduit is directly linked to the rupture and caving in of the shell plating, which, by pivoting around the horizontal part which remained attached to the hull, exerted sufficient tractive pressure on the cable conduit to break it.

Cracks in the shell plating forward of the breach in way of the port echo sounder (see photographs in appendix F.1)

The cracks are situated in way of Frame 18 and comprise a main vertical crack 650 mm long and a secondary vertical crack parallel to it a few centimetres further forward with a length of 200 mm. The edges of the main crack, where it pierces the plating, are 2 cm apart at maximum. Above these two cracks is a 280 mm long horizontal crack which runs perpendicular to them towards the stern (above the breach, therefore).

Metallurgical analysis of these cracks showed that they developed following the appearance of multiple fatigue cracks on the outer surface of the shell plating, on the side opposite the frame welds, as a result of repeated dynamic bending stresses.

The metallurgical properties of the shell plating corresponded to those of normal strength hull structural steel of type S 235 according to the AFNOR standard NF EN 10025. No traces were found of paint from outside sources nor were there any signs of metal to metal contact.

The metallurgical properties of the welds of the shell plating at Frame 18 were of mediocre quality but did not contribute to the cracking process.

Perforation of the side shell forward of the breach in way of the port echo sounder (see photographs in appendix F.1)

The perforation which was about 2 to 3 mm wide measured 15 mm at its longest in way of Frame 19. It was situated in the middle of a vertical crack, showing the beginnings of many fatigue cracks on the outer surface of the shell plating, along two weld fillets fixing the shell plating to the frame. The metal may have been perforated when two sets of fatigue cracks which had developed on separate planes came together.

The metallurgical properties of the shell plating corresponded to those of normal strength hull structural steel of type S 235 according to the AFNOR standard NF EN 10025. No traces were found of paint from outside sources nor were there any signs of metal to metal contact.

The metallurgical properties of the welds of the shell plating at Frame 19 show that they were of average quality but did not contribute to the cracking process.

Metallurgical analysis of the starboard shell plating

On the starboard side forward, there were two echo sounder transducer shoes. One of them, made of alpax, was cut in half, probably during the refloating operations; a sounder transducer is still visible, hanging from it. The other one was fitted at the same time as the port sounder shoe, during the construction of the vessel and was practically symmetrical to it; it was also fashioned from 8 mm steel plate and was fitted in an identical way.

Metallurgical analysis of the area around the port-side echo sounder had brought to light the existence of fatigue cracks and micro-cracks. It was to necessary to analyse a similar area around the starboard echo sounder in order to determine how the fatigue micro-cracks had been created, on the one hand, and to calculate the force of traction required to break the cable conduit which was mounted in exactly the same way as the port-side conduit, on the other hand.

The following elements were analysed : the welds of the side shell strakes, the welds fixing the shell plating to the frames and the weld fixing the echo sounder transducer shoe to the side shell.

No trace of any cracks starting was detected in the three areas examined.

A tensile test was carried out on the cable conduit. The results gave an utimate tensile strength of UTS = 339 Mpa and a breaking load at the root of the screw thread of 2186 daN.

Assessment of the forces required to create the breach (see appendix E.2)

The investigators had a study made to assess what forces were required to create the breach in way of the port echo sounder and to find out what caused it, using the metallurgical analyses described in the preceeding paragraphs.

The breach in way of the echo sounder resulted from the addition of three phenomena :

- ✓ The tensile fracture of the echo sounder transducer cable conduit at the coupling;
- ✓ the creation of a plastic hinge in way of that part of the plating which remained attached to the hull and around which the plating carrying the echo sounder shoe pivoted;
- ✓ the tearing of of that part of the plating on which the echo sounder shoe was mounted, which had not been affected by fatigue cracks.

Fracture of the cable conduit

Assuming that the characteristics of the starboard conduit were similar to those of the port conduit, we could base our calculations on the strength of the starboard conduit, namely an elastic limit of 195 Mpa.

By this means we calculated that the tractive force required to break the conduit was 12 600 N, or **1.3 tonnes.**

Creation of a plastic hinge

The calculations were based on the tensile tests carried out on the shell plating which gave an elastic limit in tension of around 300 Mpa.

The calculations indicated that the force required to create a plastic hinge was **0.8 tonnes.**

Tearing of the shell plating on which the echo sounder shoe was mounted

The length of the breach, excluding the areas affected by fatigue cracking, was measured at 462 mm, giving a section to be sheared of 3 700 mm².

The calculations gave a value of 55 000 N, or 55 tonnes, as the force needed to initiate the tearing.

As the metallurgical analyses had revealed the progressive character of the brutal rupture, the force required to tear the plating outside the areas affected by fatigue cracking could be estimated as half that value, or **27 tonnes**.

Total force required to create the breach

It was the sum of the three forces calculated, namely **29.1 tonnes** rounded off to **30 tonnes.**

Deformation of the bows

Visual description (see photographs appendix F.2)

The deformation of the bows was first observed by the cameras of the mine disposal vehicle from the *ANDROMEDE* just after the accident, but only on the starboard side as the *BUGALED BREIZH* was lying on her port side. When the wreck was refloated the deformation was seen to be quasi-symmetrical on both sides of the vessel. At the demand of the investigators, the fish hold lining was removed, enabling them later to inspect the damage to the frames as well as the welds fixing them to the side shell and the pillars in the fish hold.

The deformations run from the bulkhead between the fish hold and the engine room, situated at Frame 20, to the collision bulkhead at Frame 35. They concern the upper and main decks, the side shell plating and the frames and floors on both sides in way of the fish hold and the double bottom below it, the tranverse bulkheads of the fish hold and the fishing loading hatch on the forward starboard part of the work deck as well as the keel. The shell plating was not ruptured. The aluminium deckhouse which contained the wheelhouse and the skipper's cabin, was slightly deformed at its base. It had lifted off the upper deck.

The keel

The solid bar keel formed an arc with a bow of about 30 cm between Frame 20 (amidships) and the stem which had kept its original shape.

The shell plating in way of the double bottom

The shell plating between the keel and the fish hold was deformed by about thirty centimetres; the extent of the deformation was limited by the double bottom tank top. It was not possible to gain access to the double bottom spaces.

The shell plating in way of the fish hold

The shell plating in way of the fish hold, between the tank top and the main deck, was deformed longitudinally between Frames 20 and 35, the plating having been pushed inwards by about one metre; the deformation was largely symmetrical on both sides. The frames were buckled and and their bottom brackets showed some twisting. A number of welds fixing the frames to the shell plating were broken. The pillars used in the stowage of the fish boxes were practically all buckled and their head and heel brackets were often detached. The deck beams were buckled. The tank top bulged upwards in the middle of the after half of the fish hold.

The main deck

The main deck sagged from Frame 20, corresponding to the bulkhead between the engine room and the fish hold, and showed a deflection of some thirty centimetres in the longitudinal axis. It also sagged transversely towards the vessel's centre line, the outer edge of the deck retaining to a large extent its original position. The vertical cylindrical pillars remained attached to the main deck and, for this reason, pulled apart the girder brackets, which led to the bending of the upper deck.

The main deck hatches

There were three hatches on the main deck :

- ✓ In the forward store forward of the collision bulkhead there was a hatchway with a coaming giving access to the forepeak below the main deck; this hatchway remained intact.
- ✓ In the fish hold, there was a hatchway with a 600 mm coaming in way of Frame 30, on the starboard side. It was used for stowing the fish and to go down into the fish hold when the vessel was at sea. When no fish were being dealt with, it was closed by a composite board made of plywood, foam and stratified polyester,

placed at deck level to maintain insulation, and by a metal cover placed on the coamings, which could be battened down with screw cleats.

The four walls of the coaming folded inwards until they touched in the middle of the hatchway. Bits of chain and trawl webbing were sucked into the fish hold. The metal cover was found in the fish hold. The composite board was not found; it probably disintegrated and its debris was confused with the insulation material when the hold lining was removed.

- ✓ There was a large hatchway flush with the deck on the vessel's centreline between Frames 26 and 28, used for unloading the fish and taking ice on board; it was kept shut at sea. Although it was involved in the process which led to the sagging of the main deck, it remained intact and the cover closed.

<u>The upper deck</u>

It was completely intact abaft the hatchway situated between Frames 26 and 28. Forward of this hatchway, the deck had crumpled transversely from Frames 29 and 30 on the port side to Frames 32 and 33 on the starboard side.

<u>The transverse bulkheads of the fish hold</u>

The *BEA*mer investigators were unable to examine the condition of the bulkhead in way of Frame 35 between the fish hold and the fore peak, which constituted the collision bulkhead, because it was too difficult to remove the lining in this particularly cramped space.

They were, however, able to examine the bulkhead between the engine room and the fish hold which showed a prominent bulge towards the bows. The bottom part of the bulkhead seemed to have remained intact.

Photogrammetric survey

The *BEA*mer had a photogrammetric survey of the whole surface of the vessel's structure carried out which enabled all the deformations to be accurately measured. The results were used to obtain models of the deformations of the hull, the main and upper decks and the keel.

Analysis of the structure (see appendix E.3)

The observations made of the damage sustained by the vessel led the *BEA*mer investigators to make the hypothesis that the fish hold was watertight when the *BUGALED BREIZH* sank. What led them to this conclusion was the position of the damage in way of the fish hold and the double bottom below it, the fact that the damage was symmetrical on both sides as well as the type of damage sustained by the hatchway to the fish hold on the starboard side forward. Calculations on the structure were therefore carried out on this basis.

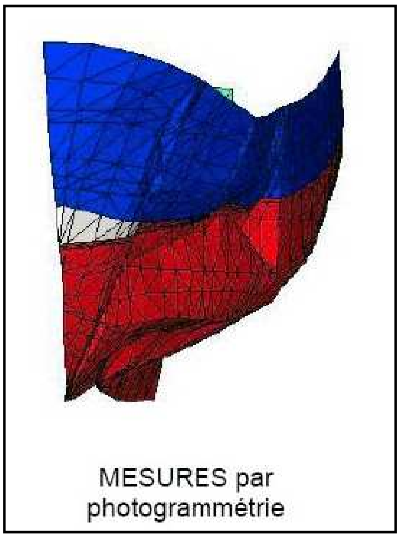
Modelling of the section of the hull corresponding to the fish hold was carried out using the general arrangement plan of the *BUGALED BREIZH* and the lines plans and other plans of the *DAMAFRAN* for information on the scantlings of the structure, as the lines plans and those containing structural information on the *BUGALED BREIZH*, were not able to be found because the shipyard which had built the *BUGALED BREIZH* had closed down. This did not constitute a problem because the *DAMAFRAN* was identical to the *BUGALED BREIZH*.

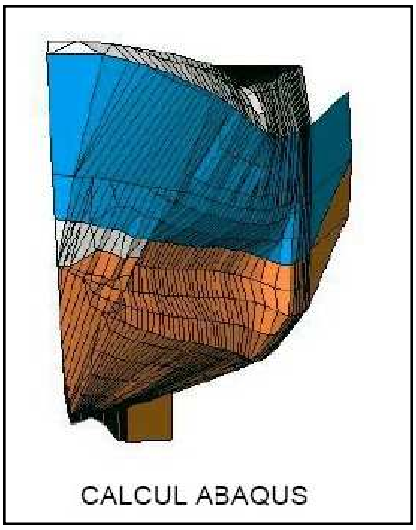
Polygon meshing of the fish hold section was carried out using software called ABAQUS. Working on the hypothesis that the fish hold and the double bottom below it were watertight, progressively larger pressures, representing the hydrostatic pressure exerted on the hull after it sank, were applied in a uniform manner.

To begin with, the pressure was gradually increased until it reached 10 bar. No depression or denting was noticed in the shell plating, but the stresses sustained greatly exceeded the elastic limit of the steel used in the construction of the *BUGALED BREIZH*.

Therefore, the possibility that the structural elements had suffered plastic deformation needed to be examined. In order to simulate this phenomenon, pressure was applied uniformly, then removed. When the pressure reached 4 bar, the permanent deformations observed when the pressure was removed were equivalent in all respects to those observed on the wreck.

These results were then compared to the measurements of the denting made by photogrammetry as translated into the ABAQUS format. The measurements of the denting made by photogrammetry of the wreck and the results of the calculations made using the original plans, by applying, then removing, a uniform pressure of 4 bar to the fish hold and the double bottom below it, were seen to be practically the same.

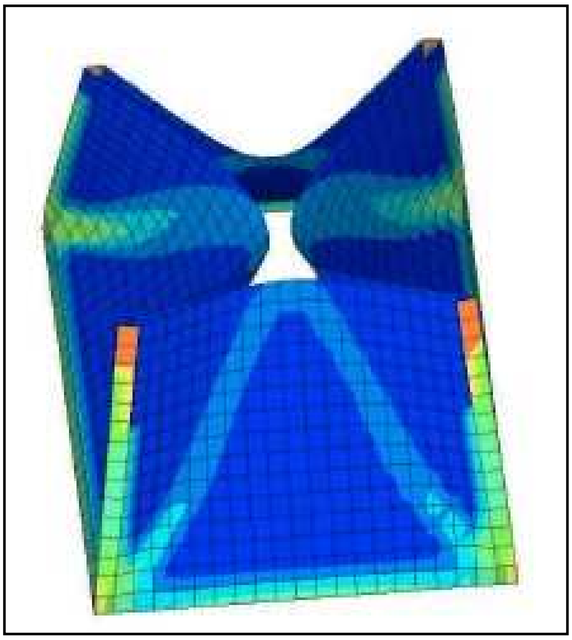




Deformation of the fish hold

Besides this, separate calculations were carried out on the deformation of the coaming around the fish-loading hatch because it would have been too complicated to include this element in the structure. Following the same method as for the calculations on the structure, the coaming was subjected to an internal depression. The simulated deformation was identical to what was observed in reality and occurred when the pressure reached one bar.

Deformation of the starboard fish hold hatchway



ABAQUS CALCULATION
Depression of 1 bar inside the coaming

Analysis of the structure showed that applying a uniform pressure to the fish hold and the double bottom below it produced identical deformations to those measured by photogrammetry of the wreck.

The *BEA*mer was, moreover, notified of three similar cases of deformation due to hydrostatic pressure by its British counterpart, the MAIB (*Marine accident investigation Branch*).

- F/V Pescado, 21.5 metres, 6 lives lost, report published in 1998 ;
- F/V Gaul, 57 metres, 36 lives lost, report published in 1999 ;
- F/V Solway Harvester, 19.4 metres, 7 lives lost, report published in 2006.

6.3 Stability calculations (see appendix E.4)

Calculations were made to determine the stability of the *BUGALED BREIZH* at the time of her sinking; a number of possibilities were considered :

- ✓ Fish hold flooded;
- ✓ Fish hold empty, progressive flooding of the engine room;
- ✓ Fish hold empty, progressive flooding of the crew's quarters;
- ✓ Fish hold empty, progressive flooding of the engine room and the crew's quarters;
- ✓ Sideways pull on a warp block for each of the above cases;
- ✓ Effect of taking water on the after main deck;
- ✓ Effect of the engine thrust and warp traction.

The calculations were made for static and dynamic conditions on the basis on an intact vessel with supplies corresponding to the halfway point in a two week trip, taking into account the fact that the vessel had not taken on supplies nor unloaded any fish during her stopover at NEWLYN just before the accident.

Details of the weights are given below :

- ➢ Diesel fuel (density = 0.85)

  - On departure : 36 000 litres, or 30.6 tonnes distributed as follows :

13 000 l under the fish hold, viz.	11.05 t;
21 000 l in 4 engine room bunker tanks, viz.	17.85 t;
2000 l in the daily tank, viz.	1.7 t.

  - On the day of the accident (consumption : 2000 litres per day)

10 000 l under the fish hold, viz.	8.5 t;
8 000 l in 4 engine room bunker tanks, viz.	6.8 t;
2 000 l in the daily tank, viz.	1.7 t.

- ➢ Oil (densty = 0.8)

Port tank : 250 l, that is to say	0.2 t;
Starboard tank forward : 440 l, viz.	0.3 t.

- Fresh water : 7,0 t.
- Fish : 12 t.
- Ice : 15 t.
- Trawl net : 1.13 t.
- Otter boards : 1.5 t.
- Warps : 3.38 t.
- Spares : 2.250 t.
- Crew : 3.75 t.
- Victuals : 0.07 t.
- Vessel light displacement : 134.75 t.

Vessel intact just before the accident

$Draught_{aft}$: 2.917 m $Draught_{Amidships}$: 2.729 m $Draught_{FWD}$: 2.541 m
Trim : 0.376 m
GMc = 0.781 m GZ_{MAX} = 0.258 m Freeboard = 2.814 m
Angle of downflooding : 54.0°

It can be seen that, at the time of the accident, the *BUGALED BREIZH* had good stability and easily satisfied the criteria of the stability regulations.

Intact static stability calculations

A number of different conditions of loading were studied : the intact vessel, with its supplies and equipment at the time of the accident, gradual flooding of the engine room, the fish hold and the crew's quarters, and finally the effects of a sideways pull on one warp on the intact vessel and with the engine room flooded. The value of the traction force – 3.2 tonnes – was chosen because it corresponds to the traction exerted on a warp during trawling operations, excluding any other traction forces. Obviously, the force exerted on a warp with a lateral component of 3.2 tonnes would be much greater : the choice of this value was therefore intended to take into into account an outside cause of the sideways pull such as snagging of the trawl net or the warps.

The table on the following page summarizes the static stability calculations for the different conditions of loading.

	Intact vessel	1 m of water in engine room	2 m of water in engine room	3 m of water in engine room	1 m of water in fish hold	2 m of water in fish hold	3 m of water in fish hold	1 m of water in crew's quarters	2 m of water in crew's quarters	Vessel intact with lateral traction of 3.2 tonnes to starboard	Engine room flooded + lateral traction of 3.2 tonnes to starboard
Displacement	196,83	201,4	218,73	238,7	203,61	232,23	269,82	206,04	233,79	200,03	267,06
$Draught_{fwd}$	2,583	2,604	2,711	2,828	2,766	3,510	4,460	2,499	2,195	2,516	3,009
$Draught_{aft}$	2,890	2,940	3,109	3,309	2,868	2,776	2,657	3,068	3,635	2,975	3,577
$Draught_{amidships}$	2,737	2,772	2,910	3,068	2,817	3,143	3,558	2,784	2,915	2,745	3,293
Δ	0,307	0,336	0,398	0,481	0,101	-0,734	-1,802	0,569	1,440	0,459	0,568
KG corrected	2,742	2,688	2,721	2,607	2,727	2,783	2,759	3,015	3,097	2,804	2,534
GM	0,781	0,835	0,774	0,872	0,790	0,718	0,629	0,500	0,316	0,728	0,951
GZ_{max}	0,409	0,445	0,389	0,424	0,416	0,356	0,309	0,198	0,031	0,334	0,372
Angle of GZ_{max}	47,8°	48,8°	43 ,1°	47,0°	48,1°	42,3°	30,1°	42,2°	34,3°	47,9°	44,7°
Area under curve (0 - 30°)	0,102	0,106	0,097	0,096	0,102	0,090	0,084	0,058	0,007	0,075	0,078
Area under curve (0 - 40°)	0,167	0,174	0,159	0,161	0,168	0,147	0,089	0,092	0,009	0,127	0,135
Area under curve (30 - 40°)	0,065	0,068	0,062	0,065	0,065	0,057	0,005	0,034	0,002	0,052	0,057
Heel at equilibrium	0,0°	0,0°	0,00°	0,7°	0,0°	0,0°	0,0°	0,71	3,6°	3,0°	1,8°
θ_f	52,8°	50,9°	43,1°	60,0°	51,0°	42,3°	31,0°	47,7°,	34,3°	50,9°	> 60°
θ_d	21,2°	21,2°	18,7°	25,2°	20,1°	18,1°	14,1°	17,9°	22,9°	22,4°	13,3°
Freeboard at after deck	0,763	0,718	0,558	0,329	0,724	0,401	-0,533	0,584	-0,144	0,532	0,013
Corresponding angle of downflooding	13,5°	12,6°	9,8°	6,4°	12,8°	7,2°	0,0°	10,9°	1,0°	12,3°	2,0°
Freeboard at coaming of crew's quarters	1,345	1,306	1,162	1,009	1.286	1,049	0,746	1,256	0,975	1,260	0,797
Corresponding angle of downflooding	52,8°	50,9°	43,1°	60,0°	51,0°	42,3°	31,0°	47,7°	34,3	50,9°	60,0°

For comparison purposes, the stability criteria for fishing vessels of less than 24 metres in length, according to present French regulations (section 211, Ministerial Order of 26th November, 2002), are:

Angle of downflooding θ_f : $\theta f \geq 40°$;

Angle of vanishing stability θ_S : $\theta_S \geq 60°$;

Area under the righting lever curve (GZ curve) [up to 40° angle of heel] : > 0.10 metre-radians

The righting lever GZ at an angle of heel equal to or greater than 30°: GZ > 0.25 m;

The maximum righting arm should occur at an angle of heel (θ) equal to or greater than 25°;

Initial metacentric height GM_o : GM_o > 0.45 m.

The criteria of the *Code on Intact Stability* of the International Maritime Organization (Resolution A.749 (18) as amended by Resolution MSC.75(69)) are :

Angle of downflooding θ_f : not specified;

Angle of vanishing stability θ_S : not specified;

Area under the righting lever curve (GZ curve) [up to 30° angle of heel] : > 0.055 metre-radians;

Area under the righting lever curve (GZ curve) [up to 40° angle of heel or $\theta_{f,}$ if $\theta_f < 40°$] : > 0.09 metre-radians

Area under the righting lever curve (GZ curve) [between 30° and 40° angle of heel or between 30° and $\theta_{f,}$ if $\theta_f < 40°$] : > 0.03 metre-radians.

The righting lever GZ at an angle of heel equal to or greater than 30° : GZ > 0.20 m;

The maximum righting arm should occur at an angle of heel (θ) equal to or greater than 25°;

Initial metacentric height GM_o : :GM_o > 0.35 m.

The following symbols/abbreviations were used

$Draught_{FWD}$: draught forward;

$Draught_{AFT}$	:	draught aft;
$Draught_{AMIDSHIPS}$	:	Draught amidships;
Δ	:	displacement of vessel;
KG	:	height of centre of gravity above baseline;
GM_o	:	initial transverse metacentic height;
GZ	:	transverse righting lever;
GZMAX	:	maximum righting lever;
GZMAX Angle	:	angle of inclination for which the righting lever is maximum;
Area (0 – XX°)	:	area under the righting lever curv e for angles of inclination between 0° and XX°;
θ	:	angle of inclination;
θ_s	:	angle of vanishing stability;
θ_f	:	angle of downflooding;
θd	:	critical angle of dynamic stability. (angle of semi-permanent heel)

Damage stability calculations

The static stability calculations with one compartment flooded were carried out on the basis of Regulation 8 of Chapter II–1 of the SOLAS Convention which concerns the stability of passengers ships in damaged condition. This regulation does not, of course, apply to fishing vessels but provides a method and criteria which can be used as a starting point for calculations.

	Engine room flooded	Fish hold flooded	Engine room flooded + 1 m of water in the crew's quarters	Engine room flooded + 1.5 m of water in the crew's quarters	Engine room flooded + 2 m of water in the crew's quarters
Displacement	196,43	196,83	206,04	219,50	233,79
$Draught_{FWD}$ (damaged)	2,932	5,759	2,861	2,096	-0,106
$Draught_{AFT}$ (damaged)	3,468	2,448	3,668	5,068	8,916
$Draught_{AMIDSHIPS}$ (damaged)	3,200	4,103	3,265	3,582	4,405
∆ (Trim)	0,536	-3,311	0,807	2,972	9,022
(intact) KG	2,742	2,742	3,015	3,102	3,097
Heel at equilibrium θ_e	1,8°	0°	- 2,2°	- 12,6°	- 7,6°
Angle of downflooding	> 60°	18,0°	> 60°	59,0°	0,0°
GM	1,095	1,277	0,686	0,114	0,048
GZ >0 range	58,23°	18,0°	57,8°	38,9°	-7,6
GZ_{MAX} [θ_e-60°]	0,500	0,383	0,243	0,084	- 0,012
Area under curve [θ_e-22°]	0,054	0,063	0,024	0,002	0,000
Freeboard at after deck	0,118	-1,810	-0,068	-2,188	-6,170
Corresponding angle of downflooding	3,8°	0,0°	1,1°	0,0°	0,0°
Freeboard of crew's quarter's coaming	0,893	0,361	0,809	0,474	-1,093
Corresponding angle of downflooding	60,0°	18,0°	60,0°	59,0°	0,0°

The criteria required by Regulation 8/II-1 of the Solas Convention are :

Angle of equilibrium θ_e : must not exceed 7°

GZ >0 range : the range (expressed in °) of the pos itive residual righting lever curve beyond the angle of equilibrium : it must be more than 15°

GZ_{max} [θ_e-22°]: maximum righting lever calculated within the range of positive stability; must be more than 0.1 m ;

Area under curve [θ_e-22°] : Area under the righting lever curve between the angle of equilibrium θ_e and 22° (one compartment flooded), or the angle of downflooding; it must be greater than 0.015 metre radians.

GM : the residual metacentric height must be greater then 0.05 m.

Static stability calculations taking into account engine thrust and snagging of the trawl net on the seabottom

Further calculations were made to complete the static stability calculations and take into account the couple of forces created by the thrust of the engine and a dissymmetrical traction on the warps.

In order to calculate the engine/snagged trawl net couple, it was assumed that the engine was at 80% of its maximum power giving it a thrust estimated at 7 tonnes. Traction on the port warp, which was considered to have burrowed into the seabed, was estimated at 9 tonnes, in line with the results of tests made on vessels which were identical to the *BUGALED BREIZH* in size and power.

The results of these calculations are given below.

Displacement	:	203.01 t;
$Draught_{FWD}$	:	2.471 m;
$Draught_{AFT}$	:	3.038 m;
$Draught_{AMIDSHIPS}$	:	2.755 m;
Δ (Trim)	:	0.567 m;
Corrected KG	:	2.832 m;
GM	:	0.729 m;
GZ_{MAX} [θ_e – 40°]	:	40°
Area under curve [0°-30°]	:	0.043
Area under curve [0°-40°]	:	0.081
Area under curve [30°-40°]	:	0.038
Angle of equilibrium θ_e	:	8.4°
θ_f	:	11.4°;
θ_d	:	22.3°;
Freeboard at after deck	:	0.172
Corresponding angle of downflooding		11.4°
Freeboard of crew's quarters coaming		0.772

In order to take into account the flooding of the after deck and the ensuing free surface effect, the calculations were made using the same method as that used for dredgers. A height of water of 0.5 metres was considered, corresponding to a weight of 11.05 tonnes, with a slurry density of 1.025 t/m^3, as was a water height of 1 metre respresenting a weight of 20.88 tonnes. The table summarizes the results :

	Vessel intact + effect of engine/snagged trawl + 0.5 m water on after deck	Vessel intact + effect of engine/snagged trawl + 1 m water on after deck	Effect of engine/snagged trawl + 1 m of water on after deck + crew's quarters flooded
Displacement	209,86	218,38	209,75
$Draught_{FORWARD}$	2,168	2,117	0,589
$Draught_{AFT}$	3,315	3,375	6,738
$Draught_{AMIDSHIPS}$	2,742	2,746	3,663
Δ (Trim)	1,147	1,258	6,149
Corrected KG	2,839	2,904	2,874
GM	0,332	0,340	1,430
GZ_{MAX}	0,335	0,335	0,059
Angle at which GZ_{MAX} occurs	48,7°	48,7°	60,0°
Area under curve (θ_e -30°)	0,052	0,052	0,004
Area under curve (θ_e -40°)	0,100	0,100	0,021
Area under curve (30-40°)	0,048	0,048	0,016
Angle of equilibrium θ_e	5,9°	6,0°	24°
θf	50,0°	50,0°	60,0°
θ_d	25,3°	25,4°	40°
Freeboard at after deck	0,067	-0,008	-4,774
Corresponding angle of downflooding	7,6°	5,7°	/
Freeboard at crew'e quarter's coaming	1,132	1,113	/
Corresponding angle of downflooding	50,0°	50,0°	/

Taking into account the weather criteria in IMO Resolution A.562 (14), a rolling period of 9.5 seconds and an angle of roll of 24° is obtained in both cases.

It will be noticed that, in both these cases, the curves, although different at their origins because of the difference in displacement, rapidly become almost identical : due to the heeling, the surplus water is evacuated.

Conclusions of the static stability study

According to the static stability study, the vessel suffers a complete loss of stability if the fish hold is flooded. The righting lever curve (GZ) remains below the abscissa. This hypothesis cannot be retained because, as the analyses of the structure described in Chapter 6.2 showed, the fish hold was wateright.

Paradoxically, flooding of the engine room means that stability values are maintained at values comparable to those of the intact condition. When the height of water reaches two metres, the free surface effect is considerable but it then lessens, as the water level rises, because the companionway stairwell giving acces to the engine room, reduces the free surface of the water. In respect to static stability, if only the engine room is flooded, the vessel's stability is not compromised although the freeboard is reduced without, however, jeopardizing buoyancy.

If progressive flooding of the crew's quarters is added to flooding of the engine room, the stability quickly deteriorates. The metacentric height GM is reduced, as well as the freeboard to the deck line at the after deck and the corresponding angle of downflooding. The probability of downflooding through the companionway to the crew's quarters becomes much geater and the process becomes irreversible.

The effects of sideways traction on one warp were investigated. To this end, a force with a horizontal component of 3.2 tonnes was applied to a warp block. This corresponds to a tension on the warp of 3.5 tonnes which was the usual traction force for the *BUGALED BREIZH.* The resulting moment was 15.546 tonne-metres.

A 3.2 tonne sideways force applied to the intact vessel leads to a marked reduction in the metacentric height GM, a considerable lowering of the righting lever curve GZ and the under curve areas compared to the same values for the intact vessel. The values obtained fall well short of the criteria required by current regulations.

The critical angle of inclination for dynamic stability is 22.4°. Freeboard at the deck line is 0.532 m with a corresponding angle of downflooding of 12.3°.

If a sideways force of 3.2 tonnes is applied to the vessel with the engine room flooded, there is a substantial increase of the initial metecentric height. But the righting lever curve is lower and the under curve areas become smaller.

The angle of equilibrium is 5.692°, the critical angle of inclination for dynamic stability is 13.3°. The freeboard at the deck line is now only 0.013 m, increasing the risk of downflooding on the after deck and in the crew's quarters leading to a rapid deterioration of stability.

The combined effect of the engine couple and a traction force of 9 tonnes on the port warp results in a deterioration of all the stability criteria – righting levers, under curve areas -

compared to the intact vessel condition : the angle of equilibrium is 8°. Freeboard at the after deck is no more than 17 centimetres.

Adding the factor of shipping water on the after deck to the engine/warp traction couple shows that, with 50 centimetres of water, the under curve areas become quite small. Freeboard at the after deck is 7 cm and the angle of downflooding 8°. The freeboard of the crew's quarter's coaming is 1.1 m.

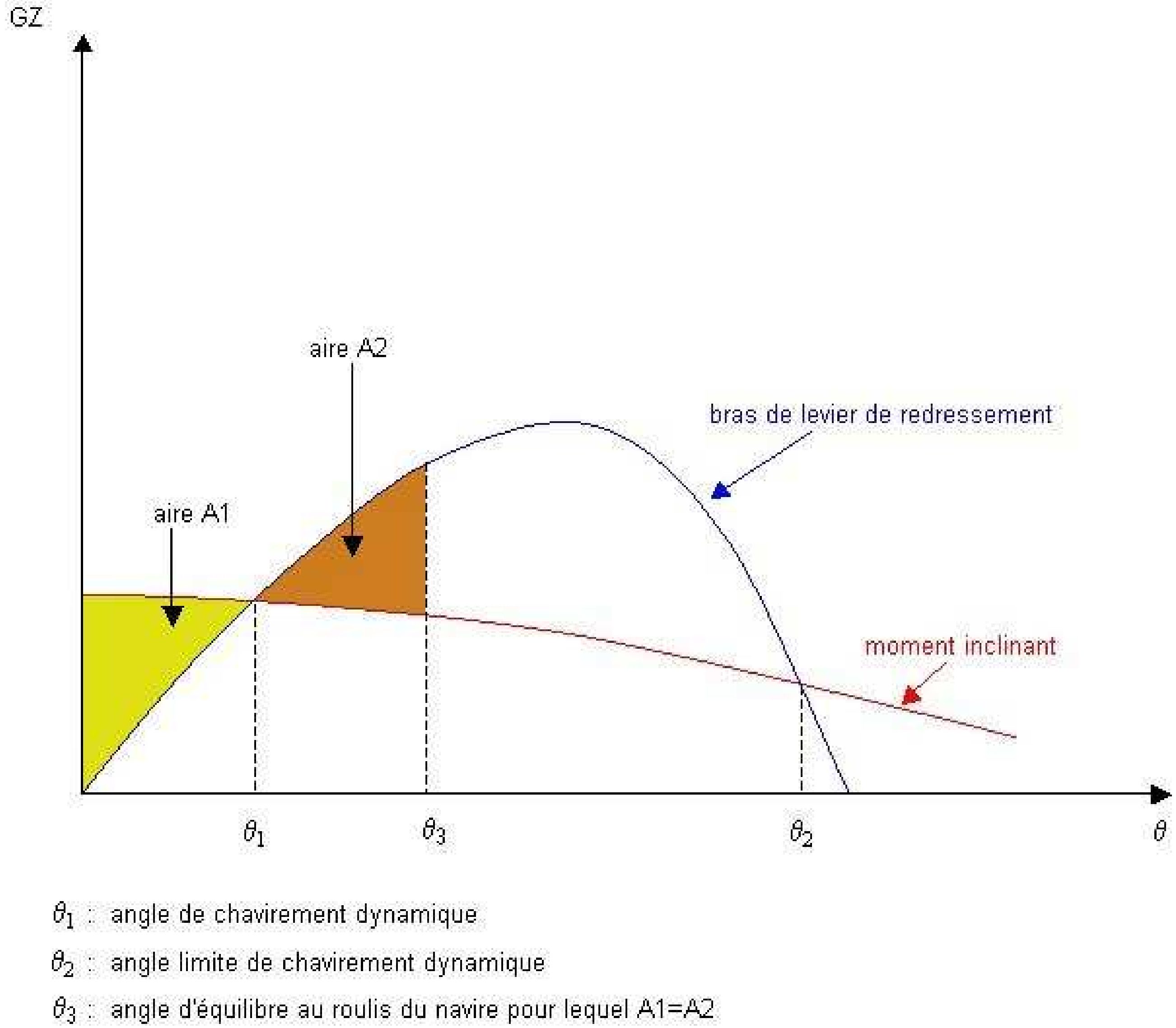
In these conditions, downflooding of the crew's quarters leads to the loss of the vessel : the area under the righting lever curve is practically flat. The after deck is submerged with a negative freeboard of almost 5 metres.

As a conclusion to the studies of static stability, it can be seen that downflooding of the engine room does not result in the vessel's sinking. For this to happen, it must be accompanied by downflooding of the crew's quarters which rapidly deteriorates the stability parameters until there is a total loss of stability and buoyancy.

Application of a sideways force by a warp reduces the vessel's stability without compromising it. The value chosen for our study, which corresponds to the normal traction value when the vessel was working, keeps the parameters within the criteria imposed by the rules.

If the couple set up by the thrust of the engine and a sideways pull on a warp is considered, the stability criteria, notably the areas under the righting lever curve, decrease compared to those of the vessel in itact condition. The phenomenon is amplified if water is shipped on the after deck. The free board at the after deck rapidly decreases, making downflooding of the crew's quarters possible, leading to foundering of the vessel.

Dynamic stability calculations



GZ = GZ Aire A1 = Area A1 Aire A2 = Area A2, Bras de levier de redressement = righting lever, moment inclinant = heeling moment

θ_1 : first intercept (static angle of heel)

θ_2 : second intercept

θ_3 : angle of equilibrium of rolling for which A1=A2

The calculation consists in plotting the heeling moment curve using M = Mo x cosθ, where Mo is the moment of the upright ship and θ the angle of heel, so that area A1 between the righting lever curve GZ, the heeling moment curve and the ordinate axis up to the pont where the two curves intersect, is equal to area A2 between the righting lever and heeling moment curves from this point of intersection, which is called the first intercept or static angle of heel. Dynamic capsizing occurs when the area to the right of the static angle of heel becomes smaller than the area to its left, that is to say, when the work done by the righting lever is less than the work done by the heeling moment.

The dynamic stability calculations were carried out in order to find out how much sideways traction was required to capsize the vessel with the door to the crew's quarters assumed to be closed, to cause downflooding of the crew's quarters with its door assumed to be open, first with the vessel having intact stability, then with the engine room and steering gear compartment flooded. They were made assuming an average wind speed of 30.5 knots.

The results of these calculations can be summarized as follows :

- ✓ Vessel intact, door to crew's quarters closed : traction T = 19.56 tonnes;
- ✓ Vessel intact, door to crew's quarters open : traction T = 14.91 tonnes;
- ✓ Engine room and steering gear compartment flooded, door to crew's quarters closed : traction T = 25.27 tonnes
- ✓ Engine room and steering gear compartment flooded, door to crew's quarters open : traction T = 20.27 tonnes

Both cases in which the door to the crew's quarters was closed, were discarded as the door was found open (see paragraph 6.10 below).

Regarding the two cases in which the door to the crew's quarters was open, the tensile stresses fall well short of the breaking strain of the warps. This shows that a sideways traction alone of between 10 and 15 tonnes on one warp can give rise to a situation in which dynamic capsizing may occur.

Analysis of seakeeping behaviour

The *BEA*mer investigators completed their analysis of the stability of the *BUGALED BREIZH* by an analysis of her seakeeping behaviour, based on an assessment of the weather conditions carried out by Méteo France (see appendix C).

Taking into account the swell conditions given by the weather analysis, the roll period of the vessel was calculated to be about 5 seconds, which would have been roughly half that of the sea swell and the waves which were practically identical, while a figure of between 33° and 42° was obtained for the roll ampli tude on both sides, taking a roll damping coefficient of between 1 and 2 compared to rolling in a calm sea.

There is still uncertainty about the minor consequences that the different conditions of loading would have on the maximum angles of heel and on the choice of the damping coefficient.

The investigators therefore decided to retain the results obtained for the roll period and roll amplitude, which seem to be realistic, but not to take the analysis further by carrying out tests on a model in a testing tank, which would have been a long and complicated process for what would probably have been very unconvincing results.

Conclusions on stability

At the time of the accident the vessel had good stability and met all the regulatory stability criteria.

Downflooding of the engine room does not lead to a reduction in the vessel's ability to right herself, but in buoyancy by decreasing the freeboard aft.

Downflooding in the crew's quarters leads to a rapid deterioration of stability, with the areas under the righting lever curve becoming substantially smaller.

The same is true if a sideways traction force is applied to a warp.

The effect of the couple exerted by the engine and the propeller producing thrust ahead and the trawl net snagged on the bottom, causes a reduction of the areas under the righting lever curve. Shipping water on the after deck amplifies this phenomenon and reduces the freeboard at the after deck.

The effect of the sea conditions would be to set up heavy rolling thereby increasing the likelihood of water being shipped on the after deck, followed by downflooding of the crew's quarters. Moreover, the impact of the waves on the port side of the vessel would produce kinetic energy which would partly counteract the work of the righting moment. They would therefore contribute greatly to the loss of stability.

6.4 Analysis of the fishing gear

Winches and net drums (see photographs appendix F.3)

Inspection of the wreck showed that the two winches were declutched with the clutch jaws aligned.

The starboard winch cable guide was not aligned with the warp on the drum and there were several overlaps in the warp coiling.

When the divers working on the refloating operation entered the wheelhouse they observed that the port winch brake lever on the winch control console was in the "off" position (see diagram and photograph in appendix F.3).

The trawl rig

The condition of the trawl rig was analysed using the underwater images and completed by a visual inspection on shore. A metallurgical analysis of the ends of the warps on the otter board side was carried out. In addition to the analyses made by the *BEA*mer, an analysis of the trawl rig and a metallurgical analysis of the warps was carried out within the framework of the judicial inquiry and their conclusions, contained in two separate intermediate reports, were made available to the *BEA*mer.

Preliminary note

The observations detailed below were made by viewing the underwater video footage shot by the mine disposal vehicle (MDV) from the *ANDROMEDE* on 18th January 2004, on the one hand, and by the divers and ROV from the STOLT company's vessel *DISCOVERY* on 21st and 23rd June 2004 just before they commenced the refloating operations, on the other hand. It is important to note that the shots of the trawl rig made by the *ANDROMEDE* were intended to determine whether the trawl rig could reveal an obvious cause of the accident, snagging of the net or other such cause, and not to show the rig in detail. The images taken by STOLT were made in order to make an as found survey of the wreck before commencing the refloating operations using material and equipment far better suited to this type of operation (Rov and divers).

However, between the two sessions of filming, conditions had evolved considerably : the images taken by the *ANDROMEDE* three days after the accident, showed a relatively flat seabed with low ridges. Those taken by the STOLT teams from the *DISCOVERY* more than six months after the accident, showed to what extent the seabed relief had changed, with far more conspicuous ridges; they also showed that the wreck and the trawl gear had been snagged by other trawl nets.

The method used was therefore to base the analysis mainly on the underwater videos from the *ANDROMEDE* and to confirm, complete and clarify it using the underwater videos from the *DISCOVERY* whenever it was deemed necessary.

Furthermore, the *BEA*mer investigators made a 1:100 scale model of the trawl rig. This enabled the arrangement of the trawl rig in normal usage to be compared with that of the trawl net lying on the sea bottom, as shown by the analysis the underwater videos. This made it easier to determine how each part the rig moved when the accident happened and to deduce what effect these movements would have had on the vessel itself.

General arrangement (see diagram in appendix E.1)

The general arrangement of the site shows that the wreck was lying on the sea bottom with her bows towards the south east. The trawl net was lying roughly in a southwest – northeast direction. The distance between the mouth of the trawl and the stern of the *BUGALED BREIZH* was 415 metres.

Inspection of the trawl net

The underwater images showed that the spread of the trawl net was smaller than in normal operation, the two upper wings being only a few metres apart. The three way connection of the trawl net had burrowed into the seabed. The foot rope fitted with bobbins was lying on the seabed. The tickler chain could be seen a little further back. The headrope was floating above the mouth of the trawl net, the vertical opening of which seemed to be about two metres higher than usual. The cod end was partially nested in the mouth of the trawl net. The webbing of the port upper wing and along the port wing line was torn. The same damage was also observed on the starboard side.

Inspection of the bridles and trawl doors (see photographs in appendix F.4)

The ballast chains connecting the trawl three way connection to the lower bridles were completely buried in the seabed on the starboard side, while on the port side most of the shackles just emerged from the seabed.

The upper bridles of the trawl net were buried under the seabed for a distance of about thirty metres from the trawl wings. Lower and upper bridles were then visible up to the trawl doors.

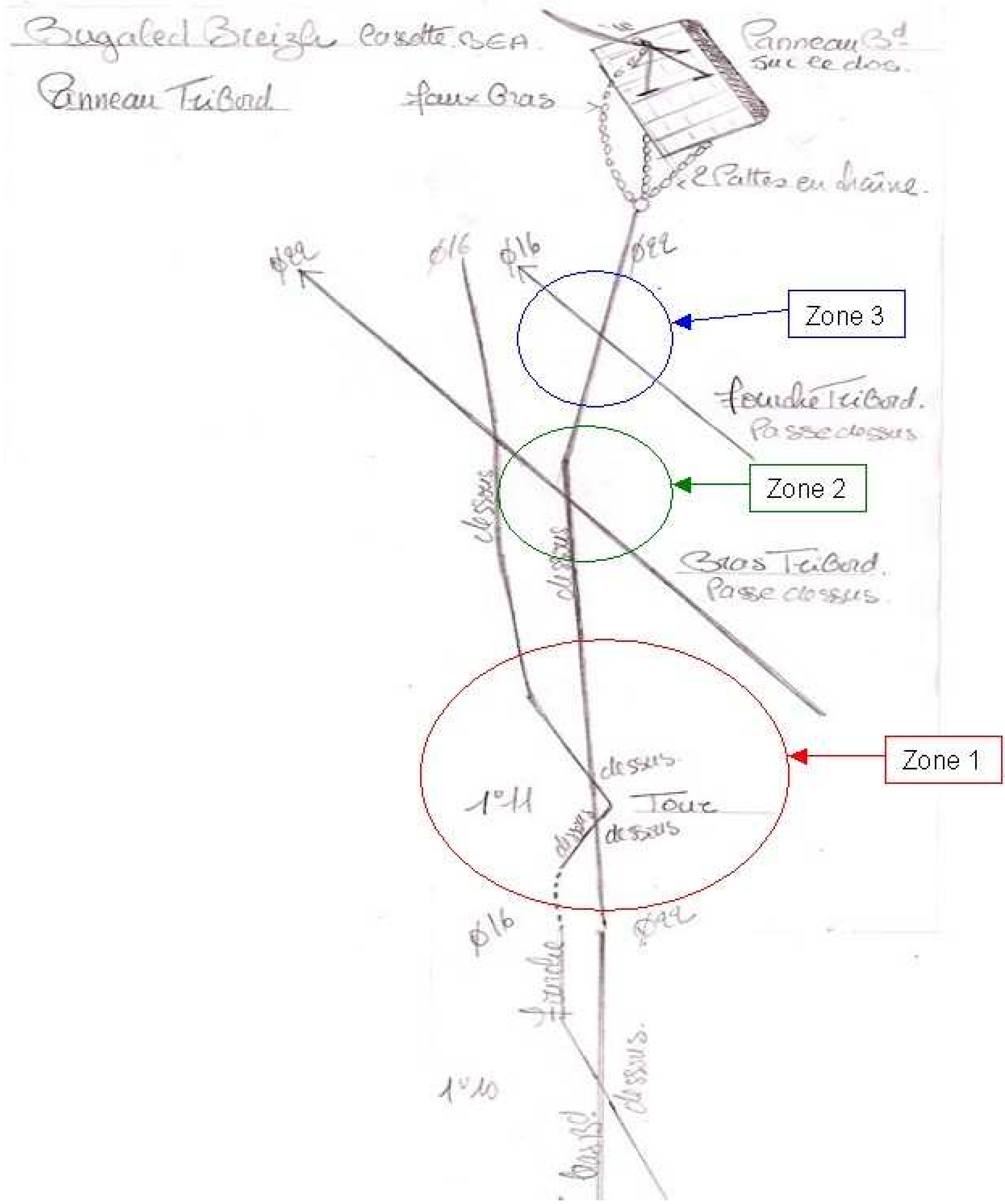
On the port side, the upper bridle (diameter 16 mm) can be seen passing over the lower port bridle (diameter 22 mm). After moving parallel to it away from the trawl net, it crosses over the lower bridle twice, in succession, forming a V-shape.

If we continue to follow the lower port bridle, the lower starboard bridle can be seen crossing over it. In order to draw their conclusions, the *BEA*mer investigators had screen captures made from the underwater video sequences; the way they went about interpreting the images deserves an explanation.

It can be seen that the light from the floodlight of the MDV from the *ANDROMEDE* illuminates the right hand side of both cables, while the left hand side remains dark. The lower port bridle, which is partially buried on either side of the crossover, throws practically no shadow on the bottom on its left hand side before the crossover; the shadow disappears completely after the crossover. The starboard bridle, on the other hand, coming from the right hand side of the bottom of the image, throws a shadow on the bottom which deepens as it gets nearer to the crossover, then decreases until it disappears when the cable buries itself in the bottom : as the height of the starboard bridle above the bottom is proportional to the surface area of the shadow it throws on the bottom, this proves that the lower starboard bridle passes over the lower port bridle.

The same reasoning can be applied for the passage of the lower starboard bridle over the upper port bridle, then as we move towards the port trawl door, examination of the video shows us that the upper starboard bridle, in turn, crosses over the lower port bridle.

The following sketch indicates the position of the fork legs and bridles as observed after examination of the video footage shot by the *ANDROMEDE.*



Area 1 :

A photograph of this area can be seen in appendix F4; on it, the port fork leg can be seen as it passes under the port bridle towards the right, it then immediately turns back under the bridle and runs parallel to it. The video film shows that the fork leg passed over the bridle 1 or 2 metres before this, looking towards the trawl net; no images were captured of this sequence. The way the port fork leg and bridle are positioned shows that the port otter board flipped over before coming to rest on the bottom with the shackling arms uppermost.

Area 2 :

A photograph of this area can be seen in appendix F4. It shows the starboard bridle crossing over the port bridle. On the left hand side of the photo, the port fork leg can be seen; further on in the video film the starboard bridle can be seen crossing over it. This photo also shows that there was a slope on the sea bottom at this point, rising towards the top of the photo.

Area 3 :

A photograph of this area can be seen in appendix F4. The starboard fork leg crosses over the port bridle.

As a conclusion to this analysis, it seems evident that the starboard otter board passed over the port otter board which had itself flipped over before settling on the bottom.

For the bridle and starboard otter board to have passes over the port bridle, the arms of the port fork need to have closed.

The boards were found lying flat on their reverse sides, with the starboard board lying about 5 metres ahead of the port board. The attachment bracket of the port board seemed to be slightly deformed.

Inspection of the forks and warps

Moving away from the boards towards the vessel, at the point where the upper bridle and lower leg of the starboard fork come together, the upper bridle is seen to be stretched tight while the lower leg is slack.

Although the video does not show the warps all the way up to the vessel, the following observations can be made :

Up to the trawl doors, the trawl rig is orientated practically in a straight line in a southwest/northeast direction; beyond that it describes a wide curve and ends up pointing towards the southeast.

The starboard warp is stretched tight over the whole distance.

The port warp, on the other hand, shows three series of wide loops in three different places, the last of which is just astern of the vessel. On the wreck itself, the warp goes up from the sheave, over the gantry and comes down again to starboard of the transom.

The two warps follow largely parallel trajectories with the port warp regularly crossing over the starboard warp.

Analysis of the warps (see appendix E.5)

As well as being examined in the underwater videos, the trawl rig was closely inspected on shore after the vessel had been refloated. The warps, in particular were the object of expert analysis; the *BEA*mer asked the Laboratoire Central des Ponts et Chaussées (LCPC) (October 2004) to carry out one such analysis while a second was ordered by the judge conducting the judicial inquiry from the Laboratoire National de Métrologie et d'Essais (LNE) (April and July 2005).

It must be remembered that the warps had spent six months in sea water at the bottom of the sea before being brought to the surface, after being cut at the stern of the *BUGALED BREIZH*. They were stored in the open air at the Brest Naval Base where they were handled several times during visual inspections in which they were laid out on the tarmac surface of a parking area, and pieces of them were taken as samples for laboratory analysis. All this handling may therefore have modified their condition compared to what it was at the time of the accident.

Analysis of the LCPC

The warps were uncoiled and laid out on a flat surface where they were inspected visually in the presence of the technical manager of their manufacturer, the owner of the vessel, an engineer from the Laboratoire Central des Ponts et Chaussées (LPCP) and the *BEA*mer inspectors.

Before they were examined, the warps had been measured by the Brigade de recherche de la Gendarmerie maritime, who were in charge of the judicial inquiry. The starboard warp was 375 metres long. The port warp, on the other hand, was 515 metres long, which is abnormally long for bottom trawling in 90 metres of water, and represents a difference of 140 metres compared to the starboard warp.

There were areas with broken wires in some strands or signs of crushing on both warps. There was no kinking, which would have been an indication of abnormal tension. There was a broken strand on the starboard warp about 10 metres from the connector linking the warp to the upper bridle and fork leg. No visible traces of paint were observed during this inspection.

About twenty metres of cable were cut from the ends of the warps nearest the boards and were taken for metallurgical analysis in a laboratory. The *BEA*mer investigators did not ask for an analysis of the chemical composition of these elements to be made as it was not deemed necessary following the visual inspection of the two warps.

The damage observed on the two elements were : crushing of the cable, broken wires, the presence of wires from the first internal layer between the wires of the outer layer and a broken strand (starboard warp).

The general conclusions of this analysis are as follows :

"The condition of the ends of the trawl warps of the BUGALED BREIZH does not demonstrate that the origin of the most visible deterioration (broken strand) affecting the starboard warp was some unexpected outside event. The warps show ordinary wear and tear without excessive stress."

Analysis made by the LNE

Within the framework of the judicial inquiry, an analysis of the trawl rig was carried out on the basis of the underwater videos and the visual inspection of the warps on shore. The appointed surveyor asked for an in-depth analysis to be carried out on one area of the port warp between 117 and 362 metres from the trawl door (taking into account the 23 metres which had already been removed from the port warp), that is, a length of 245 metres.

The analysis brought to light a certain number of permanent distorsions or kinks, the largest of which extended over 25 cm and was situated 125 metres from the trawl door end of the warp. A group of kinks extending between 7 to 15 cm was observed between 299 and 324 metres from the trawl door end.

It also revealed a number of defects : crushed, broken or twisted wires, mainly found between 115 and 220 metres.

The areas affected by the kinking and the other defects overlapped.

A qualitative analysis showed mineral particles in the areas affected by the anomalies, originating from outside the cable, which showed traces of the following elements : sodium, calcium, magnesium, chlorine, sulphur, titanium and potassium. It concludes that the presence of these elements can be explained by the prolonged immersion in seawater, except for the titanium, for the presence of which no explanation was found.

Titanium in the form of titanium dioxide is widely used as a pigment. The supplier of the paints used on board the *BUGALED BREIZH* confirmed to the *BEA*mer investigators that the paints used (white for the superstructures, blue for the deadworks and grey for the winches), contained, like many others, titanium dioxide as a pigment. Because of its opacifying properties the thickness of the coats of paint can be reduced without the undercoating showing through.

The origin of these traces may therefore come from several possible sources and for this reason their presence in such small quantities does not enable any significant conclusions to be drawn about what actually caused them.

A visual inspection of the starboard warp was carried out by the LNE. It revealed areas with anomalies (broken or crushed wires) in roughly the same places as the port warp. The same is true for the areas affected by kinking, although they are smaller and fewer in number.

6.5 Inspection of the engine and its controls, of the propeller and gland (see photographs in appendix F.5)

The sea water cooling circuits of the engine were tested at the sea water inlet valve and inspected visually; there was no possibility that the engine compartment could have been flooded by water from these circuits.

The position of the engine control lever in the wheelhouse showed that the engine was running, with the clutch engaged. It must therefore have been running at 750 rpm.

A visual examination of the propeller was made by the technical manager of a propeller manufacturing company.

The position of the blades showed that the pitch was set for ahead running.

Comparison of the underwater videos taken by the MDV from the *ANDROMEDE* and by STOLT show that the damage to the propeller blades and nozzle was sustained during the first attempt at refloating the vessel.

There is no possibility that the propeller was blocked by distorsion of the nozzle due to an outside shock or by a foreign body wedged between the blades and the nozzle.

The presence of a polypropylene rope around the propeller shaft would have had no consequences on the rotation of the propeller or the watertightness of the stern tube.

Inspection of the stern tube stuffing box in the engine room showed that there could not have been any ingress of water at this point.

6.6 Inspection of the steering gear

The rudder trunk gland was inspected by dismantling the gland ring and removing the first rounds of packing. This led to the conclusion that the steering gear compartment could not have been flooded via the rudder stock.

The underwater videos from the MDV from the *ANDROMEDE* show that the rudder was practically in the midships position when the wreck was lying on the bottom. But there was no way for the investigators to know exactly what position it was in, in the moments immediately preceeding the accident, notably what action the automatic pilot might have had.

6.7 Inspection of the bilge pumping system and the water level alarms

Bilge pumping system

The *BEA*mer investigators had the floor of the crew's quarters taken up so that they could find out exactly where the bilge pipe from the steering gear compartment ended, as the plans and diagrams they had were ambiguous about this point.

They observed that the bilge drain led to the after starboard part of the engine room at the level of the reduction gear. It was fitted with a plug valve, operated by a lever. The valve was found open.

All the plug valves on the bilge pumping system manifold in the forward port side of the engine room were found closed.

Water level detectors

A survey of the water level alarm system was entrusted to a specialist company.

Both water level detectors in the engine room were tested.

As regards mechanics, the float in the forward bilge well was found to be lightly jammed without, however, being damaged : this can be explained by the fact that the suction pipe in the bilge well had been pushed out of position when the bulkhead between the engine room and the fish hold was deformed after the vessel sank. This defect was therefore a consequence of the accident, there being no other reason for the float not to move freely.

As regards electricity, resistances of 50 kΩ (float raised) and 2 kΩ (float down) were measured whereas they should have been ∞ and a few ohms respectively. The reason for this was the prolonged immersion in sea water.

The detectors were thus working correctly at the time of the accident.

The control panel for the water level alarms in the wheelhouse was examined, as were the installation diagrams. It was possible to verify that the installation, which was protected by a fuse, received power from the emergency 24 V batteries and operated on the "passive security" principle. The "level alarm" switch on the console only cuts off the power supply to the siren. It was found in the "ON" position.

It was not possible to check the warning lights due to length and depth of their immersion.

The siren was dismantled. It could not rotate because it was obstructed by sea shells. When its casing was opened, the positive cable was seen to be solidly soldered at its cable terminal and motor ends. The negative cable, on the other hand, was solidly soldered at the motor but had become unattached at the cable terminal.

The failure of this element cannot be attributed to the shock of the vessel falling on to the sea bottom, because, in that case, other soldered joints, or all of them, would have broken apart.

<u>It can therefore be stated, without any great risk of error, that the water level detection system could function with visual, but not audible warnings.</u>

6.8 Inspection of the radio navigation aids

One of the two radars was set on the 4 miles range scale, the other on 12 miles.

The two VHF sets were found tuned to Channels P2 (interstitial channels outside Appendix 18 of the Radio Regulations) and 71 (reserved for port operations and ship movements by the Radio Regulations). The selector for Channel 16 or for double watch was in the "OFF" position on both sets.

6.9 Inspection of the lifesaving appliances

The starboard inflatable liferaft was released and inflated automatically after the correct functioning of the hydrostatic release unit when the vessel sank. It was found adrift on the day of the accident.

The container of the port inflatable liferaft was found on the sea bottom alongside the *BUGALED.BREIZH*, on her port side, slightly further forward than its cradle. It was intact, about 5 metres of the painter were uncoiled and it seemed to have been made fast to a stanchion. The weak link on the hydrostatic release unit was intact.

6.10 Open/closed status of the doors on the main deck

The following observations were made from the bows moving aft towards the stern :

- ✓ The door to the forward store was open:
- ✓ The door to the mess on the port side was open; this was of little import because the mess had no companionway going below main deck level.
- ✓ The door to the Chief engineer's cabin and the engine room, which had a 600 mm coaming, was probably closed with the dogs engaged but not screwed down tight, and was therefore not watertight. This conclusion is based on comparison of the deformations of the edges of the door and its frame on the wreck. The STOLT divers mentioned that engine room access was obstructed by rollers. These rollers fold back up level with the doors to the engine room and the crew's quarters so that they can be opened.
- ✓ The door to the crew's quarters, with a 600 mm coaming, was found tied open with ropes;
- ✓ The door of the engine room escape hatch / halon storage compartment, with a 600 mm coaming, was closed and dogged down;
- ✓ The sliding breakwater door, flush with the main deck, between the after deck and the work room, was found held open by ropes.
- ✓ The covers of the two crew quarters escape hatches, with 640 mm coamings, were closed and dogged down.

7 ANALYSIS OF THE HYPOTHESES

The aim of this chapter is to study the various hypotheses envisaged and to determine, from the observations and analyses described in Chapter 6, the possible causes of the foundering.

The hypotheses considered were :

- flooding of a compartment below the freeboard deck;
- Collision with a surface vessel;
- Snagging of the trawl gear by a submarine;
- Snagging of the trawl gear on an obstacle on the sea bottom;
- The trawl gear burrowing into the seabed.

7.1 Flooding of a compartment below the freeboard deck

The floodable compartments below the freeboard deck were :

- the steering gear compartment : this hypothesis was discarded in Chapter 6;
- the crew's quarters;
- the engine room through the echo sounder breach or access companionway;
- The fish hold.

The analysis of the vessel's structure showed that the fish hold was watertight at the time of the accident. Flooding of the fish hold was therefore not retained as a hypothesis.

As for the other compartments, the stability calculations showed that flooding of any of them was not sufficient to cause loss of stability or buoyancy.

Downflooding of the crew's quarters

As explained in paragraph 6-10, the breakwater door and the door to the crew's accommodation were both found open. The prerequisite for the ingress of water into the crew's accommodation was the shipping of seas on the after deck. The stability calculations showed that this was possible due to the state of the sea.

Downflooding of the engine compartment

The possibility of ingress of water through the door of the engine room companionway was not retained because the door was closed even if it was not completely dogged down.

Four other possible causes of engine room flooding were considered : the sea water system, the rudder stock gland via the steering gear compartment drain, the stern tube and the breach in way of the port echo sounder. Each one of these sources remained a possibility because, it must be remembered, the audible alarm of the water level detection system was inoperative, so the flooding process need not have been very rapid.

The observations and analyses described in Chapter 6 enable the first three of these possible causes to be eliminated.

Concerning the breach at the port echo sounder, the calculations and stress analysis carried out on the basis of the metallurgical analyses of the port and starboard echo sounder mounting shoes and the areas around them, attempted to determine if the breach was made before the accident or resulted from it (see paragraph 6.2.1 above and appendix E.2).

Hypothesis that the port echo sounder breach was made before the accident

There would have to have been a violent impact on the echo sounder shoe which was assumed to be intact to tear the shell plating and cause it to pivot around a horizontal axis into the engine room. The force required to cause damage of this sort was calculated to be 30 tonnes.

The object likely to have caused such an impact would need to have a small cross section because it is likely that it would only have struck the middle of the sounder shoe or its base once. Furthermore, to impart a force equivalent to the 30 tonnes calculated, it would need to be rigid and have great inertia.

The investigators consider that some floating objet, such as a container, adrift after having fallen into the sea from a vessel's deck cargo, could meet these conditions.

A 40 foot container, awash, weighs about 80 tonnes. Its corner fittings which are made of forged steel, have a radius of between 11 and 20.5 cm. It is not unusual for container ships to lose part of their cargo, especially in periods of bad weather, which was the case just before the accident. Be that as it may, the *BEA*mer investigators were not informed of any such losses. In such a busy area, the probability of colliding with a container, or snagging a container on the seabed, cannot be ruled out.

The hypothesis that the impact was directly on the shell plating under the sounder after its mounting shoe had been torn off in a previous, extraneous incident was excluded because the corner of the container would have left marks and, at the very least, traces of paint. Nothing of this sort was observed during the metallurgical analyses.

But, assuming that the sounder shoe was intact, the roll period of the vessel – 5 seconds – and its amplitude of about 30° would result in a velocity of 1.5 m/sec. at the end of the shoe. In the event of an impact, the force would be of the same order of magnitude as the 30 tonnes required to cause the breach.

This hypothesis remains a possibility, as marks indicating a metal to metal contact were observed on the upper edge of the breach and the weld connecting the sounder shoe to the plating was of a type that would easily yield if it was subjected to tension.

The two vertical cracks in the shell plating in line with the frames just forward of the echo sounder could have been caused by a violent impact on the sounder shoe leading fore to aft.

Nevertheless, the *BEA*mer investigators consider that the origin of these cracks is more likely to be found in a local vibratory phenomenon affecting this part of the structure. They think it unlikely that these vibrations were due to cyclic strains caused by the action of the sea; they were more probably caused by a relatively high frequency vibratory phenomenon linked to the main engine or a piece of auxiliary equipment such as a compressor.

The breach at the port echo sounder had an area of about 500 cm^2 and calculations showed that it would have taken eight minutes for the engine room to be entirely flooded. In this event, due to the fact that the audible alarm of the water level detection system was not working, the crew could only have been alerted by a visual alarm. However, the vessel would have become considerably heavier and it is difficult to imagine that the crew would have taken so long to react, all the more so as there would have been a black-out and the engine would have stopped when the shaft-driven alternator was submerged. Furthermore, it is possible, although there is no way of confirming this, that the crew would have been aware of the impact.

The stability calculations showed that flooding of the engine room did not jeopardize stability. It did, however, significantly reduce buoyancy because of the accompanying reduction in freeboard, notably of the coaming of the crew's quarters. If this compartment were flooded, there would be a rapid deterioration of stability.

This does not explain why the vessel turned to the right and finished up perpendicular to the alignment of the trawl net, unless this was caused simultaneously by some other external factor.

The hypothesis of engine room flooding following an impact on the hull of the *BUGALED BREIZH* of a floating object such as a container can be considerzed possible. By itself, it would not have been sufficient to cause the loss of the vessel, but could have contributed to it along with other factors. Nevertheless, this hypothesis is highly unlikely, especially taking into account the lack of reaction of the crew over a fairly long period, during which the engine would rapidly have stopped and a blackout occurred.

Hypothesis that the breach at the port echo sounder was opened after the sinking

The breach could have been caused by **the depression wave** set up by the implosion of the fish hold when the vessel had reached a depth of about forty metres. The analysis of the forces required to casue the breach concludes :

"Allowing for cavitation, the maximum value of such a depression wave cannot be greater than 4 bar. This value would be sufficient to explain the rupture of the cable conduit and the iniation of the "plastic hinge" but insufficient to start the brutal rupture which would require far higher pressures."

The hypothesis that the breach was caused by the implosion of the fish hold was therefore excluded.

The breach might also have been caused by the **collapse of the structure** of the forward part of the vessel, following the implosion of the fish hold. In this case, the forces applied to the vessel would be transmitted mechanically between the echo sounder shoe and the foundation plate on which it was mounted.

The calculations required to verify this would have been extremely complex. The problem was therefore looked at the other way round, namely, by estimating what acceleration would need to be applied at the end of the sounder shoe, assuming it was intact, to exert a force of 30 tonnes on the foundation plate. It would have been something like 400g. The quality of the weld fixing the sounder shoe to the foundation plate was such that it would have been unable to withstand the lateral forces corresponding to this acceleration; and even if it had, the plate would have shown signs of tearing and such was not the case.

The hypothesis that the breach was caused mechanically as a result of the collapse of the structure of the vessel following the implosion of the fish hold cannot be retained either.

Finally, the breach may have been caused when the vessel keeled over on to her port side as she came to rest on the sea bottom. Taking the dimensions of the starboard echo sounder as a yardstick, it can be seen that the end of the port echo sounder came just level with a line from the sole of the keel to the bilge. The STOLT team analysed the composition of the seabed. It was hard schist covered by a layer of sediment and mud about thirty centimetres thick.

When the vessel keeled over the end of the echo sounder may have touched the bottom before the bilge, the 250 tonnes of the vessel's weight then being distributed between the keel and this point. This could have been sufficient to exert a 30 tonne punching force on the bottom of the shoe which would then break loose as the plate pivoted into the engine room and strike the upper edge of the breach thus formed, leaving traces of metal to metal contact

As has previously been explained, the presence of vertical cracks forward of the sounder shoe can be accounted for in the above hypotheses.

The hypothesis that the breach was opened when the vessel keeled over on to her port side on the sea bottom thus seemed to be the most plausible to the investigators. It is confirmed by the marks of metal to metal contact on the upper edge of the breach. The fact that the sounder shoe was not found during the refloating operation does not, per se, invalidate it.

7.2 Collision with a surface vessel

When the wreck was first examined by underwater photography, only the deformations affecting the starboard side shell plating were visible. They naturally led all the people present at the survey to envisage the possibility that they had been caused by the bow of another vessel and that the sinking could therefore be the result of a collision.

As it happens, the area where the sinking occurred is an area of relatively dense traffic but one that is not monitored by a VTS system. It is also a military exercise area for surface vessels and submarines.

It was therefore essential to try and identify what ships might have been in collision with the *BUGALED BREIZH.*

Several sources were used to identify the ships present in the area when the accident happened.

- As regards the monitoring of commercial maritime traffic, MRCC FALMOUTH passed on to the *BEA*mer the list of ships which had transmitted MAREP messages on transiting the *Land's End* or *Iles of Scilly* TSSs; fifteen ships had reported.

- The MCA was carrying AIS trials in the area; this enabled the few ships in the area equipped with transponders to be identified and their courses to be plotted.
- The CROSS GRIS-NEZ draw up a list of vessels that might possibly have been involved in the accident from those which had transited the *Dover Straits*.
- Through SIRENAC the port states or associated members of the Paris Memorandum of Understanding were informed of the accident and looked for vessels showing signs of having been in collision.
- The CROSS-ATLANTIQUE FMC (Fishing Monitoring System) drew up charts showing the position of French fishing vessels at the time of the accident.
- The *BEA*mer asked the European Space Agency if any of their satellites had transited over the area. The answer was negative : although a number of satellites could have made observations, the cloud cover was so thick that any tracking was out of the question.

Although considerable information was received from several sources, both national and international, this search for merchant vessels did not make it possible to pinpoint the presence of any one merchant ship likely to represent a collision threat.

Further to this, the Royal Navy and the Maritime Prefecture in Brest made known the position of naval vessels showing that there were none in the area at the time of the sinking. A Chart drawn up by the Maritime Prefecture in Brest on 21st January 2004 (see Chart in appendix D.8) gives the position of naval vessels. It shows that none were in the vicinity of the accident area when it happened.

Moreover, a number of elements militate against the hypothesis of a collision. First, there is the statement made by the skipper of the *ERIDAN* to whom the skipper of the *BUGALED BREIZH* had said that he was capsizing. If there had been a collision, he would certainly have said so. It can also be assumed that any vessel involved in a collision would have stopped to give assistance, which is fortunately the case in most instances.

But as far as the technical inquiry is concerned these elements are not, in themselves, sufficient for this hypothesis to be excluded. Thus, after the wreck had been refloated, the *BEA*mer ordered the two surveys on the deformations of the forward part of the vessel described in paragraph 6.2.2 to be carried out : viz, the photogrammetric survey and the calculations on the structure. These surveys proved, on the one hand, that the fish hold was watertight when the *BUGALED BREIZH* sank and, on the other hand, that the deformations observed at the bows of the vessel were due to the implosion of the fish hold which occurred when the pressure on the vessel reached 4 bar, that is to say, when she had sunk to a depth of 40 metres.

This demonstration and the symmetry of the deformations makes it possible, *a contrario*, for the hypothesis of a collision to be abandoned.

The structural analysis therefore makes it possible to conclude that the fish hold was watertight when the *BUGALED BREIZH* sank and that the structural damage sustained forward of the midships perpendicular, which corresponds to the bulkhead between the engine room and the fish hold, was due to the implosion of the fish hold which occurred when a pressure of 4 bar was reached, corresponding to a depth of some forty metres.

The hypothesis of a collision with a surface vessel or a submarine on the surface was therefore excluded.

7.3 Fishing gear snagged by a submarine

An analysis of the trawl rig was ordered within the framework of the judicial inquiry. The intermediate report puts forward the hypothesis of some external force capable of pulling the trawler very rapidly towards the bottom. The findings of this report were, of course, taken into account, although the conclusions it draws were not final.

Within the framework of the technical inquiry examination of this hypothesis led the investigators to look at a number of alternatives :

- Snagging of the trawl net : this seems impossible, because the trawl net is towed along the bottom and its mouth has a vertical opening of four metres. Even supposing that a submarine could be so close to the bottom, the trawl net would have sustained considerable damage. However, the only damage sustained by the net was slight tearing of the upper wing.

- Snagging of both warps : the warps are 50 metres apart on the bottom at the trawl doors, and this distance narrows, over a distance of 375 metres, to only 6 metres at the surface. In all probability, a submarine navigating close to the warps would snag both of them and its is likely that the trawl net would be lifted off the bottom before the vessel itself was affected. Now in Chapter 6 we described how the chains of the upper and lower bridles and the three way connection were found embedded in the seabed. Moreover, the upper bridle chain would have been visible up to a height of several metres as it would have been buoyed up by the floats on the headrope. Finally, if both warps had been snagged, they would have finished up in similar positions, but the starboard warp was found rather taut while the port warp had made wide loops in three different places.

- Snagging of one warp only : this means there would have been
  - either a movement towards the outside of the trawl rig, in which case the trawl door and trawl wing on the side of the snagged warp would have tended to move outwards. However, the opening of the trawl net was found to have closed and the trawl doors were only five metres apart, having swapped sides,
  - or a movement towards the inside, which would have led to a reversal of the trawl doors and probably the crossing of the wings of the trawl net as well but this does not correspond to what was observed. In this case, the overlapping of the port bridle and fork leg cannot be explained.
  - In both case, the warps would not have been found lying almost parallel to each other between the trawl doors and the vessel.

Finally, the metallurgical analysis of the warps did not bring to light any abnormal strains which could have been caused by a submarine and the traces observed do not allow any coherent conclusions to be reached.

Having looked at all the evidence available at this time, it therefore appears that the hypothesis of a submarine snagging the trawl net is, for the most part, inconsistent with the material observations of the trawl rig.

7.4 Snagging of the fishing gear on an obstacle

The underwater videos showed no object on the seabed, such as a container or a wreck, likely to have snagged the fishing gear.

The charts show no wrecks at the position where the accident occurred.

In appendix E.1, the ENC chart of the accident area which is on the 1:250 000 scale could, however,lead us to believe that the *BUGALED BREIZH* was close to a submarine cable running approximately southsoutheast. But on the 1:2500 scale chart it can be seen that the wreck was 569 metres from the cable. The distance between the wreck and the mouth of the trawl net was measured and found to be 415 metres, which means that both the vessel and her fishing gear had gone past the cable.

If the trawl net had snagged the cable, it is probable that it would have been damaged.

The hypothesis of the fishing gear snagging on an underwater obstacle was therefore discarded.

7.5 Embedding of the fishing gear in the seabed

Although the seabed was flat with relatively low ridges, the observations made from viewing the underwater videos, which were described in paragraph 6.4 above, showed that the three way connection and bridle chains of the trawl net had burrowed into the mixture of sediment and mud on the up-slope of a shallow concavity.

The hypothesis of the trawl rig embedding itself in the seabed, or "soft snag", therefore needed to be looked at very closely.

In this hypothesis the question arises as to whether both sides of the trawl rig could have ploughed into the seabed in a symmetrical manner. If both sides burrowed in simultaneously, there would be no reason for the boards to cross over each other. Paragraph 6-4 however, indicated that the starboard trawl door passed over the port trawl door. Both sides of the trawl rig could therefore not have burrowed into the seabed symetrically.

The starboard bridles were projected over the port bridles. If the port fork had retained its normal angle of opening, the starboard trawl door would have passed between the port bridles. The reason why both starboard bridles went over the port bridles was that the angle of opening of the port fork had closed.

The only way to explain why the port fork closed is that it was subjected to two opposing forces : the upper bridle was still being towed by the vessel because the engine was still running ahead, while the lower leg of the fork was held back by the portside three way connection of the trawl net which was embedded in the seabed, the trawl door and lower port bridle.

As regards the trawl net, the upper wing was pulled in one direction by the upper port bridle and in the opposite direction by the wing line at the portside three way connection; it was thus subjected to abnormal forces and this led to the webbing of the wing and the wing line being torn.

The port side of the rig then came to an abrupt halt. The bridle chain was 10 metres long and the vessel was making 4 knots over the ground, so it took 4.9 seconds for the lower bridle to become immobilized.

In this situation, the port trawl door was no longer towing the lower bridle, but was itself still being towed by the warp and the upper bridle. It flipped over and came down flat on its side on the bottom.

As the starboard warp was still being towed by the vessel, the engine of which was still running ahead, the spread of the trawl net was reduced and the starboard ballast chain of the lower starboard bridle moved sideways and inwards before burrowing deeply into the sediment right up to the three way connection of the trawl net. Due to the fact that the warps were still towing the upper bridles, the headrope moved ahead of the bobbins until it was stopped by the wing lines on both sides. The abnormal loads thus placed on the upper wings resulted in partial tearing of their webbing.

Once the lower bridle and starboard three way connection were embedded in the seabed, the starboard trawl door was no longer towed by the lower bridle, the traction force of the warp being wholly exerted via the upper bridle. This lifted the door off the bottom sending it over the port trawl door before it came to rest on the bottom a few metres further ahead. This movement was made possible by the closing of the port fork.

The above hypothesis therefore explains, in the most plausible manner, how the trawl rig could have burrowed into the seabed, embedding its three way connection and bridles, as evidenced by the observations of the trawl gear made from viewing the underwater videos.

7.6 Conclusion

As a conclusion, among the different hypotheses considered, **that of the embedding of the trawl rig in the seabed would seem to equate most closely with the material observations** described in Chapter 6.

This is the basis on which, in the following chapter, the *BEA*mer, using its usual methods, studied the various factors likely to have played a rôle in the accident and on which the recommendations set out in Chapter 9 are based.

The hypothesis that the engine room was flooded by ingress of water through a breach in way of the port echo sounder caused by an impact with a submerged object remains highly unlikely.

8 DETERMINING AND COMMENTING ON THE CAUSES OF THE ACCIDENT

The method used for determining the causes of the accident was that used by the *BEA*mer in all of its enquiries in compliance with Resolution A.849-20 of the IMO as amended by Resolution A.884(21).

The contributory factors were placed in the following categories :

natural causes;
equipment;
the human element.

The *BEA*mer investigators listed the possible factors of each category and attempted to define their nature ; were they :

certain, probable or hypothetical,
trigger, decisive or contributory,
incidental or structural.

Their goal, after careful examination of the factors, was to rule out those which had no bearing on the events and retain only those which, with some degree of probability, could be considered as having participated in the course of events. They are aware that this means they may have left aside some of the questions raised by the accident. As their aim is to prevent this type of accident from happening again, they have favoured an impartial inductive analysis of those factors which, by their structural nature, could lead to the same thing happening again.

It was necessary to try and determine those factors that contributed to the accident so that lessons may be learned and recommendations made. They were sought according to the hypothesis which was most consistent with the observations made of the vessel and her fishing gear.

8.1 Natural causes

8.1.1 Weather conditions and currents

A detailed description of the weather conditions can be found in the weather bulletin issued by Météo France in appendix C.

The stormy weather conditions of the previous days, which had prompted the *BUGALED BREIZH* and the *ERIDAN* to take shelter in NEWLYN, had abated and become manageable.

On 15th January 2004, the two vessels were in the southeastern part of a depression which was centred westnorthwest of Ireland.

The mean wind direction and speed was southsouthwest, 25 to 27 knots (Force 6 Beaufort) with gusts between 33 and 37 knots.

The sea was rough with a significant wave height (H 1/3) of 3.7 metres and comprised wind waves from the southsouthwest combined with a swell from the westnorthwest, both having a period of 9 seconds.

The sky was cloudy with light, intermittent rain or showers; visibility was between 10 and 20 kms, decreasing to 8 kms in precipitations.

The sea water temperature was around 11 to 12 °C.

As regards the tide, the tidal coefficient was 57 with high water at Cherbourg at 1254 UTC. *L'Atlas des courants de marée et des hauteur d'eau pour la Manche* (Publication No. 564 of the SHOM) – *equivalent to the Admiralty Tidal Stream Atlas of the English Channel published by the UKHO* - indicates that, at 1225 UTC, the time of the accident, a short time before HW, there was a 0.4 knot current setting eastsoutheast at 1154 UTC becoming south by southeast, 0.3 knots, one hour later.

The vessel was proceeding on a northeasterly course at the time of the accident which corresponds to the position of the trawl net on the bottom.

The ground speed of the vessel was increased by the effects of the following sea and wind; which could only increase the risk of snagging in the shallow yet irregular sediments.

When the trawl net burrowed into the sea bed in the prevailing sea conditions a lateral inclining moment to port, the first side to snag, was set up. The kinetic energy of the swell and the wind waves could have been amplified. Indeed, as the vessel began to swing to port, she would be perpendicular to the swell and the direction of the wind waves would be much closer to her beam. In the event of waves striking the port side of the vessel simultaneously, their kinetic energy would decrease the vessel's reserve of stability which was already reduced by the inclining moment caused by the snag.

According to the respective positions of the vessel and the waves, the angle of downflooding of the deck freeing ports could be reached. The waves striking the vessel's port side form broken water which is shipped over the after deck bulwarks.

The weather conditions were therefore an **incidental contributory factor**. The kinetic energy of the waves striking the port side of the vessel decreased her reserve of stability which was already diminished by the inclining moment due to the snagging of the trawl gear in the seabed. As the vessel rolled the angle of downflooding of the freeing ports of the after deck was reached, leading to its progresssive downflooding.

8.1.2 The nature of the seabed

A large number of submarine cables pass through the area.

The underwater images and inspection of the trawl gear on shore showed no signs of snagging on a wreck or a rock.

The seabed comprised a layer of sediment and mud about 30 cms thick over a relatively flat layer of schist. In the event of warps, or more especially chains, becoming embedded, the composition of the bottom is such that a suction effect would be set up.

Small ridges can be formed; they are more like wavelets than hillocks, but can be dangerous. The images taken by the *ANDROMEDE* showed a slight incline. The images taken by STOLT six months later, on the other hand, showed far more pronounced ridges.

The nature of the seabed was therefore a second **incidental contributory factor.**

8.2 Equipment

8.2.1 Influence of the trawl gear on stability

The stability calculations showed that the intact stability of the vessel was satisfactory. The calculations were made taking into consideration the bunkers and supplies as estimated for the day of the accident.

The calculations of both static and dynamic stability took several elements into account : downflooding of the crew's quarters, downflooding of the engine room, lateral traction on one warp, free surface effect on the after deck, the couple of forces set up the engine's ahead thrust and traction on one warp. No single one of these elements by itself would have resulted in the vessel's losing her stability.

Taking into account the evidence and findings, the stability could have been modified in the following way during the accident :

- ✓ the *BUGALED BREIZH* was engaged in fishing operations on a northeast heading, with a following sea and wind and swell on her beam; she was rolling from side to side taking 30° to 40° list an d had a roll period of 5 seconds; her stability parameters were good.
- ✓ The lower port bridle and three way connection dug into the seabed and came to a stop within 5 seconds; the tension on the port warp increased and took on a sideways component to port setting up an inclining lever and couple of forces with the thrust from the engine which was still operating ahead. Under the effect of the traction to port the vessel swung to port. The tension on the starboard warp also pulled it to port and was increased when the starboard three way connection and lower bridle likewise burrowed into the seabed. According to statements made by a seafarer who formerly served as Chief mate on the *BUGALED BREIZH* and by comparison with data concerning recordings of tension ensuing from snags made on the *PERE ARTHUR* on page 20 of Jean-Paul GEORGE's book *Les Croches et les arts traînants - Snags and the art of trawling* (published by Editions IFREMER in their collection Engins et techniques de pêche (*Fishing gear and techniques)*), the tension on each of the two warps can be estimated at about 9 tonnes. The inclining lever increased by the same amount.

- ✓ As the wind waves and swell were both from the port side, their combined kinetic energy, when they struck the port side of the hull, diminished the reserve of stability.
- ✓ Broken seas were then shipped on to the after deck over the bulwarks.
- ✓ As the vessel rolled, the freeing ports did not have time to evacuate the water shipped on the after deck. A free surface effect was created. There was ingress of water into the crew's quarters due to the rolling. The stability worsened further.
- ✓ In these conditions, the vessel no longer had a sufficient righting lever and remained heeled over to port. Seas were shipped directly into the crew's quarters, reducing the stability even more.
- ✓ The brake of the port warp winch was then released. The tension on the two warps was transferred entirely to the starboard warp. The inclining moment to port decreased by half, as the port warp was no longer under tension, then the sideways component of the tension, exerted on the starboard warp alone, was transferred to starboard as the vessel heeled to starboard. The inclining moment was now to starboard and was amplified by the free surface effect. The reserve of stability was reduced yet further by the continued ingress of water into the crew's quarters.
- ✓ The angle of downflooding of the crew's quarters was quickly reached. The loss of stability became total and irreversible.

The progressive deterioration of stability was the **decisive factor in the foundering**.

In the event of simultaneous flooding of the engine room, which has not been totally excluded, the process would only have been accelerated : reduction of the freeboard aft would have made it easier for water to be shipped aft, and thereby, facilitated downflooding of the crew's quarters.

8.2.2 The lifesaving appliances

The accident happened very quickly : only two or three minutes, at most, went by between the beginning of the snag and the total loss of stability.

The starboard liferaft was released and inflated automatically when the vessel sank. The port liferaft was probably released manually but could not be inflated due to lack of time.

The fact the the immersion suits were stowed in the crew's quarters made it difficult to use them. But even if they had been placed on the main deck or upper deck, there would probably not have been sufficient time for them to be donned.

8.3 The human factor

8.3.1 Operating conditions

Keeping doors open when engaged in fishing operations is common practice, especially with a following sea. The sliding breakwater doors were found tied solidly open, as was the door to the crew's quarters.

Logically speaking, if they had been closed, the sequence of events which led to the foundering would have been interrupted. Keeping the sliding breakwater door closed would not have had any great effect on the free surface effect on the after deck, but would have prevented the flooding of the crew's quarters, a crucial factor in the total loss of stability in the event of a snag.

The failure to apply safety rules concerning the closing of doors on the freeboard deck was a **decisive factor**.

8.3.2 Reactions to the situation just prior to the accident

Within the framework of the "embedding" hypothesis, when the three way connection and lower bridles of the trawl buried themselves in the seabead, the vessel lost way and listed heavily to port. The skipper did not think it was a normal snag, because, in that case, he would have disengaged the engine and paid out both warps. It was more like a "soft" snag which can be overcome by using the power of the engine. But the traction to port combined with the energy of the waves, and the water shipped on the after deck, heeled the vessel over to port and she was not capable of righting herself.

The skipper called the *ERIDAN* for the first time. Between this call and the second call to the *ERIDAN* no more than two minutes can have gone by, just enough time for her skipper to inform his crew about what was happening.

The port warp was paid out. On the vessel which no longer had any reserve of stability, the heel, transverse inclining moment and free surface effect were brutally transferred from the port side to the starboard side. Massive downflooding of the crew's quarters led to the total loss of the vessel's stability.

The reason why the skipper did not manoeuvre the engine control lever can be explained by the fact that there seemed to be very little risk of snagging in the area : no wrecks were indicated on the course plotter and the bottom was relatively flat. But the situation was unfavourable, with the following sea and swell on the beam; keeping the breakwater door and the watertight to the crew's quarters open meant that the situation could become dangerous if some outside event altered the circumstances.

In short, the course followed by the vessel in the prevailing sea conditions and the fact the breakwater door and door to the crew's quarters were kept open represented risks which were probably underestimated due to the fact that the crew knew their vessel well and were working in an area which was not considered to be dangerous. This may explain why the engine was not manoeuvred or the propeller pitch set to zero. In such circumstances, action on the port winch brake alone could only make the process of loss of stability inevitable. This accumulation of underlying factors was, in itself, **a decisive factor.**

8.3.3 Management of communications and the rescue operation

Maritime safety information

The *BUGALED BREIZH* was not equipped with a NAVTEX receiver, which receives weather bulletins and navigation warnings for coastal areas, notably those containing messages about military exercises.

The same information is given by VHF, in English, after a preliminary call on Channel 16 (telephony) or Channel 70 (digital selective calling).

The investigation showed that maritime safety information resources were only partially used. In the case under review, weather bulletins were received from different sources and enabled fishing operations to be organized accordingly; thus the vessel spent two days in NEWLYN sheltering from the inclement weather. But, as far as the *BEA*mer investigators were able to establish, coastal or inshore navigation warnings were not recieved, either by NAVTEX because the vessel was not equipped, or by VHF from the local English stations. During the course of their investigations on the accident, the *BEA*mer investigators discovered that it was common practice for fishing vessels to receive navigation warnings by INMARSAT C which is widely used on fishing vessels. INMARSAT only broadcasts NAVAREA messages concerning offshore commercial traffic routes on its SAFETYNET system. Fishermen tend to neglect

NAVTEX because it is considered to be too long-winded; the NAVTEX system, however, broadcasts inshore warnings including messages about military exercises. It is worth noting that superfluous messages can be avoided by correct usage of the NAVTEX receiver, by selecting the transmitters and the type of message received.

Because of the mutiplicity and redundancy of resources for broadcasting maritime information, it is up to the seafarer to make sure that he has the relevant information about those areas for which specific dangers are mentioned on the charts or in the sailing instructions.

Distress messages

The skipper of the *BUGALED BREIZH* did not transmit a distress message to MRCC FALMOUTH. He informed the skipper of the *ERIDAN* that he was capsizing and gave his position.

The first distress message received by MRCC FALMOUTH was from UKMCC at 1239 UTC : the emergency position indicating radio beacon of the *BUGALED BREIZH* had been detected by the COSPAS-SARSAT system at 1223 UTC. The wheelhouse clock had stopped at 1325 UTC +1. It may have been 2 or 3 minutes fast. It is just as likely that the epirb was activated when it was taken out of its holder on the after bulkhead of the wheelhouse by the skipper or a crewmember during the two minute period between the two calls made by the skipper of the *BUGALED BREIZH* to the *ERIDAN.*

The distress message was received by the COMBE MARTIN LUT in the United Kingdom, by both the geostationary satellite MSG-1 and the orbiting satellite S08. It contained the MMSI number of the *BUGALED BREIZH* enabling her to be identified.

The frequency detected was 406.025 MHz and the Two DOPPLER positions measured were :

A 49 39 44 N / 005 11 21 W probability 84%
B 57 54 36 N / 033 12 31 E probability 16 %

Position ambiguity resolution was made using only three points and on the basis of geostationary / low earth orbit processing, this being due to the fact that the S08 satellite must have been close to the limit of "visibility" for the epirb. Moreover, the message was not picked up the the Toulouse LUT which the satellite had passed over shortly before. This affected the accuracy of the position calculations, although this remained within the limits of the 5 kilometre margin of error required for the 406 MHz system.

Position A from this distress message was the first one to be taken into account by MRCC FALMOUTH.

At 1236 the CROSS GRIS-NEZ received the distress relay which the *ERIDAN* had transmitted at 1228 by INMARSAT C. This, in fact, indicated the position of the *ERIDAN* at that time : 49°44N, 005°19W, course 085°. At that time t he *ERIDAN* must have been finishing hauling her trawl. Her skipper called the CROSS GRIS-NEZ on IRIDIUM telephony to confirm that the *BUGALED BREIZH* had foundered and gave her position. The CROSS GRIS-NEZ transmitted this information to MRCC FALMOUTH at 1240.

From 1240 onwards, MRCC FALMOUTH tried to contact the *BUGALED BREIZH* by digital selective calling and telephony on VHF and MF. The position used was position A from the COSPAS-SARSAT message, which was the most probable one.

At 1245 MRCC FALMOUTH received a call by VHF telephony from the *ERIDAN* confirming the sinking, giving the position as indicated by the skipper of the *BUGALED BREIZH* : 49°42N, 005°10W.

At 1246 MRCC FALMOUTH requested a helicopter from 771 Squadron in CULDROSE; it took off at 1259 with the latest position. It arrived on scene at 1314, did not see anything but picked up a signal on 121.5 MHz.

At 1305 MRCC FALMOUTH received a further COSPAS-SARSAT message detected at 1253 by the SPITZBERG LUT and transmitted by the NMCC via the UKMCC. Both positions were calculated on a five point basis and were :

A : 49 42 12 N, 005 10 49 W probability 99% ;
B : 49 42 28 N, 005 10 51 W probability 78%.

The new data was transmitted to the helicopter which was able to alter course accordingly.

If the *BUGALED BREIZH* had transmitted a distress message on VHF Channel 16, the MRCC FALMOUTH would immediately have picked it up and its remote VHF stations in Cornwall and the Isles of Scilly would have been able to pinpoint the position of the *BUGALED BREIZH* with their VHF direction finding equipment.

The same would have been true if the distress message had been sent by digital selective calling on VHF, but the vessel did not have DSC (see Chapter3).

In this case, MRCC FALMOUTH would have known, between 1223 and 1225, the identity of the vessel, her position, given verbally from GPS data, then confirmed by RDF, as well as other relevant information concerning the rescue : number of persons on board, liferafts, status of the vessel. With these elements in hand the MRCC could have alerted the CULDROSE base as soon as they were received but had to try and obtain them between 1236 when the first distress message was received and 1245 when the foundering was confirmed. By and large, the helicopter could have arrived on scene twenty minutes earlier, about ten minutes before the first rescuers, the *ERIDAN.*

It cannot be stated incontrovertibly that the time thus saved would have made it possible to rescue any possible survivors. But it can be said, a contrario, that non-respect of distress procedures certainly **may have hindered** the search and rescue operation.

Regarding the exact position of the foundering, the position given by the skipper of the *BUGALED BREIZH* to his counterpart on the *ERIDAN* was known seven minutes after the COSPAS-SARSAT message was received, giving a position three miles away. It was confirmed by the second COSPAS-SARSAT message which resolved the ambiguity with certainty; the helicopter was informed of the corrected position while in transit. The difference in position did not therefore have any consequences on the deployment of rescue resources at the precise spot where the vessel sank.

On the other hand, the distress message transmitted by the *ERIDAN* by INMARSAT C was no more than a possible souirce of confusion : as the message contained the name and the position of the *ERIDAN*, it could be thought that she was also in distress. Any risk of error was, however, removed when the *ERIDAN* called MRCC FALMOUTH and the CROSS GRIS-NEZ immediately afterwards.

8.4 Conclusion

The weather conditions and the nature of the seabed, in themselves, did not cause the accident – many similar vessels meet such conditions frequently – but they did create the conditions in which the accident could take place. They therefore constituted **the two incidental factors which contributed** to the accident.

In these conditions, the interaction between the trawl gear and the sea bottom led to a reduction in stability, which was amplified by the sea state to such an extent that there was a total loss of stability : this was **a decisive factor** in the accident.

This loss of stability was, however, only made possible by the existence of a number of other conditions connected with the vessel : the fact that the breakwater door and the door to the crew's quarters were kept open, the fact the the engine and propeller were kept in ahead operation, the fact that only the port warp was slacked away. These conditions constituted the **second decisive factor in the foundering**.

The non-respect of procedures for transmitting distress messages delayed the direct arrival of the rescue resources at the scene of the foundering. It constitutes a **factor which hindered** the search and rescue operation.

9 RECOMMENDATIONS

9.1 Keeping doors closed

It is common practice on trawlers to continuously keep doors open when they should be closed, even in unfavourable sea conditions. The *BEA*mer reminds all concerned that watertight doors to compartments below the freeboard deck must remain closed and dogged down at all times when the vessel is at sea; the same applies to breakwater doors, particularly when navigating in a following sea.

It also reminds all seafarers that the watertight integrity of a vessel must be continuously adjusted to suit the prevailing weather conditions.

9.2 Construction of fishing vessels

Particular attention should be paid to the design and ventilation systems of crew's quarters when they are placed below the freeboard deck so that the crew will be encouraged to keep their doors closed at sea.

9.3 The need for instructions on precautionary measures

The design characteristics of stern trawlers can make them unsafe when they are exposed to high, following seas. In strong winds or with the curent running from astern, the risk of snagging becomes greater as the ground speed increases. The risk becomes greater still if there is a swell from abeam.

In the event of a snag, stability may be jeopardized by the kinetic energy of cross seas reducing the reserve of stability which has already been affected by the inclining moment set up by the snag. The *BEA*mer recommends :

- that existing works on snags should be consulted in order to limit the risks inherent to this type of incident.
- that shipyards and repair yards should draw up clear instructions for each type of vessel so that their skippers can learn what courses and speeds correspond best to the prevailing sea conditions and currents; these instructions should also indicate what measures should be taken, according to these conditions, when trawling and in the event of a snag.

9.4 Centralizing available information

Studies have been carried out in various countries to analyse the behaviour of fishing vessels in swell. An inventory of these studies coupled with an analysis based on model tests of the hull forms of different types of trawlers, would almost certainly supply concrete information enabling the above-mentioned instructions to be drawn up. The *BEA*mer has undertaken to see what can be done along these lines.

9.5 Use of radio equipment

Practically all fishing vessels are now equipped in compliance with GMDSS requirements. This accident shows, however, that radiocommunications procedures are not always adhered to.

The *BEA*mer recommends that when training courses are held with a view to issuing general, restricted or special operator's certificates, great care should be taken to underline the absolute necessity of complying with established radiocommunications procedures, whether it be to transmit or relay distress messages or to make full use of maritime safety information.

It further recommends the widest distribution possible among professional fishermen of information on distress procedures such as can be found, for example, in the brochure on the safety of fishing vessels edited by the Institut Maritime de prévention (IMP) (a French organisation whose goal is to further occupational risk prevention for seafarers and fishermen).

9.6 Echo sounder transducer mountings

The analyses carried out on the *BUGALED BREIZH* showed that the way the echo sounder transducers were mounted could set up fatigue areas in the hull, depending on the quality of the welding or the position of the sounder with respect to possible areas of vibration.

The *BEA*mer recommends that all approved classification societies concerned with the issue and renewal of freeboard certificates for fishing vessels should be particularly attentive to the correct mounting and ageing of any appendages added to vessels, such as echo sounders, and that they should require any welding work carried out on the hull during the installation of such equipment to be effected by welders having their approval.

LIST OF APPENDICES

A. **Decision to hold an inquiry**

B. **Vessel particulars**

C. **Analysis of weather conditions**

D. **Charts**

E. **Analyses and tests carried out on the vessel**

F. **Photographs**

Decision to hold an inquiry

Ministère
de l'équipement
des transports
du logement du
tourisme et de la mer
Inspection générale
des services des
affaires maritimes
Bureau des enquêtes
techniques et
administratives après
accidents et autres
événements de mer
(BEAmer)

Le directeur

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Paris, le 16 JAN. 2004
N/réf. : *BEA*mer/IGSAM/SET

000022

DÉCISION

Le directeur du Bureau des enquêtes techniques et administratives après accidents et autres événements de mer ;

Vu la loi n°2002-3 du 3 janvier 2002 relative aux enquêtes techniques après événements de mer ;

Vu l'arrêté ministériel du 16 décembre 1997 portant création du Bureau des enquêtes techniques et administratives après accidents et autres événements de mer (BEAmer) ;

Vu l'arrêté ministériel du 28 novembre 2003 portant nomination du directeur du Bureau des enquêtes techniques et administratives après accidents et autres événements de mer ;

Vu le message SITREP N° 25 du CROSS Gris Nez du 15 janvier 2004 ;

DÉCIDE

Article unique : En vue d'en rechercher les causes et d'en tirer les enseignements qu'il comporte pour la sécurité maritime, le naufrage au large du Cap Lizard le 15 janvier 2004, du chalutier français « *BUGALED BREIZH* », immatriculé au Guilvinec, fera l'objet d'une enquête technique dans les conditions prévues par le titre III de la loi sus-visée.

pour

L'administrateur en chef de première
classe des affaires maritimes
Jean-Marc SCHINDLER

P. I.

Germain VERLET

Directeur-adjoint du BEA/mer

*BEA*mer
22, rue Monge
75005 PARIS
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+ 33 (0) 140 813 824
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+ 33 (0) 140 813 842
Bea-Mer@equipement.gouv.fr

Appendix B

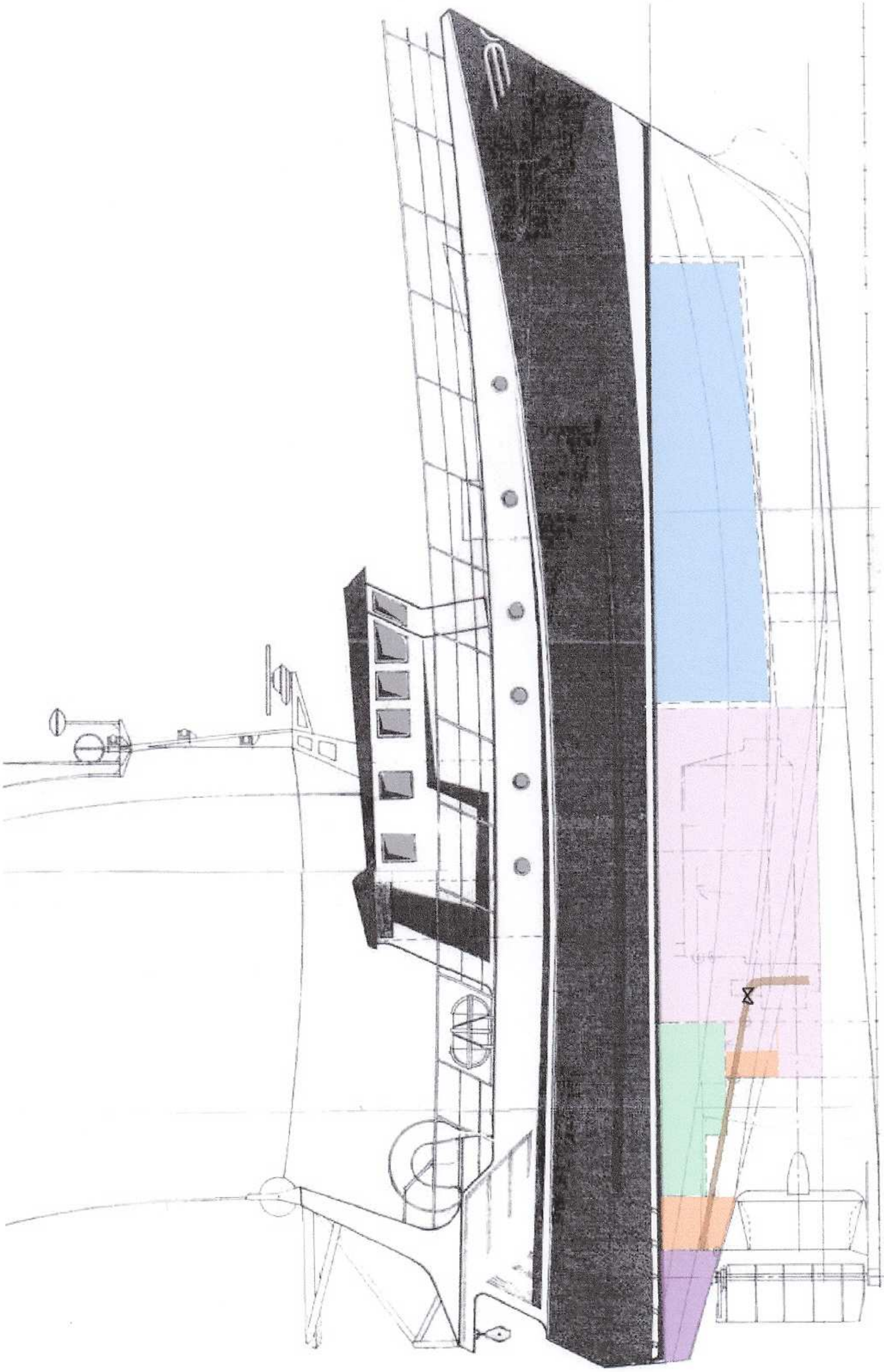
Vessel particulars

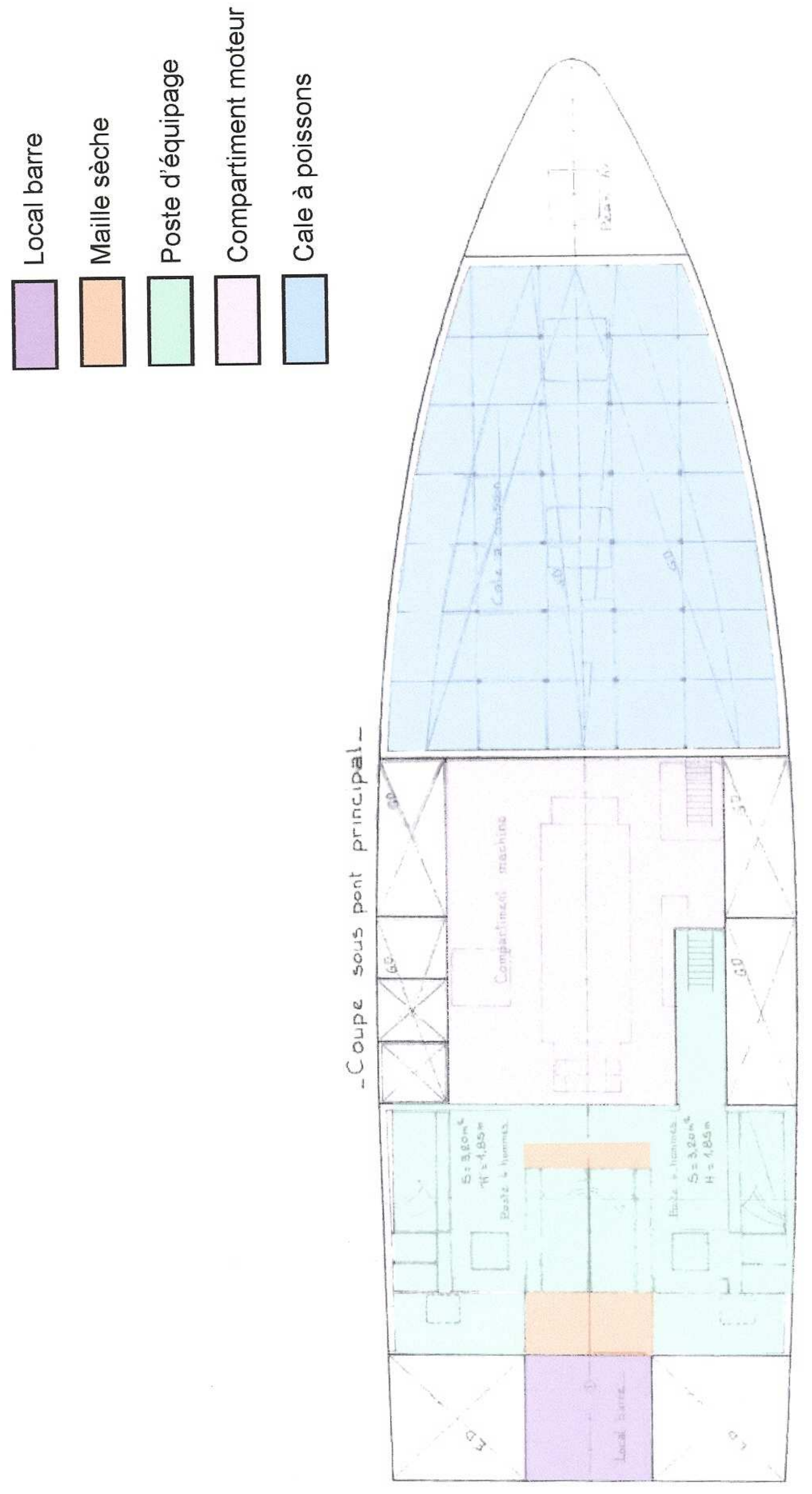
B.1 General arrangement

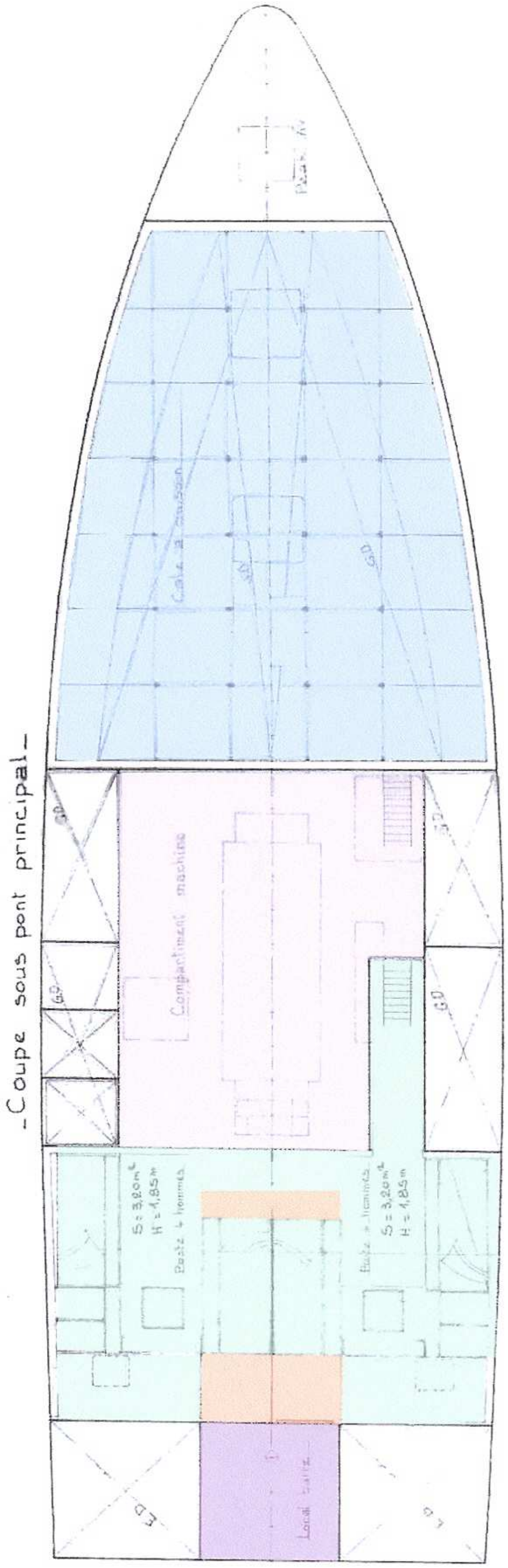
B.2 Diagram of the trawl rig

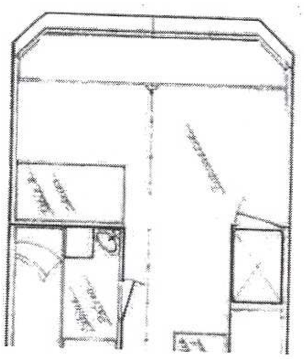
Appendix B.1

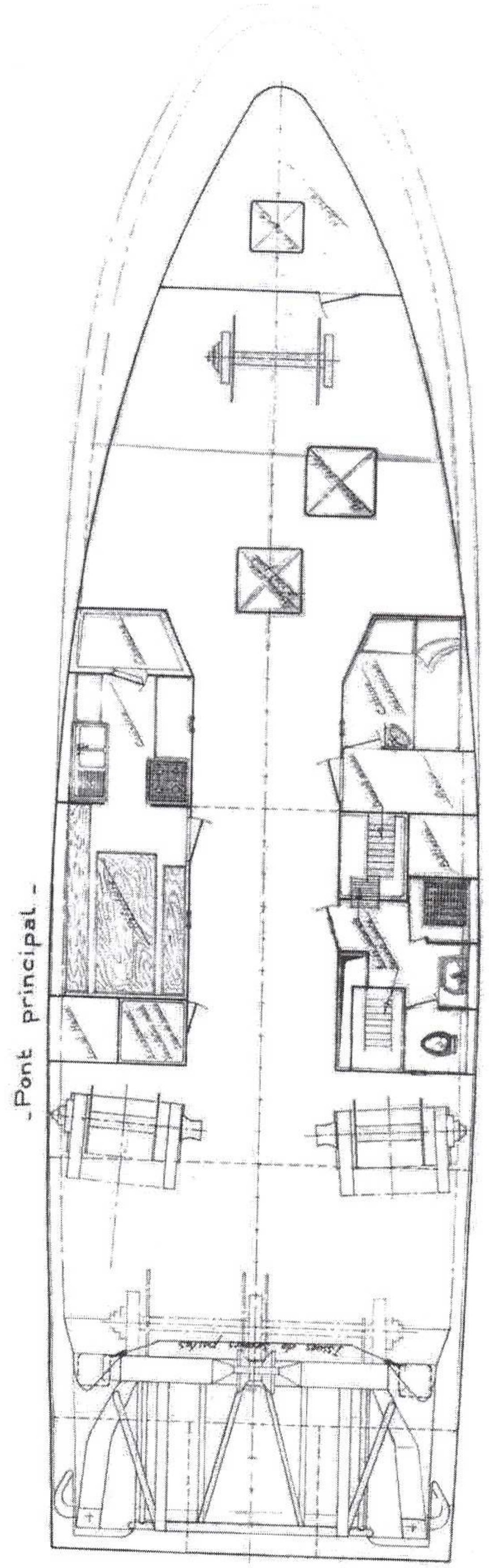
General arrangement




Local barre
Maille sèche
Poste d'équipage
Compartiment moteur
Cale à poissons
-Coupe sous pont principal-
Compartiment machine
S=3,20m²
H=1,85m
Local barre


Coupe sous pont principal
Compartiment machine
S = 3,20 m²
H = 1,85 m
Poste 4 hommes
S = 3,20 m²
H = 1,85 m
GD

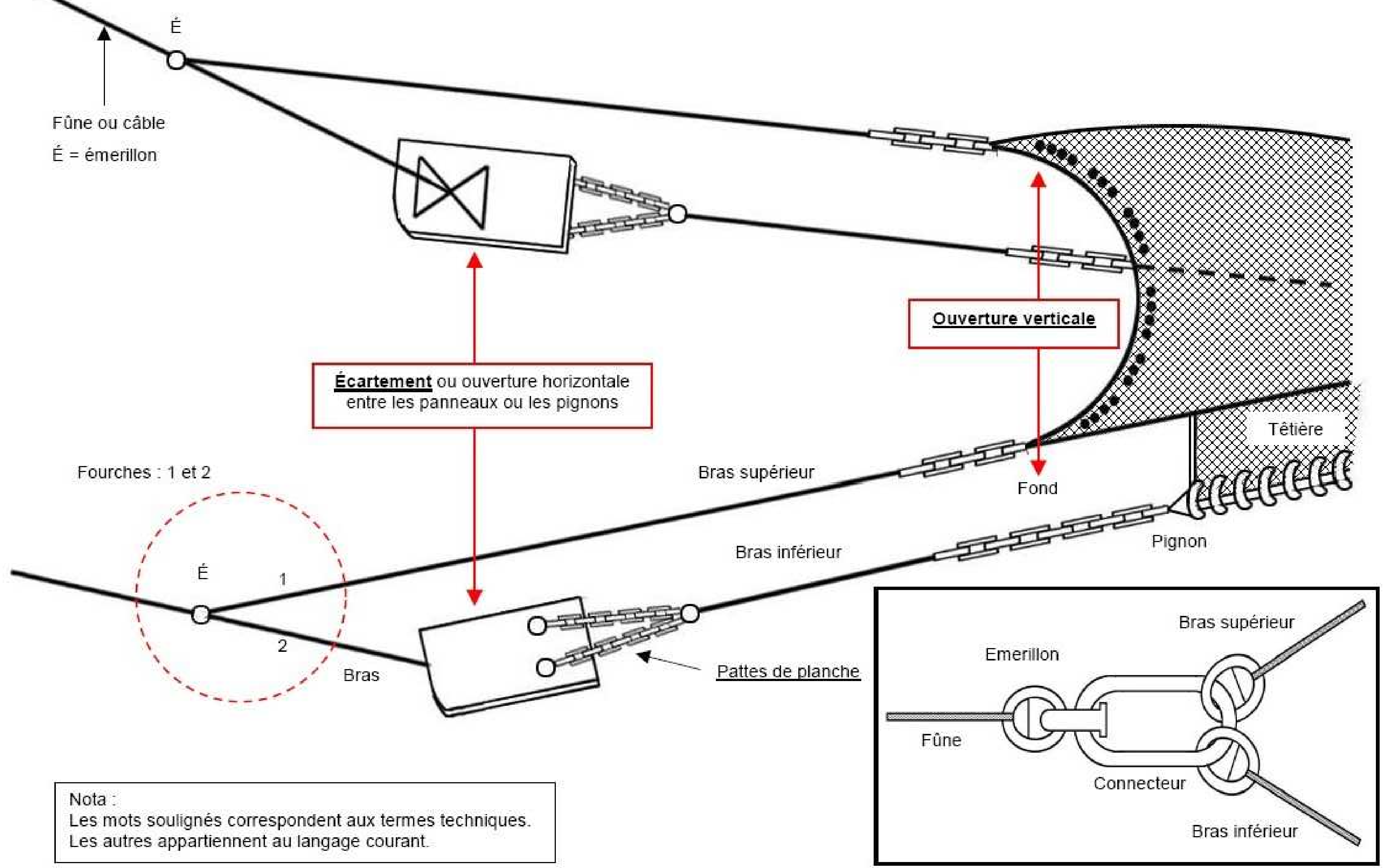



Pont principal

Appendix B.2

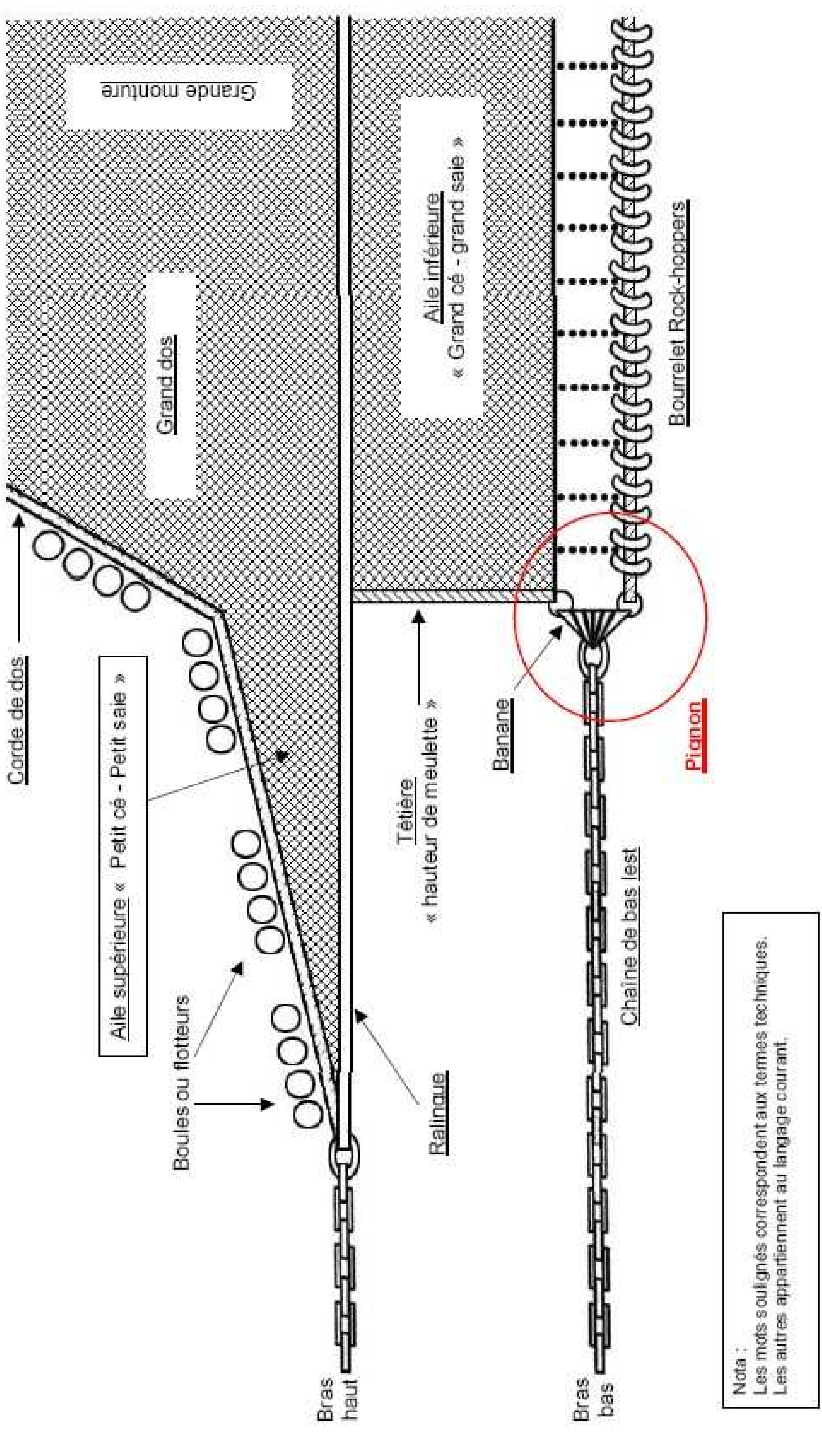
Diagram of the trawl rig

Gréement à fourches « *BUGALED BREIZH* »



Nota :
Les mots soulignés correspondent aux termes techniques.
Les autres appartiennent au langage courant.

Gréement du chalutier « BUGALED BREIZH »



Appendix C

Analysis of the weather conditions

RAPPORT DE SITUATION METEOROLOGIQUE au moment du naufrage du « BUGALED BREIZH »

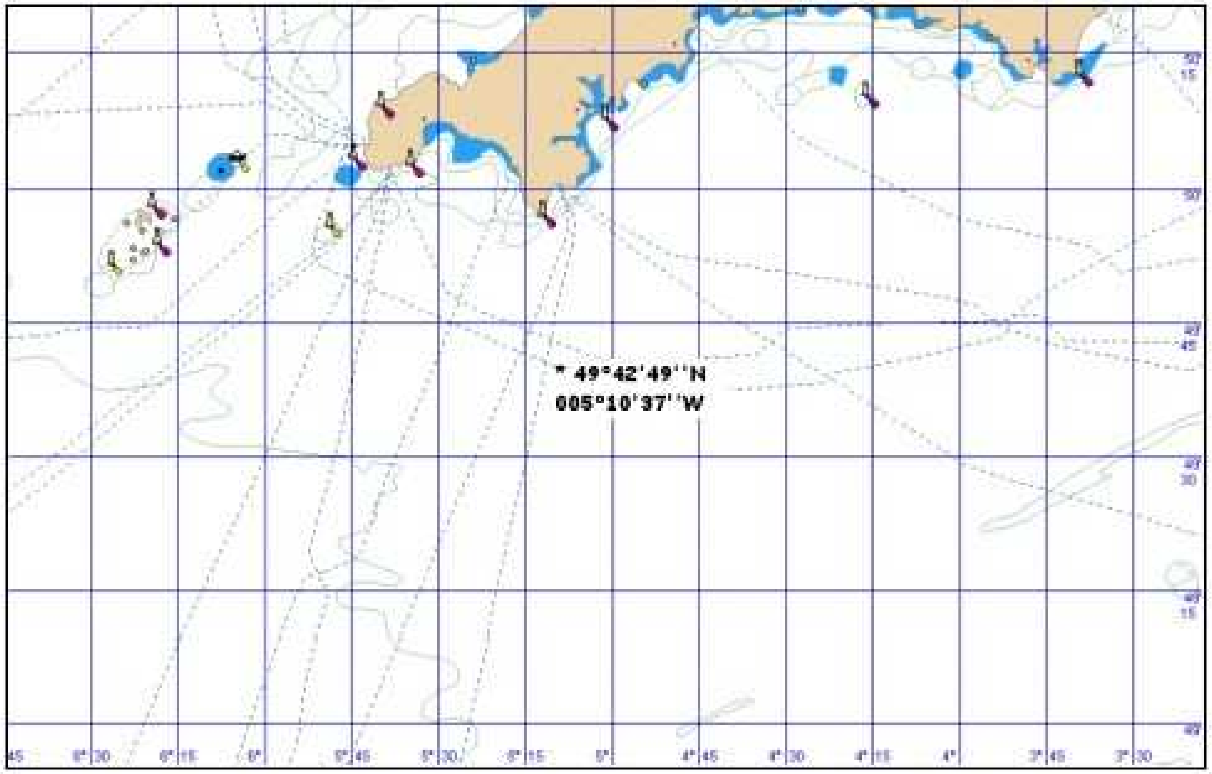
[**Pour** le Bureau des Enquêtes techniques et administratives après Accident et autres évènements de mer (**BEAmer**)]

dans la zone météorologique :

- « Ouessant » (France)
- « Plymouth » (United Kingdom)

Position 49°42'49'' Nord / 005°10'37'' Ouest

le jeudi 15 janvier 2004 à 12h36 UTC



Rendu le 12 mars 2004

Direction de la Prévision, Division « Marine et Océanographie »
42, Avenue G. Coriolis, 31057 Toulouse Cedex
Téléphone : +33 (0)5 61 07 82 40, Télécopie : +33 (0)5 61 07 82 09,
http://www.meteo.fr/marine
Météo-France, Etablissement public administratif sous la tutelle du ministère chargé des Transports

Sommaire

(* CEPMMT = Centre Européen de Prévisions Météorologiques Moyen Terme)

Conditions en mer

dans le sud -est de le sud de la Pointe Lizard (Grande Bretagne)
près de la position 49°42'49'' Nord et 005°10'37'' Ouest
le 15 janvier autour de 12 h 36 UTC :

Situation générale :

La zone du naufrage, avec une pression de l'ordre de 1002 hectoPascals, se situe :
- dans la partie Sud-Est d'une dépression, centrée 983 hPa dans l'Ouest-Nord-Ouest de l'Irlande,
- en bordure Sud du secteur chaud d'une vaste perturbation.

Vent :

Le vent moyen (sur 10 minutes) est de Sud-Sud-Ouest (voisin de 220°), pour une vitesse de 25 à 27 noeuds, soit une force de 6 Beaufort (conforme aux prévisions, tant de Météo France pour la zone « Ouessant », que du Met Office (United Kingdom) pour la zone « Plymouth »).
Les vents instantanés, en rafales, sont estimés atteindre 33 à 37 nœuds.

Mer :

La mer totale est forte, avec des creux de hauteur significative (H1/3) de l'ordre de 3.70 mètres sur la zone considérée.
La mer totale est constituée de deux « trains » de vagues principaux, de directions Sud-Sud-Ouest pour la mer du vent, et Ouest-Nord-Ouest pour la houle, mais de hauteurs significatives relativement proches ; la mer du vent est tout de même prédominante dans la constitution de la mer totale.

Temps :

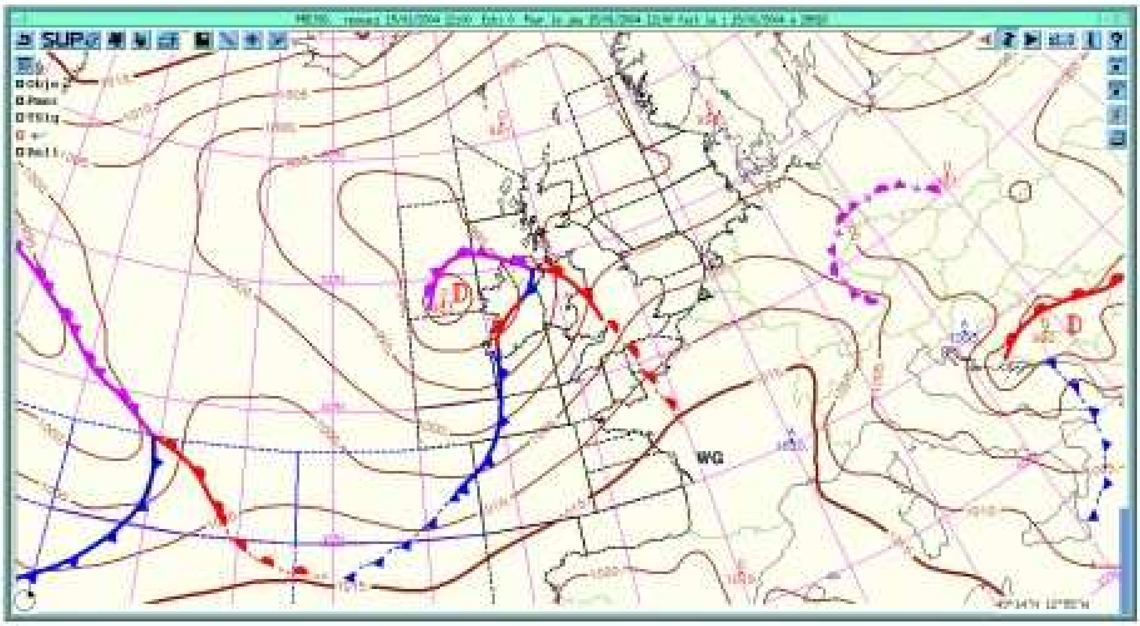
Aucun phénomène dangereux (orages, trombes, ...) n'a été observé durant la période sur la zone considérée, mais le ciel est couvert avec des pluies ou averses intermittentes et faibles autour de la zone et la période considérées, mais pas sur la zone (cf. cartes d'observations et images mosaïque radar pluies).

Visibilité :

La visibilité est bonne ; toutes les observations autour et à proximité de la zone du naufrage sont de l'ordre de 10 à 20 kilomètres et ne sont que faiblement réduites sous les précipitations. L'étude complémentaire ne laisse pas apparaître de facteurs réducteurs de la visibilité (cf. page 19).

Description des conditions sur zone le jeudi 15 janvier 2004 à 12h UTC
dans la zone météorologique « Ouessant » (France) ou « Plymouth » (United Kingdom)
et à la position 49°42'49'' Nord / 005°10'37'' Ouest

Situation générale



Carte d'analyse en surface (Pression mer et frontologie)

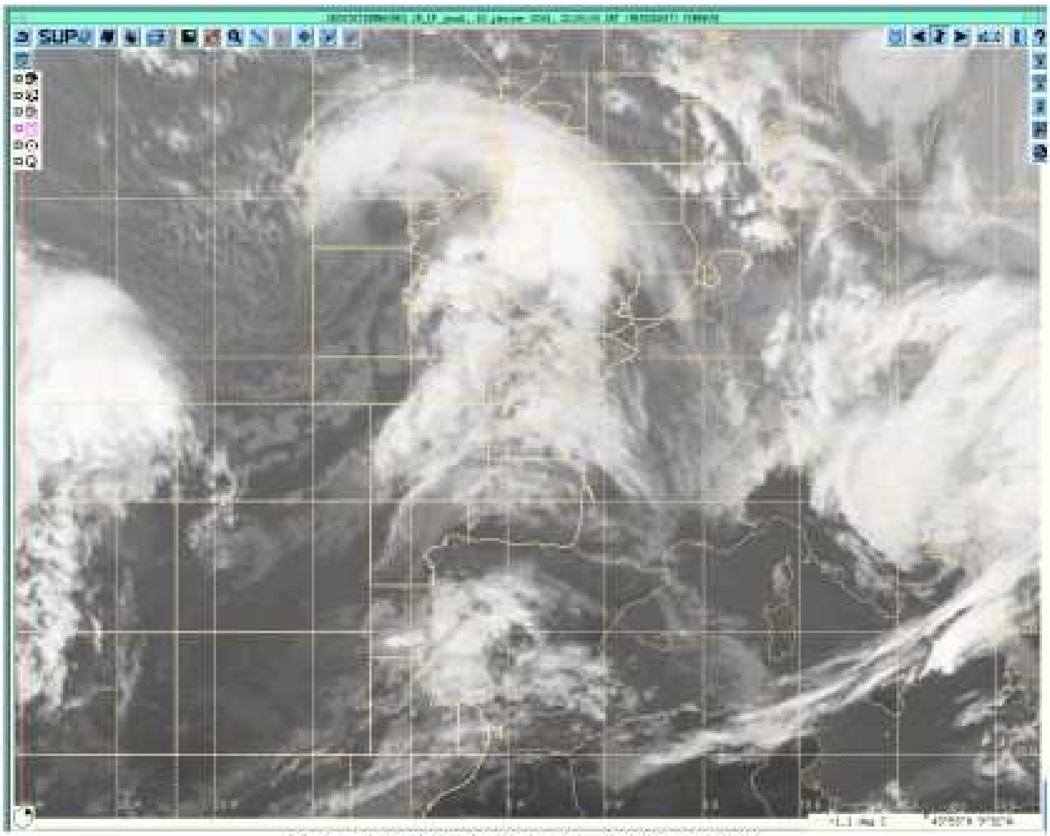
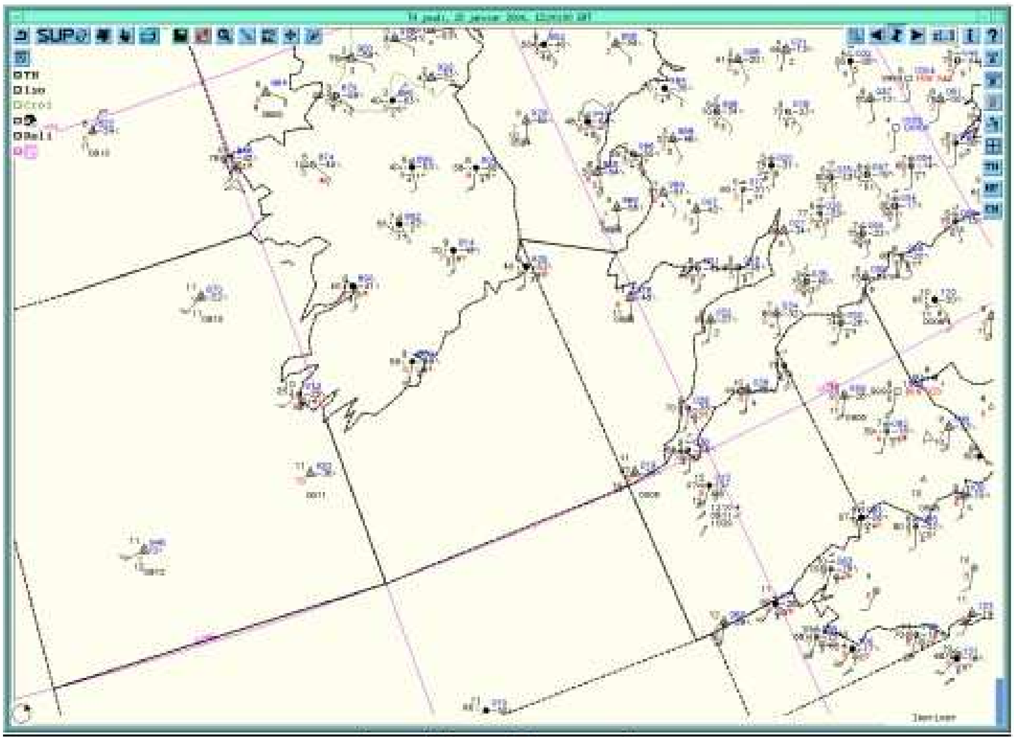


Image satellite Infra rouge (Meteosat 7)



Carte d'observations en surface

Relevés d'Observations maritimes (« Ship » et bouées) dans la zone 48°N à 51°N / 004°W à 007°W

Observations en mer (bouées) (zone prise en compte 48°N à 51°N / 004°W à 007°W)

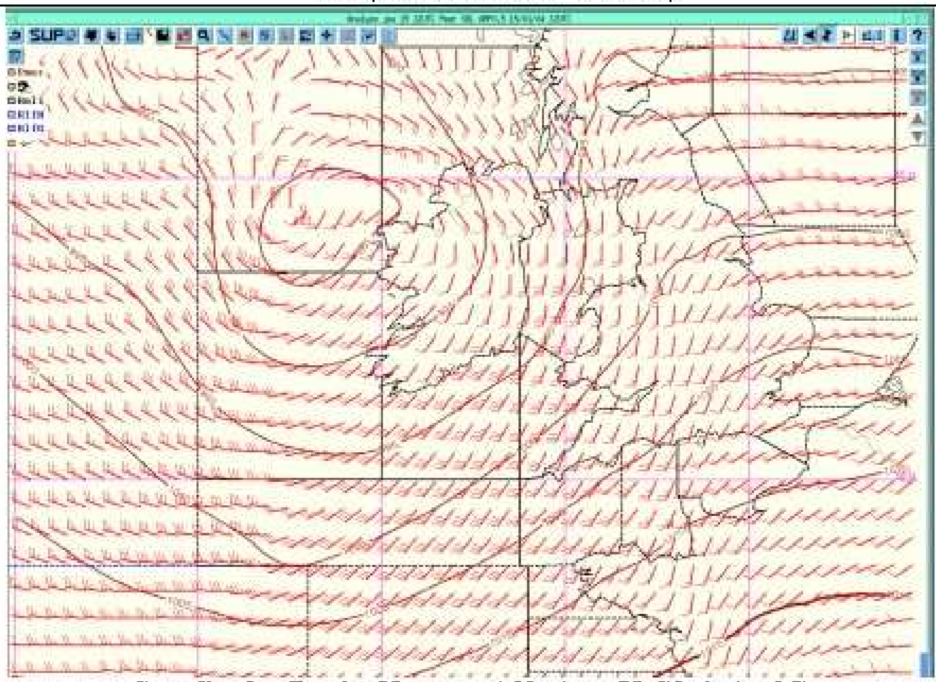
15/01/04 à ... (heure UTC)	Indicatif	Latitude (Nord)	Longitude (Ouest)	Vent		Mer du vent	
				Direction en degré	Vitesse en noeuds	Hauteur (mètres)	Période (secondes)
12 H	Bouée 62052	48°30	005°48	210	23	-	-
12 H	Bouée 62107	50°06	006°06	240	28	3.10	9
13 H	Bouée 62052	48°30	005°48	210	21	-	-
13 H	Bouée 62107	50°06	006°06	230	29	3.60	9

1 seule observation en mer (ship) (zone prise en compte 48°N à 51°N / 004°W à 007°W)

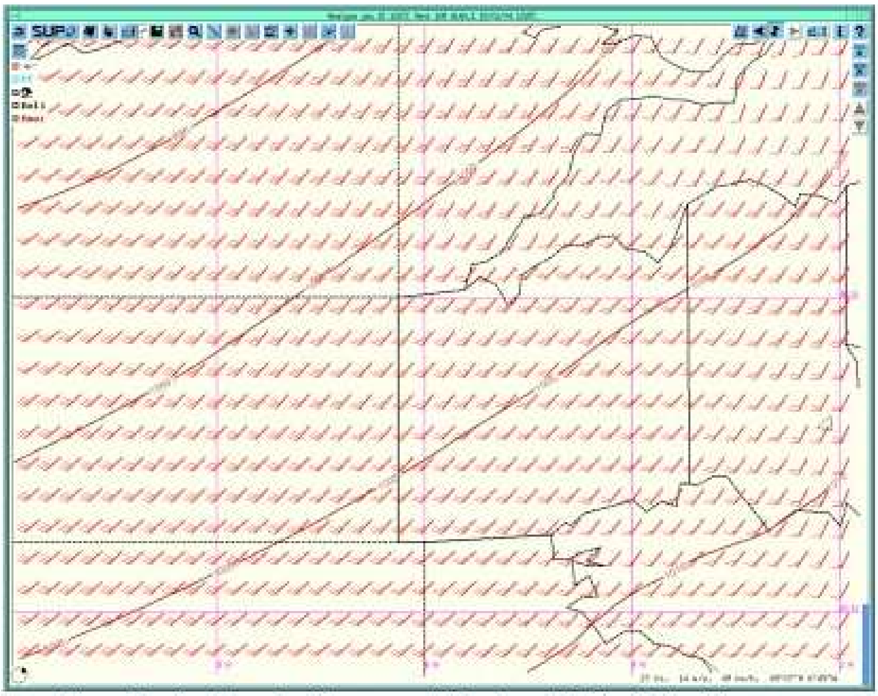
Indicatif KRHX en route au 270° pour 18nds

15/01/04 à ... (heure UTC)	Latitude (Nord)	Longitude (Ouest)	Pression en hPa	Vent		Mer du vent		
				Direction en degré	Vitesse en noeuds	Hauteur (mètres)	Période (secondes)	
12 H	49°42	005°12	1001.2	220	27	5.00	12	
			Ciel	Visibilité / temps présent	Houle primaire			
					Direction (degré)	Hauteur (mètres)	Période (secondes)	
			Couvert	10 à 20 km Brume sèche	250	5.50	8	

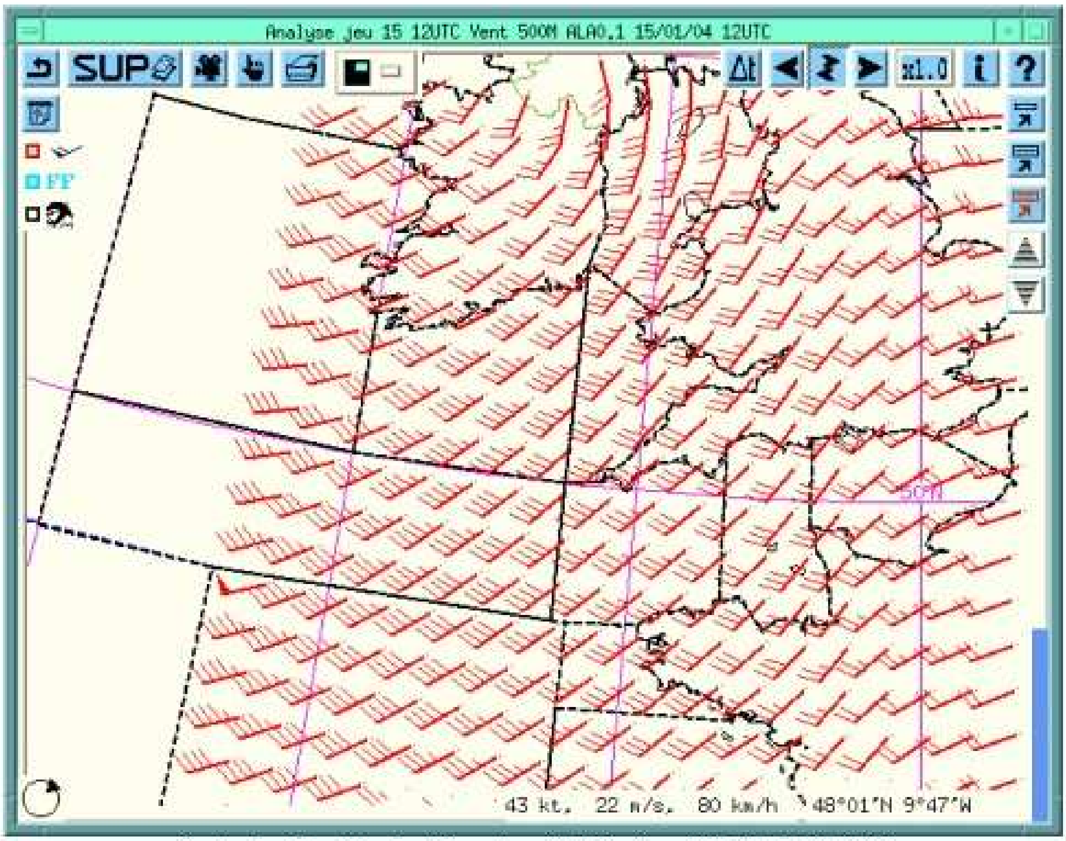
Vent (données de Météo France)



Carte d'analyse Pression Mer et vent à 10 mètres (Modèle Arpège 0.5)



Carte d'analyse Pression Mer et vent à 10 mètres (Modèle Aladin 0.1)



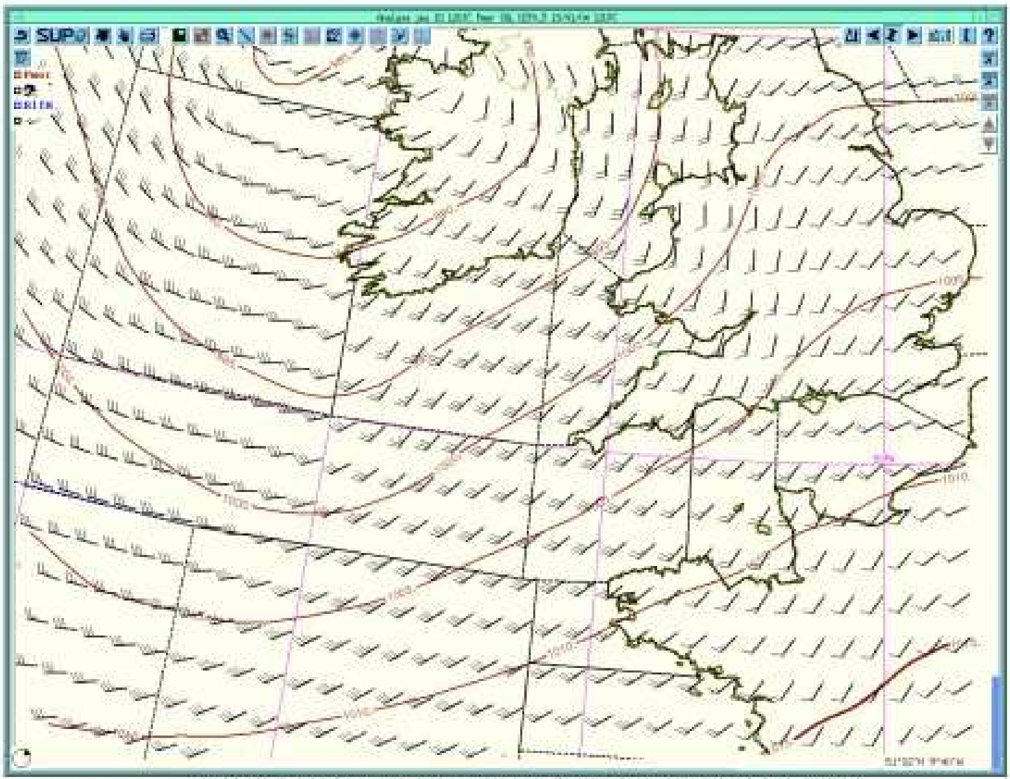
Carte d'analyse Pression Mer et vent à 500 mètres (Modèle Aladin 0.1)

Données analysées (modèle numérique Météo France « Arpège ») :
(données par pas de 1/4 de degré, dans la zone définie entre 50°00 N et 49°00 Nord & 006°00 Ouest et 005°00 Ouest, le 15/01/2004 à 12h UTC

VENT : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	219	219	219	218	216
49°45 Nord	219	221	222	**222**	220
49°30 Nord	219	221	222	223	222
49°15 Nord	217	218	219	221	222
49° 00 Nord	218	217	218	219	219

VENT : vitesse en mètres / seconde					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	14.3	14.0	13.3	13.1	13.3
49°45 Nord	14.0	13.8	13.8	**13.7**	13.5
49°30 Nord	13.6	13.6	13.7	13.8	13.7
49°15 Nord	13.2	13.0	13.2	13.4	13.6
49° 00 Nord	13.0	12.8	12.9	13.0	13.2

Vent (données du CEPMMT)



Carte d'analyse Pression Mer et vent à 10 mètres Modèle CEP 0.5)

Données analysées (modèle numérique météo du CEPMMT) :
(données par pas de 1/4 de degré, dans la zone définie entre 50°00 N et 49°00 Nord & 006°00 Ouest et 005°00 Ouest, le 15/01/2004 à 12h UTC

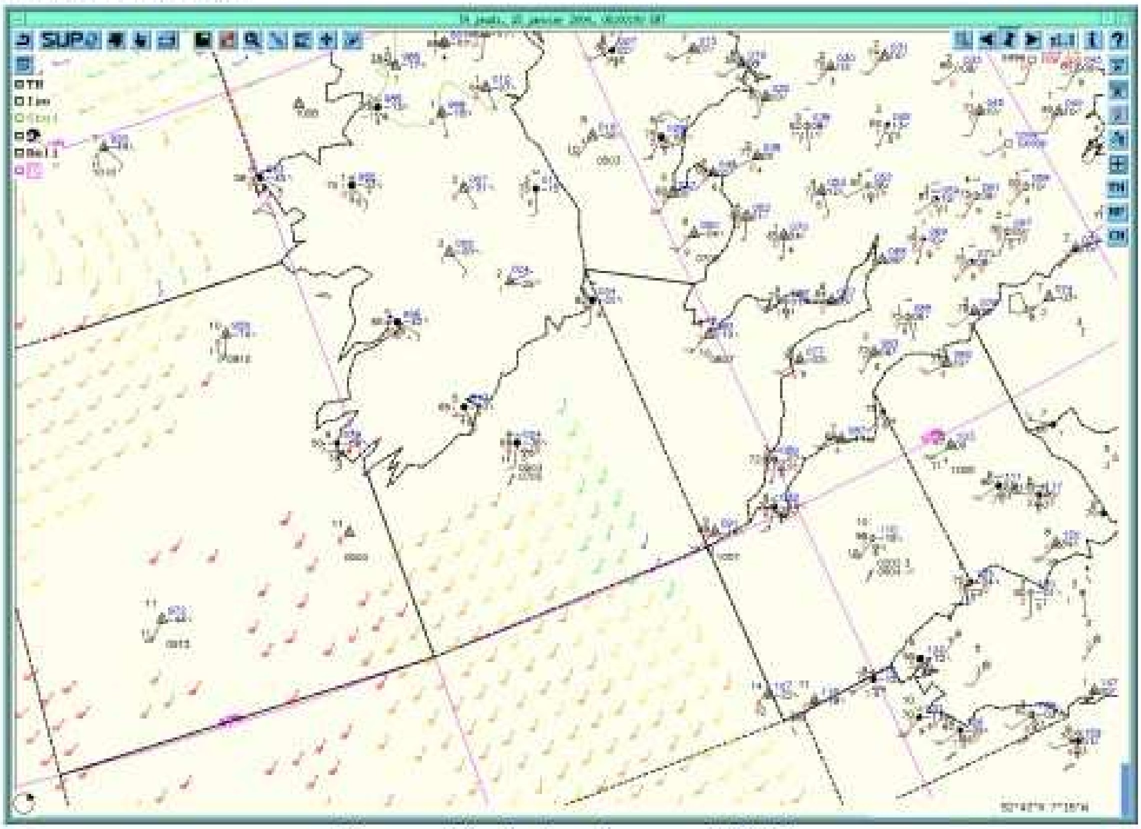
VENT : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	220	220	219	219	219
49°45 Nord	222	221	220	**220**	220
49°30 Nord	223	223	222	222	221
49°15 Nord	224	224	224	223	223
49° 00Nord	225	225	225	225	224

VENT : vitesse en mètres / seconde					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	14.8	14.9	14.9	14.5	14.1
49°45 Nord	14.9	14.9	14.9	**14.7**	14.5
49°30 Nord	15.3	15.2	15.2	14.9	14.7
49°15 Nord	15.6	15.5	15.4	15.1	14.9
49° 00Nord	15.7	15.6	15.5	15.4	15.2

Vent (données Satellite)

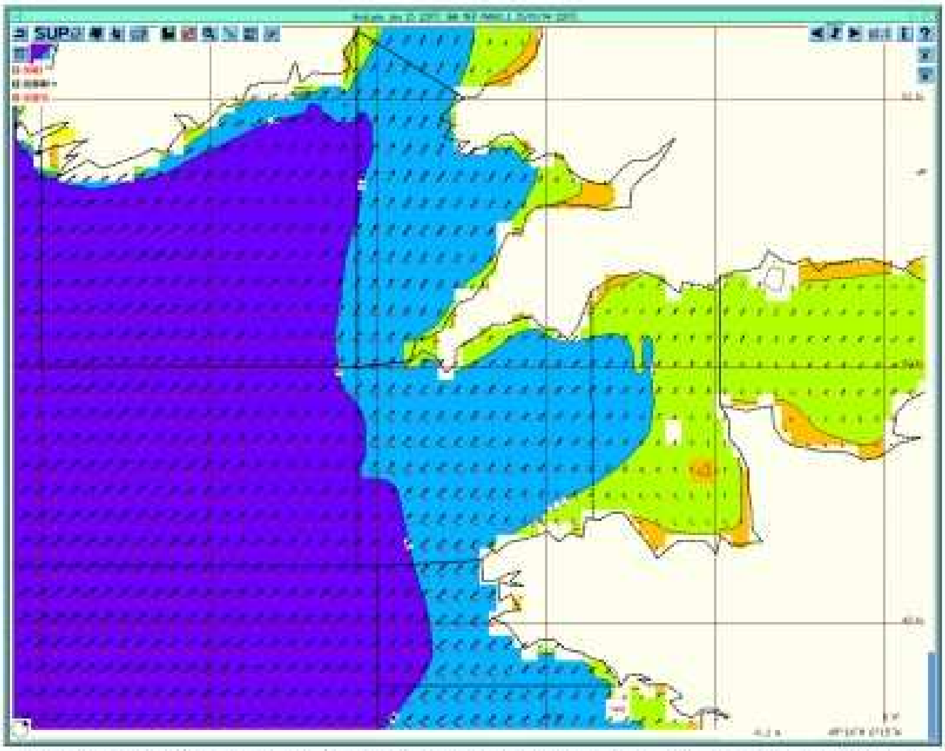
Pas de passage satellite sur la zone autour de 12h UTC

Pour information :



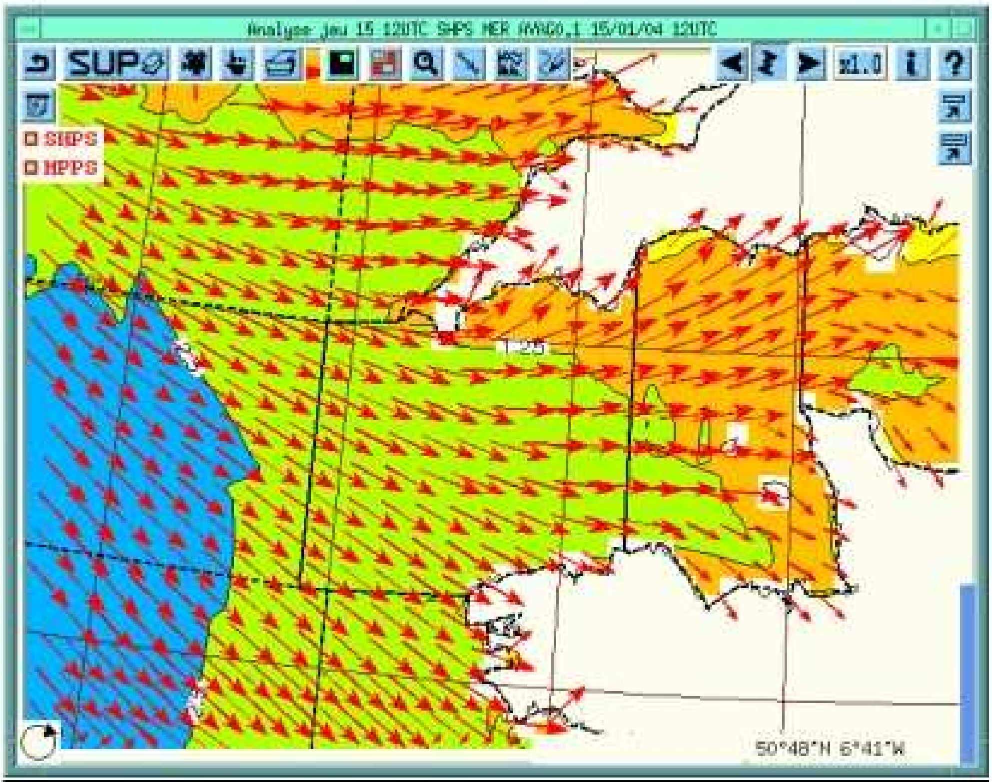
Vents satellite Quikscat (passage de 20h13)

Mer (données de Météo France)

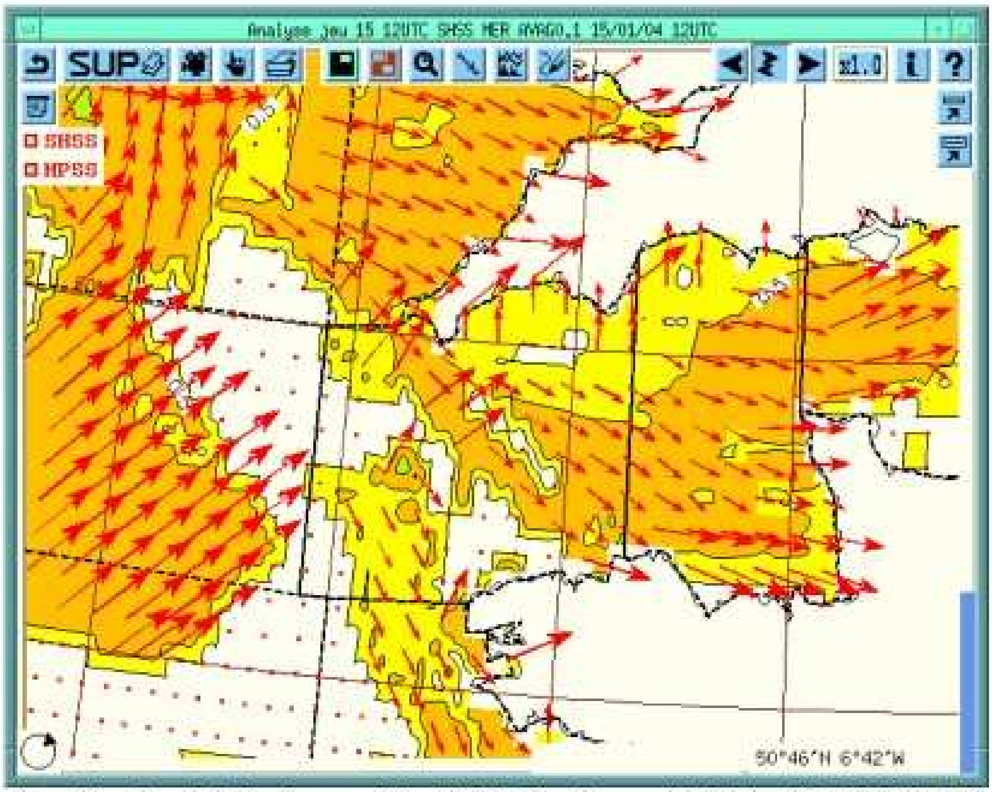


<u>Carte d'analyse de la mer totale [H 1/3, direction et période] (modèle Alad-Vag0.1)</u>

<u>Carte d'analyse de la mer du vent [H 1/3, direction et période] (modèle Alad-Vag0.1)</u>



Carte d'analyse de la houle primaire [H 1/3, direction et période] (modèle Alad-Vag0.1)



Carte d'analyse de la houle secondaire [H 1/3, direction et période] (modèle Alad-Vag0.1)

METEO FRANCE

Données analysées de mer totale, mer du vent, houle primaire et houle secondaire [Hauteur significative (H1/3), direction et période des vagues] du modèle numérique Météo France « Vag » :

(données par pas de 1/4 de degré, dans la zone définie entre 50°00 N et 49°00 Nord & 006°00 Ouest et 005°00 Ouest, le 15/01/2004 à 12h UTC

MER TOTALE : hauteur (H1/3) en mètres					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	4.10	3.98	3.84	-	2.30
49°45 Nord	4.09	3.98	3.91	**3.75**	3.62
49°30 Nord	4.11	3.97	3.93	3.84	3.73
49°15 Nord	4.14	4.02	3.95	3.86	3.73
49° 00 Nord	4.19	4.11	4.00	3.92	3.78

MER TOTALE : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	239	240	240	-	219
49°45 Nord	242	243	244	**241**	239
49°30 Nord	241	247	248	247	246
49°15 Nord	244	248	249	250	250
49° 00 Nord	245	246	248	249	252

MER TOTALE : période en secondes					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	9	9	9	-	7
49°45 Nord	9	9	9	**9**	9
49°30 Nord	9	9	9	9	
49°15 Nord	9	9	9	9	9
49° 00 Nord	9	9	9	9	9

MER DU VENT : hauteur (H1/3) en mètres					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	3.58	3.46	3.33	-	2.14
49°45 Nord	3.48	3.37	3.29	**3.13**	3.07
49°30 Nord	3.37	3.13	3.10	3.04	3.00
49°15 Nord	3.35	3.11	3.04	2.96	2.88
49° 00 Nord	3.37	3.29	3.06	2.98	2.84

MER DU VENT : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	220	220	220	-	215
49°45 Nord	220	220	220	**220**	220
49°30 Nord	215	220	220	220	220
49°15 Nord	215	220	220	220	220
49° 00 Nord	215	215	215	215	220

MER DU VENT : période en secondes					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	8	8	8	-	6
49°45 Nord	8	8	8	**8**	8
49°30 Nord	8	8	8	8	8
49°15 Nord	8	8	8	7	7
49° 00 Nord	8	8	8	7	7

METEO FRANCE

HOULE PRIMAIRE : hauteur (H1/3) en mètres					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	1.65	1.58	1.48	-	0.82
49°45 Nord	1.77	1.72	1.67	**1.76**	1.66
49°30 Nord	1.91	1.90	1.87	1.82	1.76
49°15 Nord	2.43	1.96	1.94	1.90	1.87
49° 00Nord	2.49	2.47	2.55	2.52	2.42

HOULE PRIMAIRE : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	283	281	280	-	229
49°45 Nord	285	284	284	**273**	271
49°30 Nord	287	284	283	282	280
49°15 Nord	295	287	286	285	284
49° 00Nord	297	298	295	294	295

HOULE PRIMAIRE : période en secondes					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	13	13	13	-	11
49°45 Nord	13	13	13	**13**	13
49°30 Nord	13	13	13	13	13
49°15 Nord	11	13	13	13	13
49° 00Nord	11	11	11	11	11

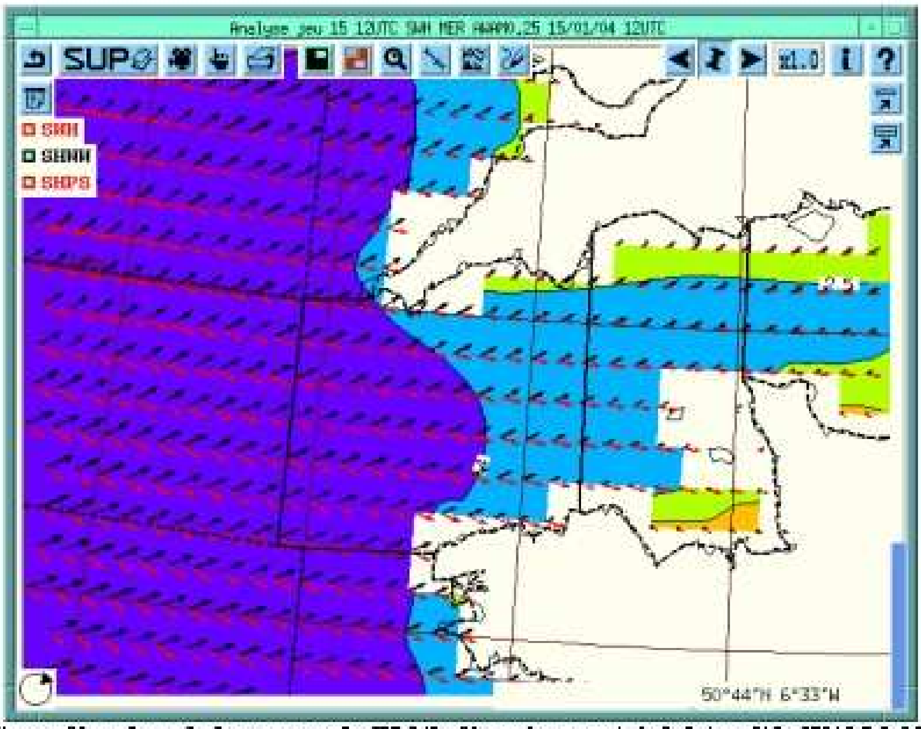
HOULE SECONDAIRE : hauteur (H1/3) en mètres					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	1.10	1.16	1.20	-	0.19
49°45 Nord	1.17	1.23	1.29	**1.08**	0.93
49°30 Nord	1.37	1.41	1.44	1.37	1.28
49°15 Nord	-	1.44	1.48	1.45	1.41
49° 00Nord	-	-	-	-	0.57

HOULE SECONDAIRE : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	309	309	310	-	169
49°45 Nord	310	311	311	**307**	305
49°30 Nord	305	306	307	306	304
49°15 Nord	-	308	309	308	306
49° 00Nord	-	-	-	-	191

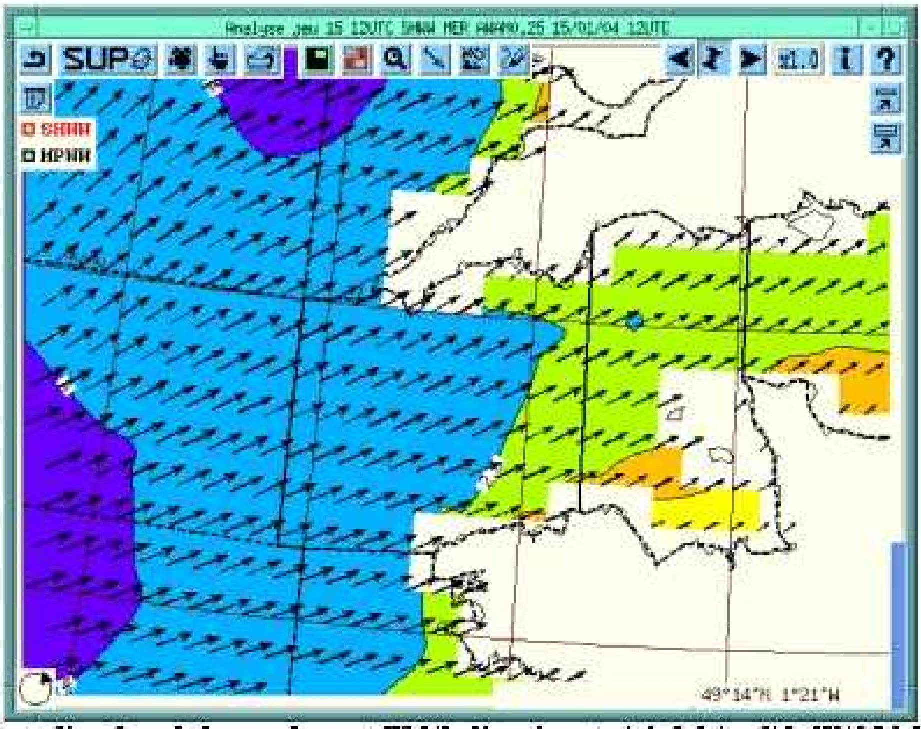
HOULE SECONDAIRE : période en secondes					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	7	7	7	-	8
49°45 Nord	8	7	7	**8**	8
49°30 Nord	8	8	8	8	8
49°15 Nord	-	8	8	8	8
49° 00Nord	-	-	-	-	10

- **Hauteur de la mer totale, de la mer du vent et de la houle (H1/3 - chiffres en mètres)**
- **Période de la mer totale, de le mer du vent et de la houle (chiffres en secondes)**
- **Direction de la mer totale, de la mer du vent et des houles (la direction de propagation indique d'où viennent les vagues)**

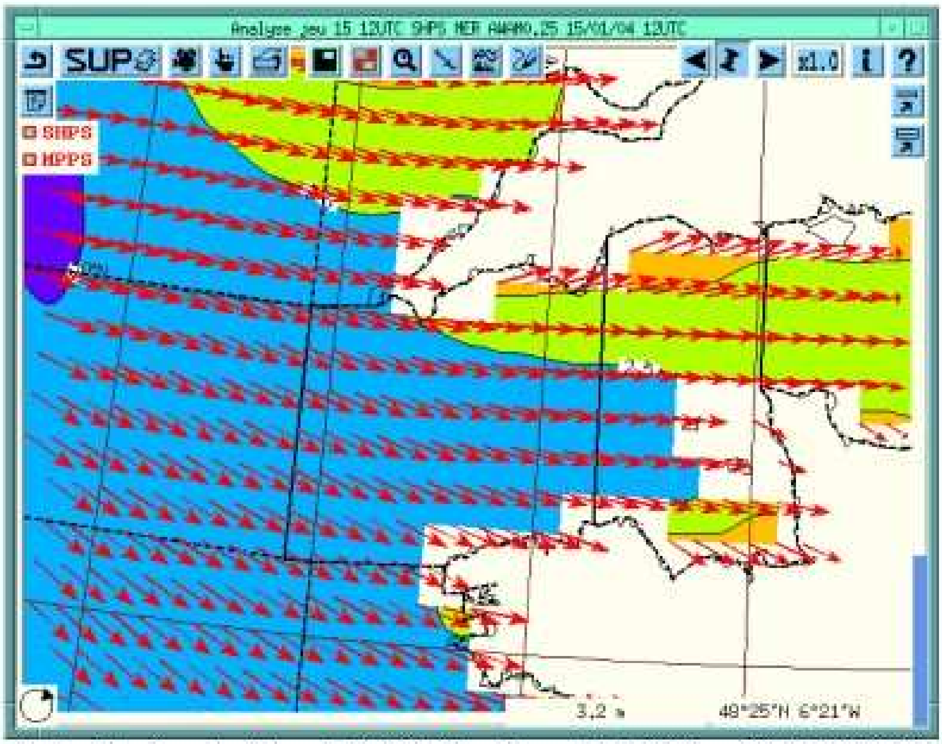
Mer (données du Centre Européen de Prévisions Météorologiques Moyen Terme)



Carte d'analyse de la mer totale [H 1/3, direction et période] (modèle WAM 0.25)



Carte d'analyse de la mer du vent [H 1/3, direction et période] (modèle WAM 0.25)



Carte d'analyse de la houle [H 1/3, direction et période] (modèle WAM 0.25)

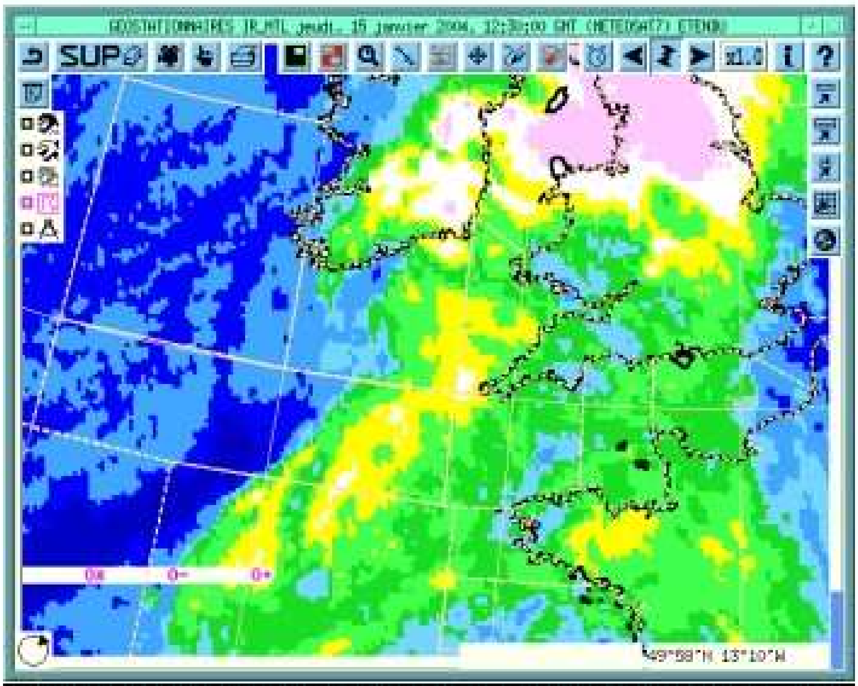
Données analysées de mer totale [Hauteur significative (H1/3), direction et période des vagues] du modèle numérique du CEPMMT « WAM 0.25 » :
(données par pas de 1/4 de degré, dans la zone définie entre 50°00 N et 49°00 Nord & 006°00 Ouest et 005°00 Ouest, le 15/01/2004 à 12h UTC

MER TOTALE : hauteur (H1/3) en mètres					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	3.89	3.77	3.64	3.57	3.53
49°45 Nord	3.92	3.84	3.76	**3.70**	3.66
49°30 Nord	3.94	3.91	3.87	3.83	3.80
49°15 Nord	3.90	3.88	3.85	3.81	3.76
49° 00 Nord	3.86	3.84	3.82	3.82	3.82

MER TOTALE : direction en degrés					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	259	259	258	257	256
49°45 Nord	261	260	260	**260**	260
49°30 Nord	262	262	262	261	261
49°15 Nord	263	263	263	263	263
49° 00 Nord	265	264	264	264	264

MER TOTALE : période en secondes					
15/01/04 à 12h UTC	06°00 Ouest	05°45 Ouest	05°30 Ouest	005°15 Ouest	005°00 Ouest
50°00 Nord	11	11	11	11	11
49°45 Nord	11	11	11	**11**	11
49°30 Nord	11	11	11	11	11
49°15 Nord	11	11	11	11	11
49° 00 Nord	11	11	11	11	11

Temps



Loupe sur image satellite Infra rouge (Meteosat 7 / Météotel CMC)

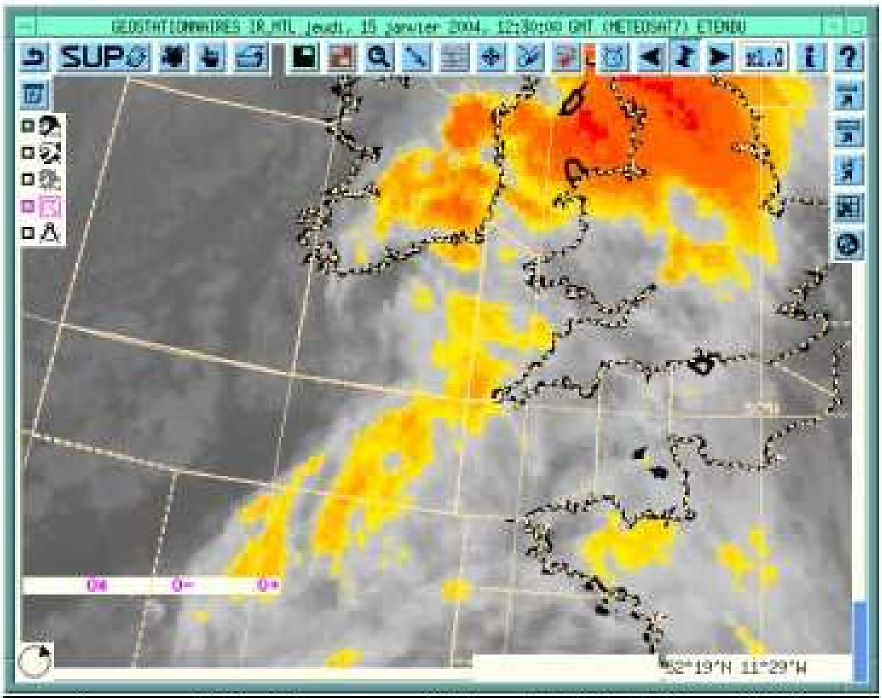


Image satellite Infra rouge (Meteosat 7 /) T<-40 deg.C AF)

Nota : Les zones colorées en rose, blanc et jaune (image Météotel CMC) et en rouge, orange et jaune (image T<-40°C AF) indiquent la présence de nuages « froids », élevés ou d'extension verticale importante et, par voie de conséquence dans ce dernier cas, peuvent être associés à des zones de précipitations plus importantes.

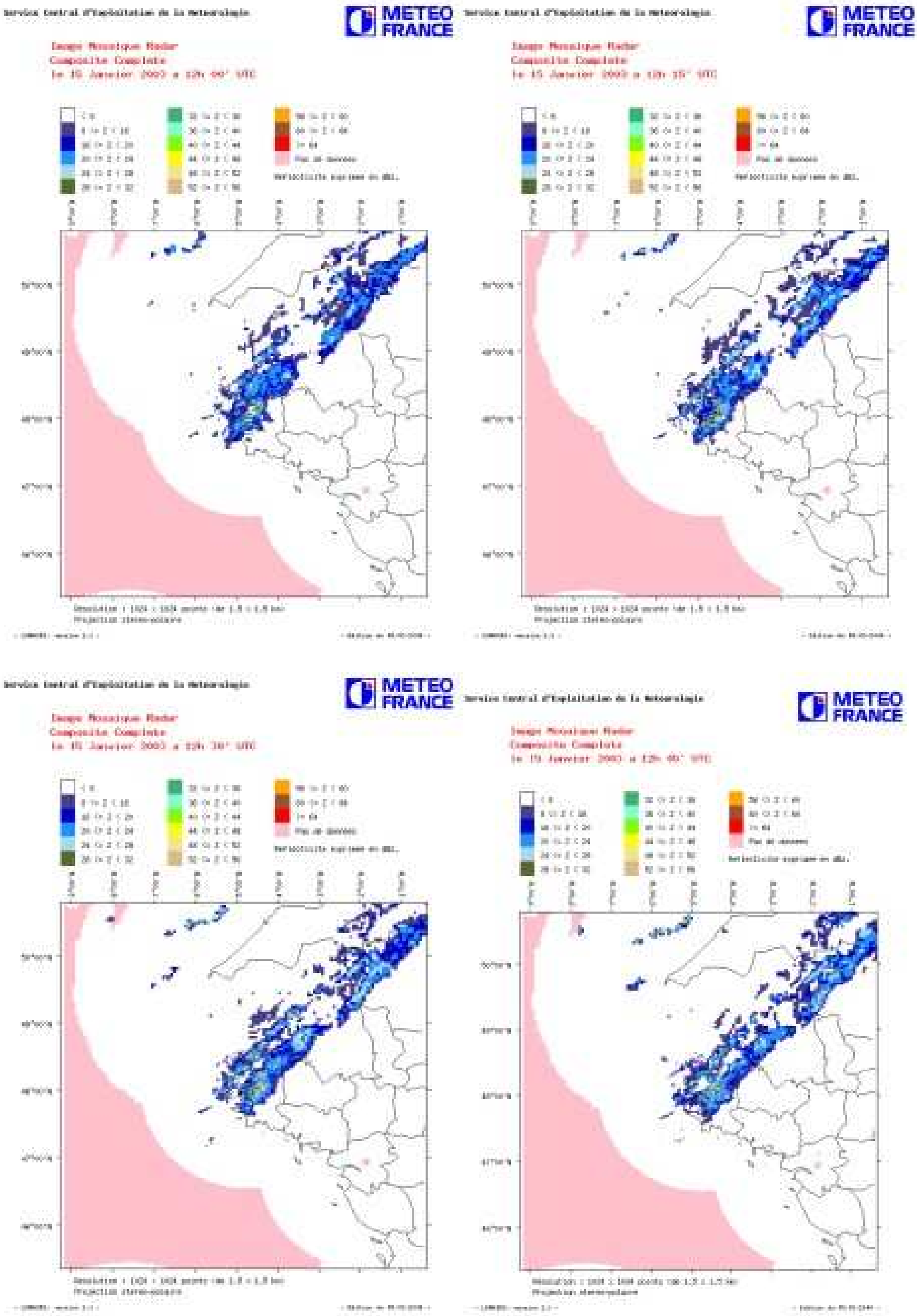


Image Mosaïque Radar Pluies – Le 15 janvier 2004 de 12h00 UTC à 12h45 UTC

METEO FRANCE

Visibilité (information complémentaire)

<u>Recherche liée aux observations terrestres et maritimes et aux images satellites et radar mosaïque pluies :</u>
Les observations terrestres et maritimes indiquent des visibilités de l'ordre de 10 à 20 kilomètres, réduites 8 à 9 kilomètres sous précipitations (cf. Page 6).
L'observation du bateau d'indicatif KRHX, la seule à proximité de la zone considérée à 12h UTC, signale également de bonnes visibilités, malgré le chiffrement erronée de brume sèche.
Les images radar mosaïque pluies de 12h UTC, 12h15 UTC, 12h30 UTC et 12h45 UTC ne font pas apparaître de pluies sur la zone considérée (cf. Page 18).

<u>Recherche liée aux températures :</u>
Les températures de la mer observées aux abords de la zone considérée sont de 11 à 12°C. Les températures du point de rosée (Td) sont comprises entre 7 et 9°C.
La masse d'air plus froide que la surface océanique sous jacente ne favorise pas la formation de brumes ou de brouillard « d'advection ».

<u>Recherche liée aux produits expérimentaux d'étude de la visibilité Nimrod :</u>

Les produits de visibilité Nimrod de la journée du 15 janvier 2004 ont été désarchivés et mis à disposition, via le service de Météo-France - Direction de la Prévision / Prévision Immédiate. les fichiers consultés donnent les visibilités analysées et la probabilité d'occurrence de visibilités inférieures à 5000 mètres, 1000 mètres et 200 mètres.

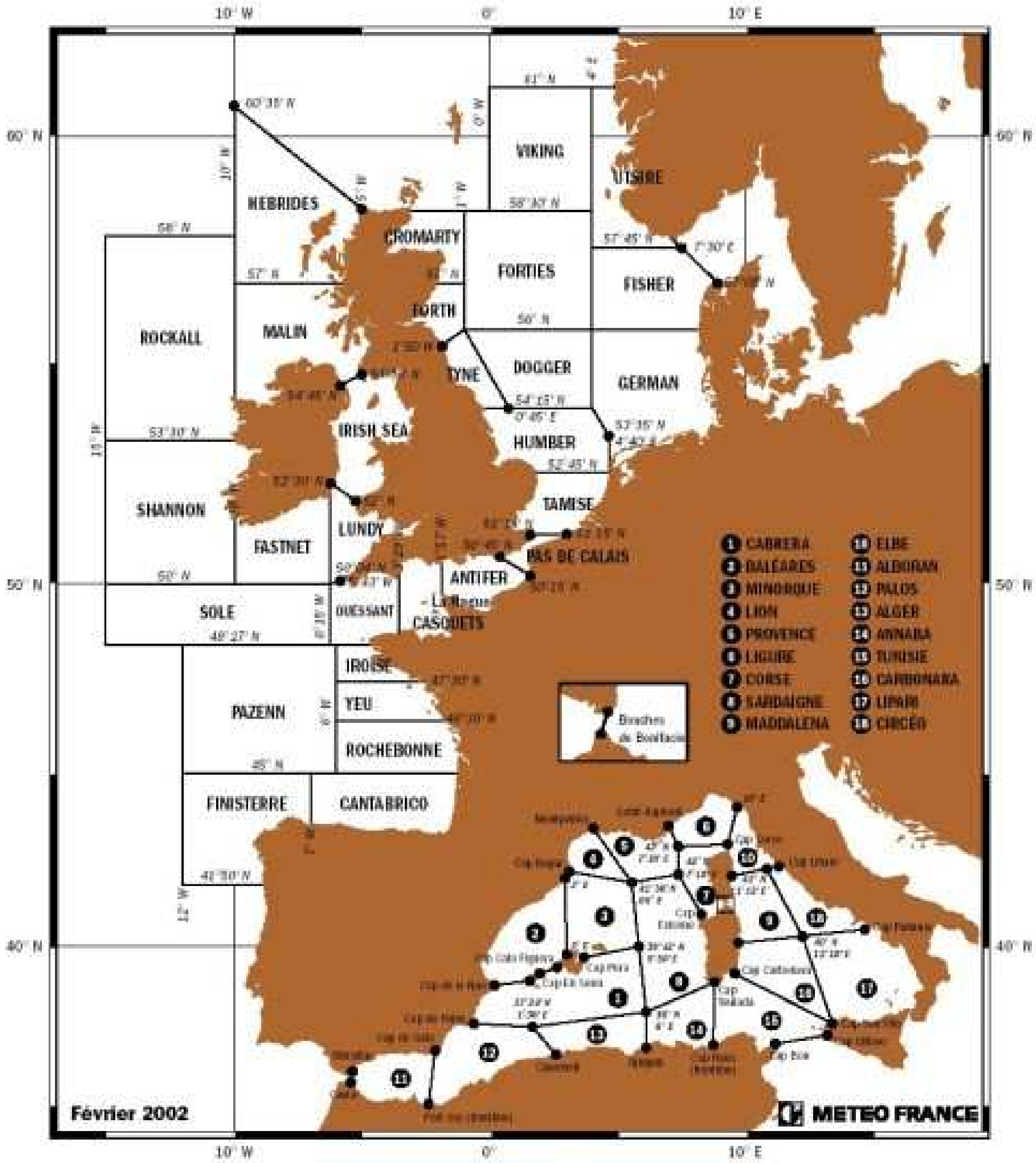
En ce qui concerne l'usage de ces données :
- Le Met Office (UK) met ces informations à disposition de Météo France pour l'expérimentation et l'évaluation des produits de visibilité Nimrod avec la Direction Inter Régionale de la région Nord et Roissy (action engagée dans le cadre du projet Concorde). Ces données ne peuvent apparaître dans ce rapport mais, si nécessaire, la demande peut en être faite officiellement au Met Office.
- D'autre part, une des principales conclusions de l'expérimentation, est que l'analyse de visibilité Nimrod présente peu de capacité à la spatialisation des faibles visibilités. La qualité de la visibilité en un point est fortement liée à la disponibilité d'une observation sol en ce point, ce qui n'est pas le cas dans ce rapport.

Néanmoins et en conclusion, l'étude des produits de visibilité Nimrod, même imparfaits à ce jour, renforce la probabilité d'absence de mauvaises visibilités dans la zone et pour la période considérées.

Bulletins de prévisions météorologiques des 14 et 15 janvier 2004
Météo France

Définition des zones

Zones "large"



Bulletins de prévisions météorologiques pour la zone considérée
le 14 janvier 2004
(Extraits des bulletins « Large » / Météo France : zone « Ouessant »)

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WHFX43 LFPW 140317
NAVTEX MBI178
TXT
FFFF
ORIGINE METEO-FRANCE
BMS LARGE ATLANTIQUE nr 26
du mercredi 14 janvier 2004 a 03 UTC
annule et remplace le nr 25

Coup de vent a tempete large pour CASQUETS, **OUESSANT**, IROISE, YEU, ROCHEBONNE, CANTABRICO, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, ROCKALL.

Situation generale le mercredi 14 janvier 2004 a 00 UTC et evolution :
Depression 993 hPa a 100 milles a l'ouest de l'Irlande, se decale vers le sud-est a 30 nds, prevue 991 hPa sur le nord de la France le soir, puis s'evacue vers l'Europe centrale.
Vaste systeme depressionnaire 980 hPa entre l'Ecosse et L'Islande evoluant peu.

CASQUETS, **OUESSANT**
Imminent et valable jusqu'au 15.00UTC
Sud-ouest 8 a 9, virant Ouest a Nord-Ouest 8 a 10 le matin. Fortes rafales. Mer grosse.
...
BT
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WHFX43 LFPW 141659
NAVTEX MBI183
TXT
FFFF
ORIGINE METEO-FRANCE
BMS LARGE ATLANTIQUE nr 27
du mercredi 14 janvier 2004 a 1700 UTC
annule et remplace le nr 26

Coup de vent a fort coup de vent large en cours ou prevu pour :
Coup de vent a tempete large pour CASQUETS, **OUESSANT**, IROISE, YEU, ROCHEBONNE, CANTABRICO, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, ROCKALL.

Situation generale le mercredi 14 janvier 2004 a 12 UTC et evolution :
Depression relative 992 hPa sur le sud de l'Angleterre, s'evacue rapidement vers l'est.
Depression 992 hPa centree 1000 milles a l'ouest de l'Irlande, se deplace rapidement vers le nord-est en se creusant, elle est prevue 984 hPa au nord-ouest immediat de l'Irlande demain midi.

CASQUETS, **OUESSANT**, IROISE
En cours jusqu'au jusqu'au 14 a 21UTC.
Nord-Ouest 8 passagerement 9. Fortes rafales. Mer parfois grosse, s'attenuant.
Reprise du 15 a 15UTC au 15 a 21UTC au moins.
Sud-ouest 8, passagerement 9. Rafales.
...
BT

METEO FRANCE

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ZCZC
FQFX41 LFRN 141824
ORIGINE: METEO-FRANCE TOULOUSE

Rappel: prière de citer l'origine du bulletin: METEO-FRANCE

Bulletin large du mercredi 14 janvier 2004 à 18h UTC pour l'Atlantique au nord

du 46.5N, l'ouest de la Manche et le golfe de Gascogne.

- Vitesse du vent en échelle Beaufort - Mer : Significative totale -

1/ BMS large numéro 27.
Coup de vent à fort coup de vent large en cours ou prévu pour :
CASQUETS, **OUESSANT**, IROISE, YEU, ROCHEBONNE, CANTABRICO, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, ROCKALL.

2/ Situation générale le mercredi 14 janvier 2004 à 12h UTC et évolution:
Dépression relative 992 hPa sur le sud de l'Angleterre, s'évacue rapidement vers l'est.
Vaste zone dépressionnaire 981 hPa entre l'Ecosse et l'Islande se décale progressivement vers le sud.
Dépression atlantique, 992 hPa centrée 1000 milles à l'ouest de l'Irlande, se déplaçant rapidement vers le nord-est en se creusant, elle est prévue 984 hPa au nord-ouest immédiat de l'Irlande demain midi en fusionnant avec le système précédent.
Anticyclone 1024 hPa sur la Péninsule ibérique, s'affaiblit légèrement.
Nouvelle dépression relative prévue 1012 hPa au large du Portugal demain midi.

3/ Prévisions par zones valables jusqu'au jeudi 15 janvier à 18h UTC:
CASQUETS, **OUESSANT**, IROISE :
Nord-ouest 6 à 8, mollissant secteur Ouest 4 à 5 cette nuit, puis fraîchissant progressivement Sud-ouest 6 à 8 demain. Fortes rafales. Mer forte à très forte,
s'atténuant temporairement. Grains au début, pluie à la fin.
...

4/ Tendance pour les 24 heures suivantes :
Dépressions sur les îles britanniques, coup de vent à fort coup de vent sur la Manche, golfe de Gascogne et ouest Irlande.

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Bulletins de prévisions météorologiques pour la zone considérée le 15 janvier 2004
(Extraits des bulletins « Large » / Météo France : zone « Ouessant »)

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WHFX43 LFPW 150447
NAVTEX MBI187
TXT
FFFF
ORIGINE METEO-FRANCE
BMS LARGE ATLANTIQUE nr 28
du jeudi 15 janvier 2004 a 0450 UTC
annule et remplace le nr 27

Coup de vent a fort coup de vent large en cours ou prevu pour :
CASQUETS, **OUESSANT**, IROISE, YEU, ROCHEBONNE, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, IRISH SEA, ROCKALL, MALIN.

Situation generale le jeudi 15 janvier 2004 a 00 UTC et evolution :
Depression 992 hPa a 400 milles a l'ouest de l'Irlande, se decale rapidement vers l'est en se creusant, elle est prevue 983 hPa a l'ouest immediat de l'Irlande a midi puis 979 hPa sur le nord de la Mer d'Irlande la nuit prochaine, et 977 hPa au centre de la Mer du Nord demain matin.

CASQUETS, **OUESSANT**
Valable du 15/15UTC au 16/09UTC
Sud-ouest 8 a 9 virant Ouest 8 la nuit. Fortes rafales. Mer localement grosse.
...
BT
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ZCZC
FQFX41 LFRN 150545
ORIGINE: METEO-FRANCE TOULOUSE

Rappel: prière de citer l'origine du bulletin: METEO-FRANCE

Bulletin large du jeudi 15 janvier 2004 à 06h UTC pour l'Atlantique au nord du 46.5N, l'ouest de la Manche et le golfe de Gascogne.

- Vitesse du vent en échelle Beaufort - Mer : Significative totale -

1/ BMS large numero 28
Coup de vent à fort coup de vent large en cours ou prévu pour : CASQUETS, **OUESSANT**, IROISE, YEU, ROCHEBONNE, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, IRISH SEA, ROCKALL, MALIN.

2/ Situation générale le jeudi 15 janvier 2004 à 00h UTC et évolution:
Dépression 992 hPa à 400 milles à l'ouest de l'Irlande, se décale rapidement vers l'est en se creusant, elle est prévue 983 hPa à l'ouest immédiat de l'Irlande à midi puis 979 hPa sur le nord de la Mer d'Irlande la nuit prochaine, et 977 hPa au centre de la Mer du Nord demain matin.
Vaste zone dépressionnaire 987 hPa au nord de l'Ecosse et l'Islande se décale progressivement vers le sud et fusionne avec la précédente dépression cet après-midi.
Anticyclone 1020 hPa sur la Péninsule ibérique, s'affaiblit légèrement.

3/ Prévisions par zones valables jusqu'au vendredi 16 janvier à 06h UTC:

CASQUETS, **OUESSANT**, IROISE :
Revenant Sud-ouest 4 à 6 ce matin, puis fraîchissant par l'ouest 5 à 7 en mi-journée et 8 à 9 cet après-midi, virant Ouest 7 à 8 la nuit. Fortes rafales. Mer forte devenant très forte, localement grosse en Manche. Pluie et averses, parfois orageuses.
...

4/ Tendance pour les 24 heures suivantes :
Le flux, assez fort, s'oriente au nord-ouest et fraîchissant par l'ouest à partir de vendredi après-midi. Menace de grand frais à coup de vent sur toutes les zones à partir de vendredi soir.

TERMINE
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WHFX43 LFPW 151647
NAVTEX MBI191
TXT
FFFF
ORIGINE METEO-FRANCE
BMS LARGE ATLANTIQUE nr 29
du jeudi 15 janvier 2004 a 1645 UTC
annule et remplace le nr 28

Coup de vent a fort coup de vent large en cours ou prevu pour
CASQUETS, **OUESSANT**, IROISE, YEU, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, IRISH SEA, ROCKALL, MALIN.

Situation generale le jeudi 15 janvier 2004 a 12 UTC et evolution :
Depression 984 hPa a l'ouest immediat de l'Irlande, se decale vers l'est en se creusant, prevue 980 hPa sur l'Angleterre cette nuit vers 00h UTC et 978 hPa en Mer du Nord demain.

CASQUETS, **OUESSANT**
En cours jusqu'au 16/06UTC
Sud-ouest 8 passagerement 9 au debut, virant Ouest la nuit. Fortes rafales. Mer localement grosse.
...
BT
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ZCZC
FQFX41 LFRN 151752
ORIGINE: METEO-FRANCE TOULOUSE

Rappel: prière de citer l'origine du bulletin: METEO-FRANCE

Bulletin large du jeudi 15 janvier 2004 à 18h UTC pour l'Atlantique au nord du 46.5N, l'ouest de la Manche et le golfe de Gascogne.

- Vitesse du vent en échelle Beaufort - Mer : Significative totale -

1/ BMS large numero 29

Coup de vent à fort coup de vent large en cours ou prévu pour CASQUETS, **OUESSANT**, IROISE, YEU, PAZENN, SOLE, SHANNON, FASTNET, LUNDY, IRISH SEA, ROCKALL, MALIN

2/ Situation générale le jeudi 15 janvier 2004 à 12h UTC et évolution:

Dépression 984 hPa à l'ouest immédiat de l'Irlande, se décale vers l'est en se creusant, prévue 980 hPa sur l'Angleterre cette nuit vers 00h UTC et 978 hPa en Mer du Nord demain.
Anticyclone 1020 hPa sur la Péninsule ibérique, s'affaiblit légèrement.
Pluie ou averses pour toutes les zones.

3/ Prévisions par zones valables jusqu'au vendredi 16 janvier à 18h UTC:

CASQUETS, **OUESSANT** :
Ouest à Sud-ouest 7 à 8 passagèrement 9 au début avec fortes rafales, mollissant Ouest 5 à 6 le matin, puis 4 à 5 l'après-midi l'après-midi. Fortes rafales. Mer devenant très forte localement grosse sur OUESSANT.
...

4/ Tendance pour les 24 heures suivantes :
Menace de coup de vent de Nord-ouest pour toutes les zones.

TERMINE
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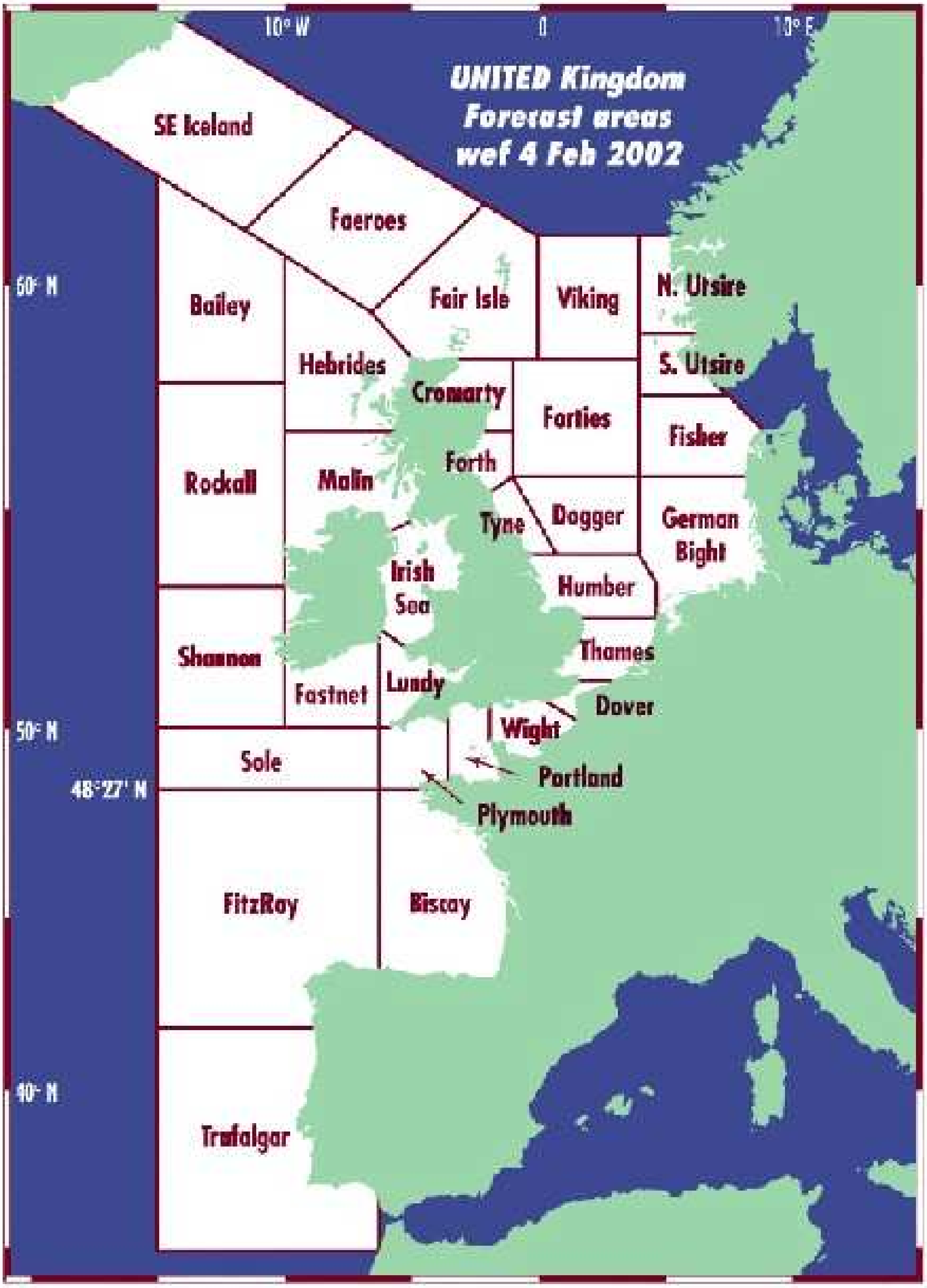
Bulletins de prévisions météorologiques des 14 et 15 janvier 2004
Met Office [United Kingdom]

Définition des zones



METEO FRANCE

Bulletins de prévisions météorologiques pour la zone considérée
le 14 janvier 2004
(Extraits des bulletins « off shore » / Met Office [United Kingdom] ; zone « Plymouth »)

FPUK71 EGRR 140900
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET.OFFICE
AT 1130 ON WEDNESDAY 14 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA SHANNON ROCKALL BAILEY FAEROES SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT 0600
LOW LUNDY 993 MOVING STEADILY EAST WITH LITTLE CHANGE. LOW BAILEY 978 EXPECTED FAIR ISLE 987 BY 0600 TOMORROW

THE AREA FORECASTS FOR THE NEXT 24 HOURS
...
WIGHT PORTLAND **PLYMOUTH**
WEST OR NORTHWEST BACKING SOUTHWEST 7 TO SEVERE GALE 9. SHOWERS THEN RAIN. GOOD
...

WOUK50 EGRR 140955
$NMC GALE WARNING

GALE WARNING WEDNESDAY 14 JANUARY 0955 GMT 03
...
PORTLAND **PLYMOUTH**
GALE FORCE 8 VEERING NORTHWESTERLY AND INCREASING SEVERE GALE FORCE 9 IMMINENT
...

FPUK71 EGRR 141500
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET.OFFICE
AT 1725 ON WEDNESDAY 14 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA SHANNON ROCKALL BAILEY FAEROES SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT MIDDAY
LOW FAEROES 980 EXPECTED HEBRIDES 987 BY MIDDAY TOMORROW. ATLANTIC LOW MOVING RAPIDLY EAST EXPECTED WESTERN IRELAND 987 BY SAME TIME. LOW SOUTHERN ENGLAND 992 MOVING RAPIDLY EAST AND FILLING

THE AREA FORECASTS FOR THE NEXT 24 HOURS
...
WIGHT PORTLAND **PLYMOUTH**
NORTHWEST BACKING SOUTHWEST 7 TO SEVERE GALE 9 DECREASING 6 FOR A TIME. SHOWERS THEN RAIN. GOOD
...

WOUK50 EGRR 141600
$NMC GALE WARNING

GALE WARNING WEDNESDAY 14 JANUARY 1600 GMT 04

WIGHT PORTLAND **PLYMOUTH**
NORTHWESTERLY SEVERE GALE FORCE 9 DECREASING GALE FORCE 8 IMMINENT
...

FPUK71 EGRR 142100
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET. OFFICE
AT 0015 ON THURSDAY 15 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA SHANNON BAILEY FAEROES AND SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT 1800
LOW FAEROES 984 AND FAIR ISLE 986 MERGING EXPECTED HEBRIDES 987 BY 1800 THURSDAY. LOW 450 MILES WEST OF SHANNON 991 EXPECTED IRISH SEA 982 BY SAME TIME. LOW HOLLAND 990 MOVING RAPIDLY EAST AND FILLING

THE AREA FORECASTS FOR THE NEXT 24 HOURS
...
PLYMOUTH
WEST OR SOUTHWEST 6 TO GALE 8, OCCASIONALLY SEVERE GALE 9. RAIN OR SHOWERS. GOOD OCCASIONALLY MODERATE
...

WOUK50 EGRR 142150
$NMC GALE WARNING

GALE WARNING WEDNESDAY 14 JANUARY 2150 GMT 05

...
PLYMOUTH
GALE FORCE 8 BACKING SOUTHWESTERLY AND INCREASING SEVERE GALE FORCE 9 SOON
...

Bulletins de prévisions météorologiques pour la zone considérée
le 15 janvier 2004
(Extraits des bulletins « off shore » / Met Office [United Kingdom] ; zone « Plymouth »)

FPUK71 EGRR 150300
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET. OFFICE
AT 0505 ON THURSDAY 15 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** THAMES DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA SHANNON ROCKALL BAILEY FAEROES AND SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT MIDNIGHT
LOW 200 MILES WEST OF SHANNON 989 EXPECTED IRISH SEA 978 BY MIDNIGHT TONIGHT. LOW 250 MILES WEST OF SOLE 995 EXPECTED HUMBER 981 BY SAME TIME. LOW FAIR ISLE 987 LOSING ITS IDENTITY

THE AREA FORECASTS FOR THE NEXT 24 HOURS
...
WIGHT PORTLAND **PLYMOUTH** NORTH BISCAY
MAINLY WEST OR SOUTHWEST 6 TO GALE 8, OCCASIONALLY SEVERE GALE 9. RAIN OR SQUALLY SHOWERS. GOOD OCCASIONALLY MODERATE
...

WOUK50 EGRR 150400
$NMC GALE WARNING

GALE WARNING THURSDAY 15 JANUARY 0400GMT 06

THAMES
SOUTHWESTERLY GALE FORCE 8 EXPECTED SOON

DOVER
GALE FORCE 8 BACKING SOUTHWESTERLY SOON

WIGHT
GALE FORCE 8 BACKING SOUTHWESTERLY AND INCREASING SEVERE GALE FORCE 9 SOON

PORTLAND BISCAY
GALE FORCE 8 BACKING SOUTHWESTERLY IMMINENT INCREASING SEVERE GALE FORCE 9 SOON

ROCKALL
SOUTHWESTERLY GALE FORCE 8 EXPECTED SOON

FPUK71 EGRR 150900
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET. OFFICE
AT 1130 ON THURSDAY 15 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** HUMBER THAMES DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA SHANNON ROCKALL MALIN BAILEY FAEROES SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT 0600
LOW SOUTH ROCKALL 986 EXPECTED HUMBER 973 BY 0600 TOMORROW

THE AREA FORECASTS FOR THE NEXT 24 HOURS

...
PORTLAND **PLYMOUTH** BISCAY FITZROY
SOUTHWEST VEERING WEST 7 TO SEVERE GALE 9. RAIN THEN SHOWERS. MODERATE BECOMING GOOD
...

WOUK50 EGRR 150955
$NMC GALE WARNING

GALE WARNING THURSDAY 15 JANUARY 0955GMT 07

HUMBER
SOUTHERLY GALE FORCE 8 EXPECTED SOON

THAMES DOVER
SOUTHWESTERLY GALE FORCE 8 INCREASING SEVERE GALE FORCE 9 SOON

SHANNON
SEVERE GALE FORCE 9 DECREASING GALE FORCE 8 IMMINENT, VEERING NORTHWESTERLY SOON

ROCKALL
GALE FORCE 8 VEERING NORTHWESTERLY SOON

MALIN
NORTHERLY GALE FORCE 8 EXPECTED SOON

FAEROES
NORTHEASTERLY GALE FORCE 8 CONTINUING

SOUTHEAST ICELAND
NORTHEASTERLY SEVERE GALE FORCE 9 DECREASING GALE FORCE 8 SOON

FPUK71 EGRR 151500
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET. OFFICE AT 1725 ON THURSDAY 15 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** SOUTH UTSIRE FORTIES FISHER GERMAN BIGHT HUMBER THAMES DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA SHANNON ROCKALL MALIN HEBRIDES BAILEY FAEROES SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT MIDDAY
LOW SOUTH ROCKALL 981 EXPECTED DOGGER 974 BY MIDDAY TOMORROW

THE AREA FORECASTS FOR THE NEXT 24 HOURS
...
PORTLAND **PLYMOUTH** BISCAY FITZROY
SOUTHWEST VEERING WEST 7 TO SEVERE GALE 9, DECREASING 6. RAIN THEN SHOWERS. MODERATE BECOMING GOOD
...

WOUK50 EGRR 151600
$NMC GALE WARNING

GALE WARNING THURSDAY 15 JANUARY 1600GMT 08

...
PORTLAND **PLYMOUTH** SOLE
SEVERE GALE FORCE 9 VEERING WESTERLY AND DECREASING GALE FORCE 8 SOON
...

FPUK71 EGRR 152100
AND NOW THE SHIPPING FORECAST ISSUED BY THE MET.OFFICE
AT 0015 ON FRIDAY 16 JANUARY 2004

THERE ARE **WARNINGS OF GALES IN** SOUTH UTSIRE FORTIES DOGGER FISHER GERMAN BIGHT HUMBER THAMES DOVER WIGHT PORTLAND **PLYMOUTH** BISCAY FITZROY SOLE LUNDY FASTNET IRISH SEA ROCKALL MALIN HEBRIDES BAILEY FAEROES AND SOUTHEAST ICELAND

THE GENERAL SYNOPSIS AT 1800
LOW MALIN 976 EXPECTED DOGGER 978 BY 1800 FRIDAY

THE AREA FORECASTS FOR THE NEXT 24 HOURS

...
PORTLAND **PLYMOUTH** BISCAY
SOUTHWEST VEERING WEST 6 TO GALE 8, OCCASIONALLY SEVERE GALE 9 AT FIRST IN BISCAY. OCCASIONAL RAIN OR SQUALLY SHOWERS. GOOD OCCASIONALLY MODERATE
...

WOUK50 EGRR 152150
$NMC GALE WARNING

GALE WARNING THURSDAY 15 JANUARY 2150GMT 09

DOGGER
EASTERLY GALE FORCE 8 EXPECTED SOON

LUNDY FASTNET
NORTHWESTERLY GALE FORCE 8 INCREASING SEVERE GALE FORCE 9 IMMINENT

IRISH SEA
NORTHWESTERLY SEVERE GALE FORCE 9 INCREASING STORM FORCE 10 IMMINENT

SHANNON
GALE NOW CEASED

BAILEY FAEROES
NORTHEASTERLY SEVERE GALE FORCE 9 DECREASING GALE FORCE 8 IMMINENT

ANNEXES

METEO FRANCE

A1. Conventions / Notations

Heures : exprimées en UTC , temps universel compensé (France : en été UTC + 2h, en hiver UTC+1).
Pressions : ramenées au niveau de la mer et exprimées en hPa (hectoPascal)

Direction, Force et Evolution du vent

Direction : Exprimée avec huit directions et possibilité d'employer la notion de secteur (22.5° de part et d'autre de la direction).

DIRECTION	DEGRES
NORD (N)	360
NORD-EST (NE)	045
EST (E)	090
SUD-EST (SE)	135
SUD (S)	180
SUD-OUEST (SW)	225
OUEST (W)	270
NORD-OUEST (NW)	315

Force : Les vitesses se rapportent au vent moyen sur 10 minutes exprimée en Beaufort.
(1 noeud = 1.852 km/h = environ 0.5 m/s) et non aux rafales.

Echelle Beaufort

Degrés	Termes descriptifs	Vitesse moyenne	État de la mer
0	calme	< 1 noeud	comme un miroir
1	très légère brise	1 à 3 noeuds	quelques rides
2	légère brise	4 à 6 noeuds	vaguelettes ne déferlant pas
3	petite brise	7 à 10 noeuds	les moutons apparaissent
4	jolie brise	11 à 16 noeuds	petites vagues, nombreux moutons
5	bonne brise	17 à 21 noeuds	vagues modérées, moutons, embruns
6	vent frais	22 à 27 noeuds	lames, crêtes d'écume blanche, embruns
7	grand frais	28 à 33 noeuds	lames déferlantes, traînées d'écume
8	coup de vent	34 à 40 noeuds	tourbillons d'écume à la crête des lames, traînées d'écume
9	fort coup de vent	41 à 47 noeuds	lames déferlantes grosses à énormes, visibilité réduite par les embruns
10	Tempête	48 à 55 noeuds	
11	violente tempête	56 à 63 noeuds	
12	Ouragan	≥ 64 noeuds	

Rafales

RAFALES	différence de 10 noeuds entre le vent moyen et les rafales prévues.
FORTES RAFALES	différence entre 15 et 25 noeuds entre le vent moyen et les rafales prévues.
VIOLENTES RAFALES	différence supérieures à 25 noeuds ou plus entre le vent moyen et les rafales prévues.

Etat de la mer

L'état de la mer comprend la mer du vent et la houle.
La mer du vent désigne le ou les systèmes de vagues qui se forment sur place sous l'action locale du vent.
La houle désigne les trains de vagues formés ailleurs et qui se sont propagés hors de l'aire génératrice.

La hauteur significative des vagues (H1/3), est la hauteur moyenne du tiers des vagues les plus hautes (correspondant à la hauteur indiquée par les observateurs en mer). C'est la hauteur significative qui est décrite dans cette étude et dans les bulletins de prévision marine de Météo-France. Il convient de noter que, statistiquement, la hauteur maximale que l'on peut observer dans un train de vagues de mer du vent peut atteindre 1,6 à 2 fois cette hauteur significative.
La période (T) est l'intervalle de temps moyen entre 2 crêtes.
La longueur d'onde (L) est la distance moyenne (ici pour le tiers des vagues les plus hautes) entre 2 crêtes.

Mer du vent:

ETAT DE LA MER	hauteur (H1/3) en mètre
CALME ou RIDEE	de 0m à 0,1m
BELLE	de 0,1m à 0,5m
PEU AGITEE	de 0,5m à 1,25m
AGITEE	de 1,25m à 2,5m
FORTE	de 2,5m à 4m
TRES FORTE	de 4m à 6m
GROSSE	de 6m à 9m
TRES GROSSE	de 9m à 14m
ENORME	supérieur à 14m

A2. Documents : BULLETINS METEOROLOGIQUE SPECIAUX (BMS) LARGE

Les bulletins météorologiques spéciaux (BMS) sont émis **dès que la vitesse du vent observé ou prévu dans les prochaines 24 heures atteint ou dépasse 8 Beaufort pour le Large,** 7 Beaufort pour la Côte,
(Bulletins Météo France) Les messages BMS, ainsi que les bulletins réguliers (rédigés et diffusés à heure fixe 2 fois par jour), sont rédigés dans le cadre des missions de sécurité de Météo-France. Ils sont diffusés en mer, pour la zone concernée, par le CROSS Corsen.

Appendix D

Charts

D.1 **Charts of the accident area**

D.2 **Traffic separation schemes**

D.3 **Exercise areas**

D.4 **Search and rescue areas**

D.5 **GMDSS coverage**

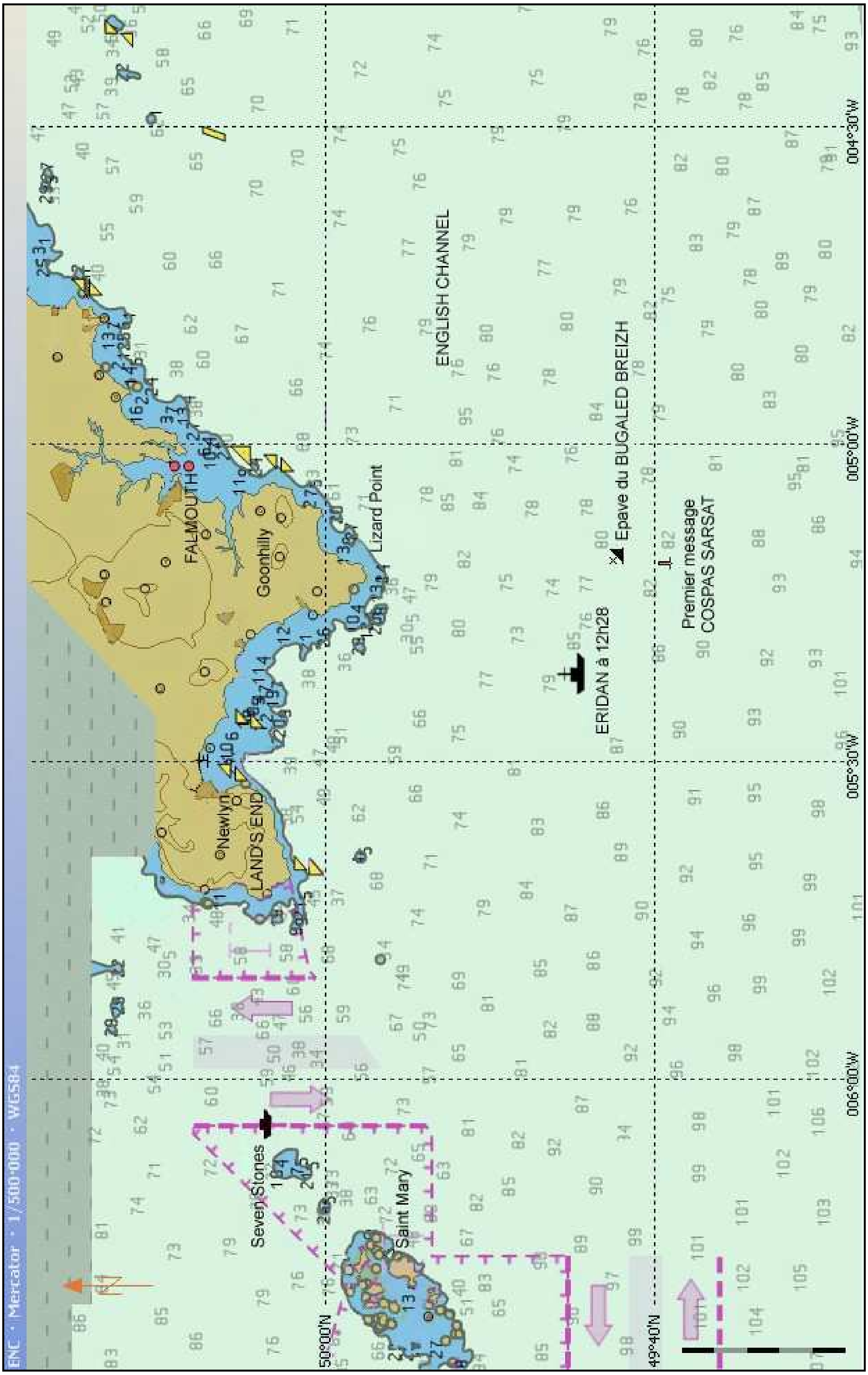
D.6 **Charts showing areas for weather forecasts and inshore navigation warnings**

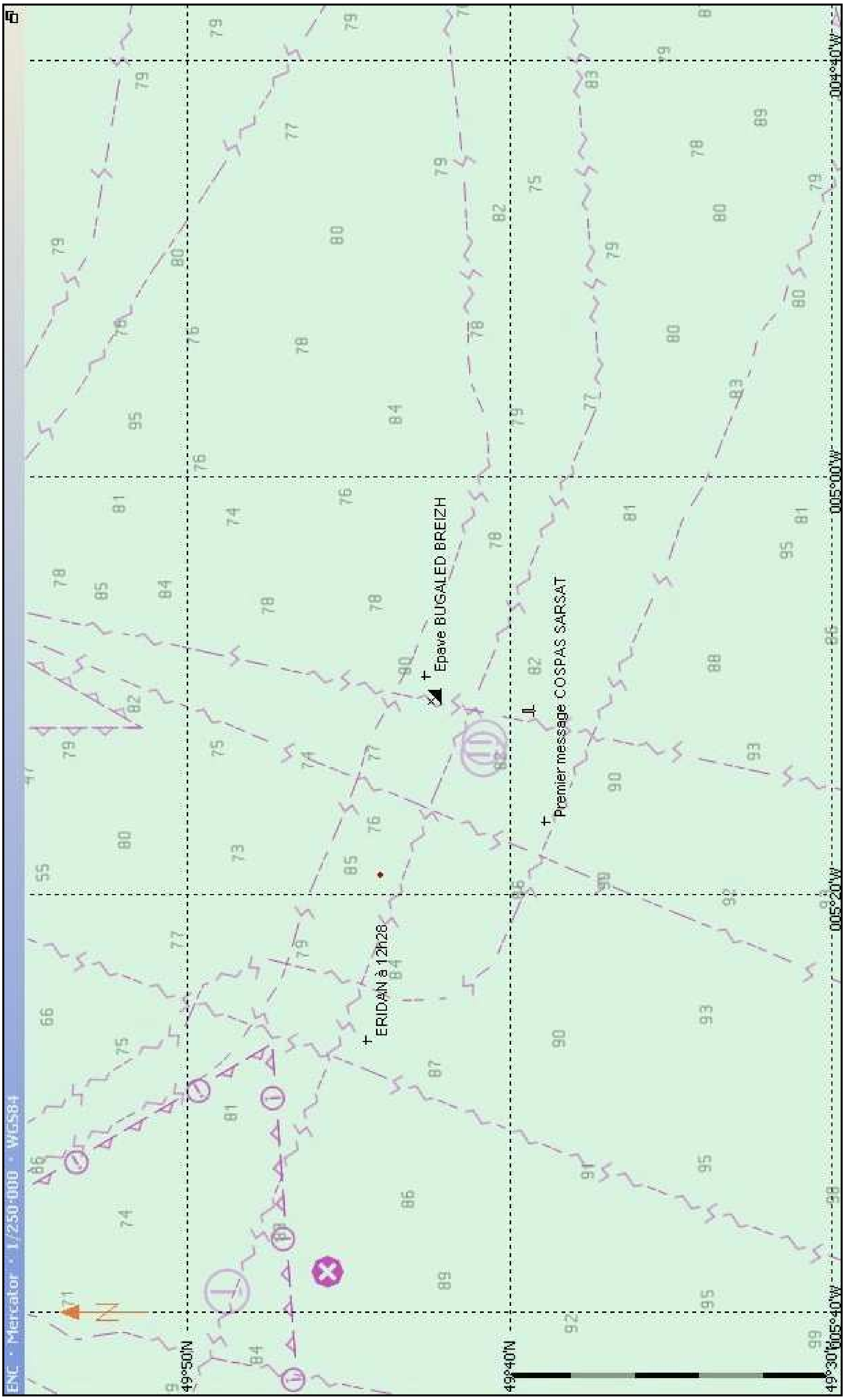
D.7 **Flow chart of COSPAS-SARSAT data distribution**

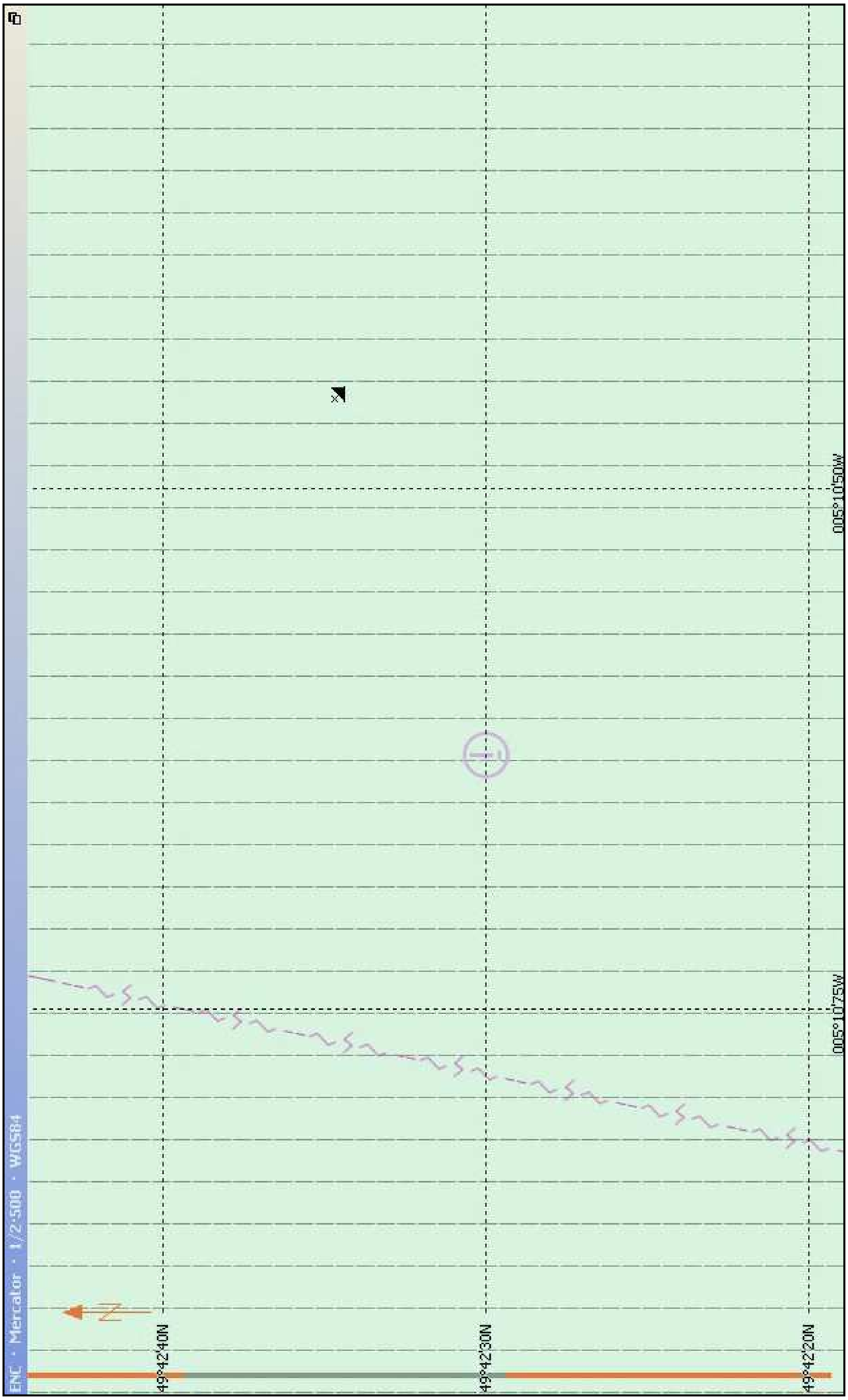
D.8 **Chart giving the positions of naval vessels on 15th January 2004**

Appendix D.1

Charts of the accident area


ENC · Mercator · 1/500 000 · WGS84
ENGLISH CHANNEL
FALMOUTH
Goonhilly
Lizard Point
Newlyn
LAND'S END
Seven Stones
Saint Mary
ERIDAN à 12h28
Epave du BUGALED BREIZH
Premier message
COSPAS SARSAT
50°00'N
49°40'N
004°30'W
005°00'W
005°30'W
006°00'W

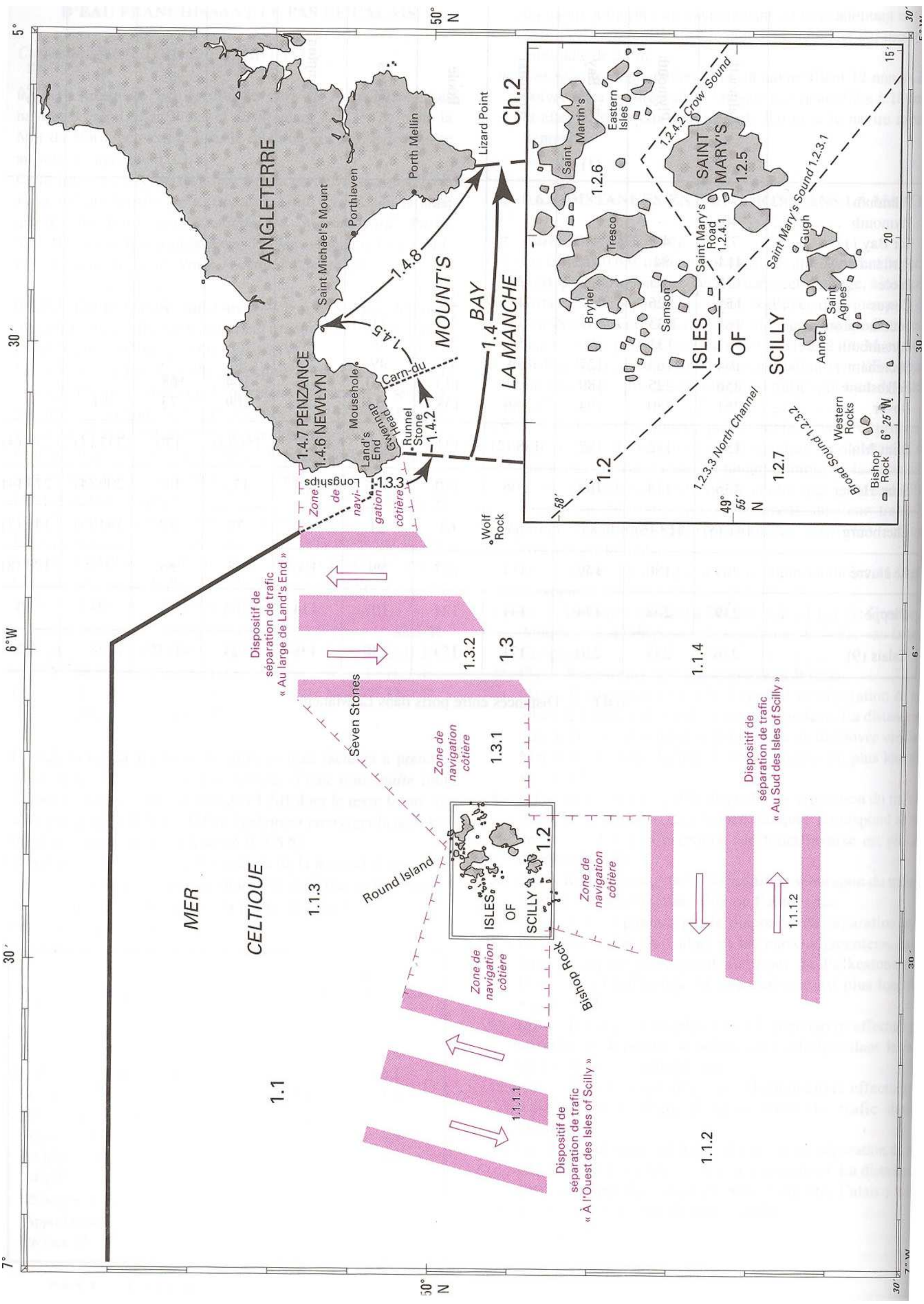

ENC · Mercator · 1/250 000 · WGS84
Epave BUGALED BREIZH
Premier message COSPAS SARSAT
ERIDAN à 12h28
49°50'N
49°40'N
49°30'N
005°40'W
005°20'W
005°00'W
004°40'W


ENC · Mercator · 1/2 500 · WGS84
49°42'40N
49°42'30N
49°42'20N
005°10'50W
005°10'75W

Appendix D.2

Traffic separation schemes

Chart reproduced from "Instructions Nautiques Angleterre côte Sud"
(publication C-1 published by the SHOM, 1999 edition).



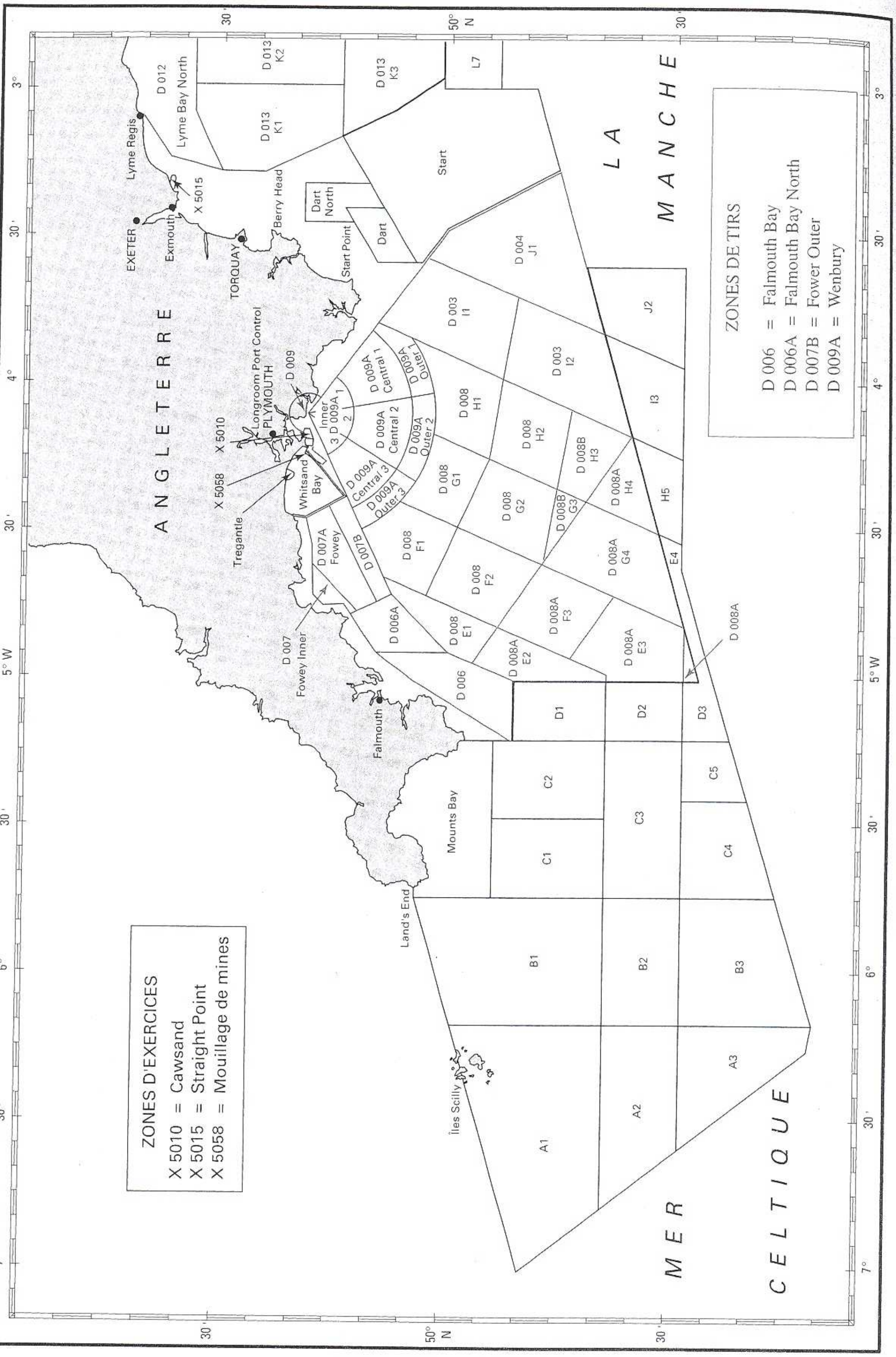
ANGLETERRE
MER
CELTIQUE
LA MANCHE
MOUNT'S
BAY
Ch.2
Lizard Point
Porth Mellin
Porthleven
Saint Michael's Mount
1.4.7 PENZANCE
1.4.6 NEWLYN
Mousehole
Carn-du
Land's End
Gwennap Head
Runnel Stone
Longships
Wolf Rock
Seven Stones
Round Island
Bishop Rock
ISLES OF SCILLY
Zone de navigation côtière
Dispositif de séparation de trafic « Au large de Land's End »
Dispositif de séparation de trafic « Au Sud des Isles of Scilly »
Dispositif de séparation de trafic « À l'Ouest des Isles of Scilly »
1.1
1.1.1
1.1.2
1.1.1.2
1.1.3
1.1.4
1.2
1.3
1.3.1
1.3.2
1.3.3
1.4
1.4.2
1.4.5
1.4.8
SAINT MARY'S
Saint Martin's
Eastern Isles
Tresco
Bryher
Samson
Saint Mary's Road 1.2.4.1
Saint Agnes
Gugh
Annet
Western Rocks
Bishop Rock
1.2.4.2 Crow Sound
Saint Mary's Sound 1.2.3.1
1.2.3.3 North Channel
Broad Sound 1.2.3.2
1.2.5
1.2.6
1.2.7
7° W
6° W
5°
30′
50° N
49° 55′ N
6° 25′ W

Appendix D.3

Exercise areas

Chart reproduced from "Instructions Nautiques Angleterre côte Sud"
(publication C-1 published by the SHOM, 1999 edition).

RSX 92.1 **ZONES SUD OUEST D'EXERCICES DE TIRS, GUNFACTS ET SUBFACTS.**



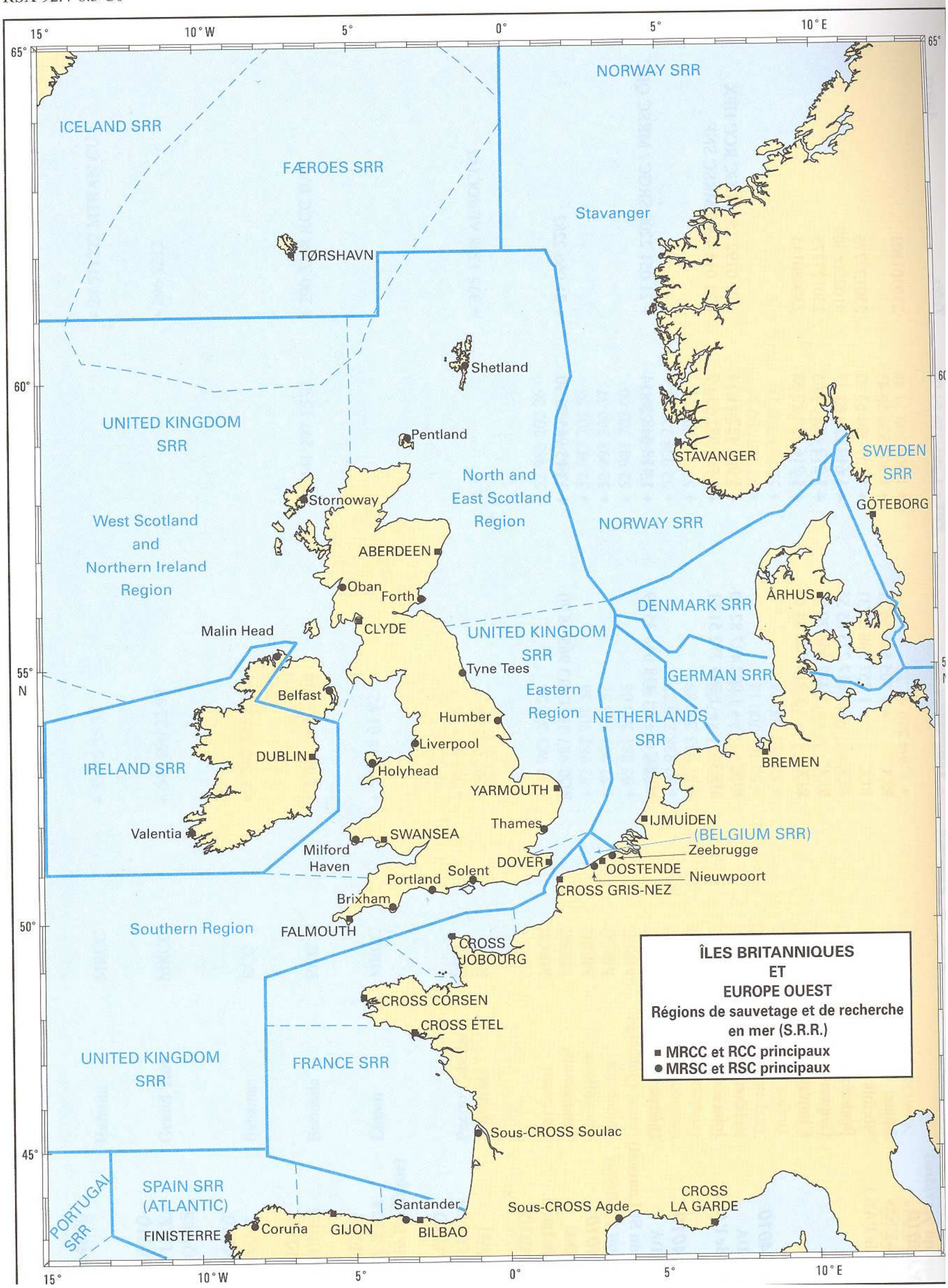
Appendix D.4

Search and rescue areas

Chart reproduced from "Radiocommunications Maritimes"
(volume 4 published by the SHOM, 2000 edition).

6.5. Limites et couverture des régions et zones de responsabilité SAR

RSX 92.4-6.5 C0



Appendix D.5

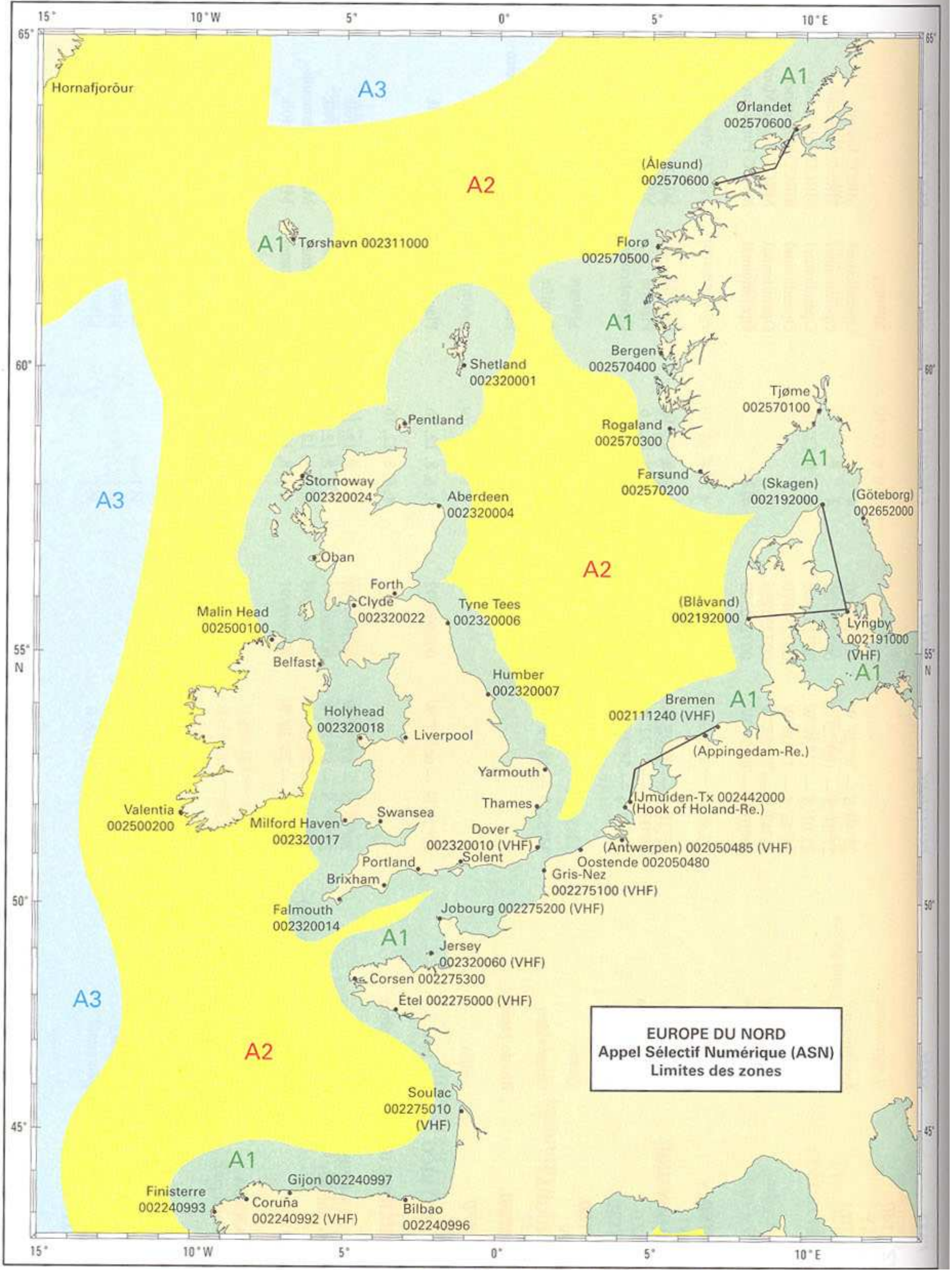
GMDSS coverage

Chart reproduced from "Radiocommunications Maritimes"
(volume 4 published by the SHOM, 2000 edition).

5.5. Planches descriptives de la couverture des stations ASN des Zones A1, A2, A3 et A4.

Certaines stations contrôlées à distance sont reliées par un trait noir à la station de référence.

RSX 92.4-5.5 Z1



Appendix D.6

Charts showing areas for weather forecasts and inshore navigation warnings

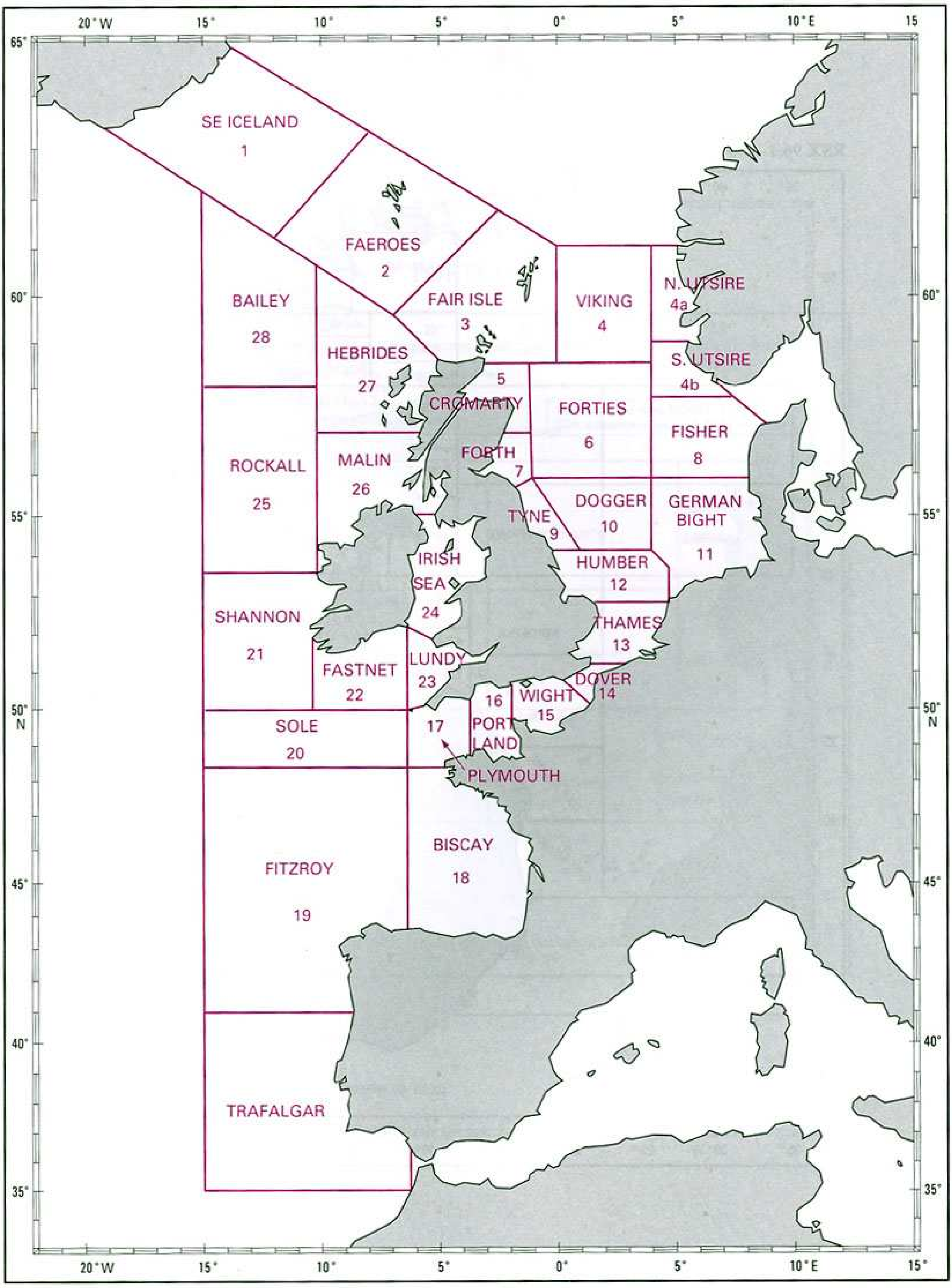
Charts A2 and A26 are reproduced from "Stations Radiométéorologiques" (volume 1 published by the SHOM, 2004 edition).

The chart for inshore navigation warnings is reproduced from "Instructions Nautiques Angleterre côte Sud" (publication C-1 published by the SHOM, 1999 edition).

A26

GRANDE-BRETAGNE ET IRLANDE

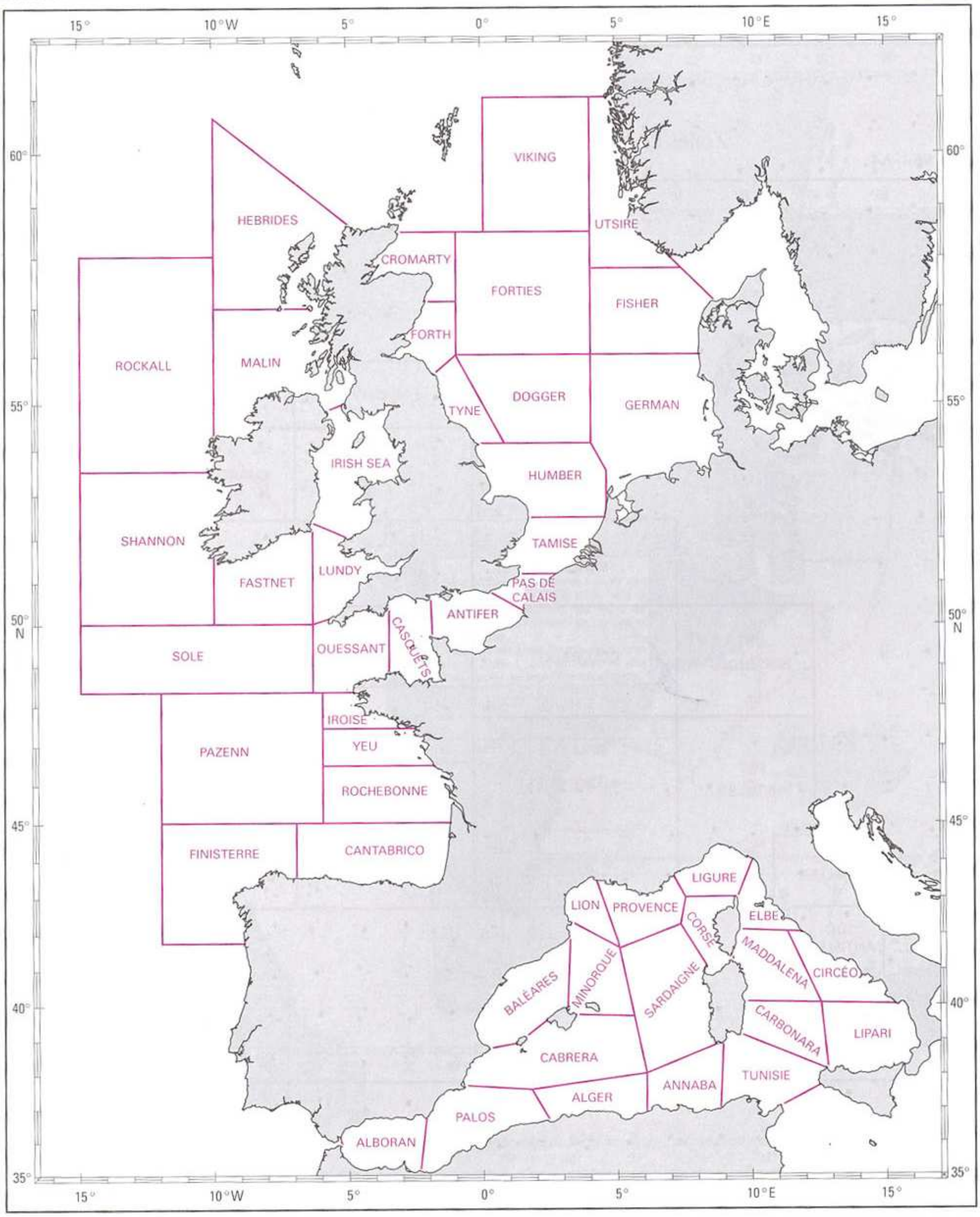
RSX 96.1-A26

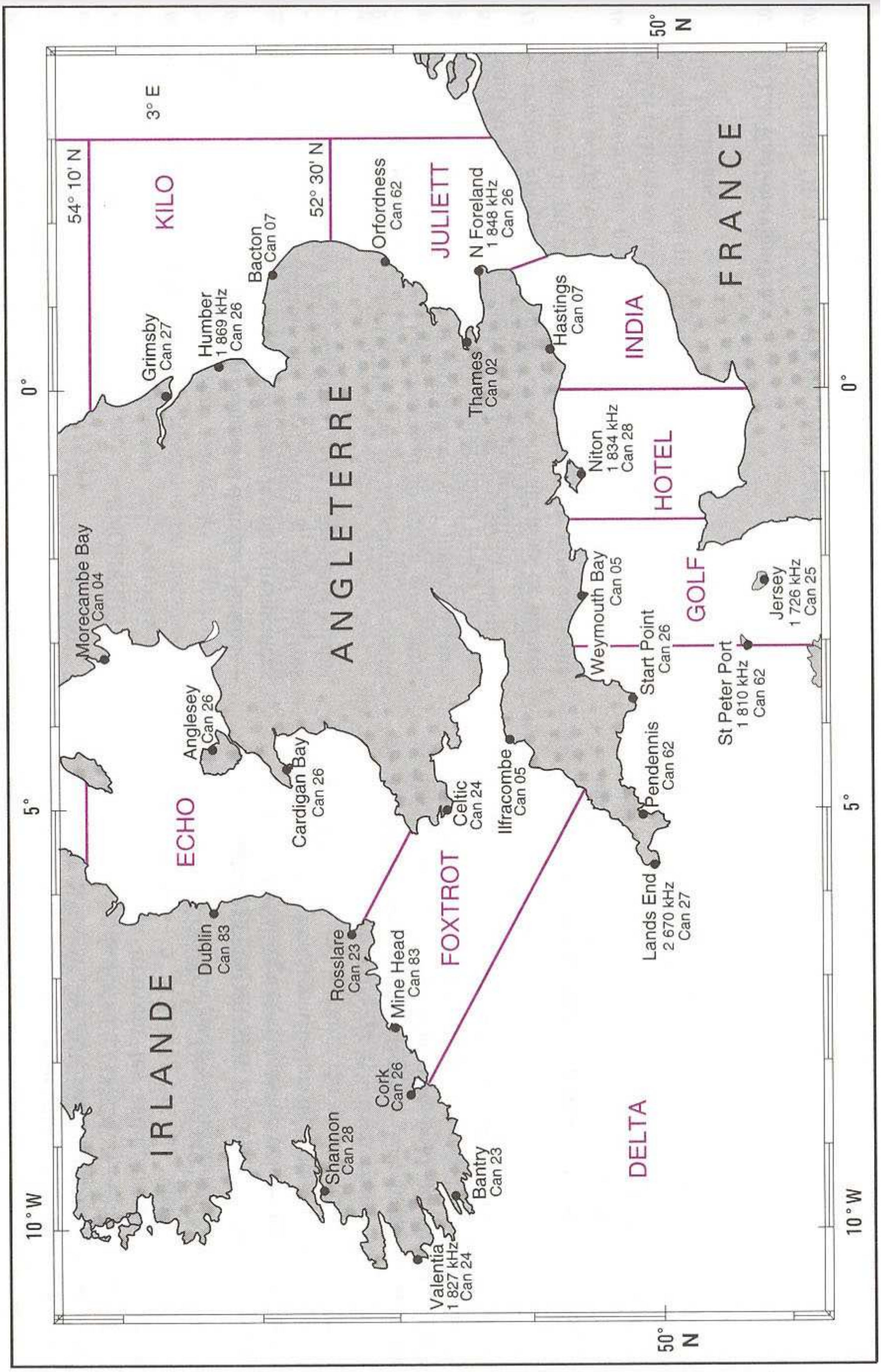


A2

FRANCE
(zones du large)

RSX 96.1-A2





IRLANDE
ANGLETERRE
FRANCE
KILO
JULIETT
INDIA
HOTEL
GOLF
ECHO
FOXTROT
DELTA
54° 10' N
52° 30' N
3° E
0°
5°
10° W
50° N
Grimsby
Can 27
Humber
1 869 kHz
Can 26
Bacton
Can 07
Orfordness
Can 62
N Foreland
1 848 kHz
Can 26
Thames
Can 02
Hastings
Can 07
Niton
1 834 kHz
Can 28
Weymouth Bay
Can 05
Start Point
Can 26
Jersey
1 726 kHz
Can 25
St Peter Port
1 810 kHz
Can 62
Pendennis
Can 62
Lands End
2 670 kHz
Can 27
Ilfracombe
Can 05
Celtic
Can 24
Cardigan Bay
Can 26
Anglesey
Can 26
Morecambe Bay
Can 04
Dublin
Can 83
Rosslare
Can 23
Mine Head
Can 83
Cork
Can 26
Shannon
Can 28
Bantry
Can 23
Valentia
1 827 kHz
Can 24

Appendix D.7

Flow chart of COSPAS-SARSAT data distribution

Diagram reproduced from COSPAS-SARSAT Distribution Plan
(document C/S A.001 - Issue 4 - Rev 7 - October 2004)

III / A.4.2 Central DDR

Data flow in Central DDR (ALMCC, FMCC, ITMCC, NIMCC*, NMCC, SPMCC and UKMCC) is described in Figure III / A.3. Central DDR MCCs validate locations before forwarding them to the SAR organizations.

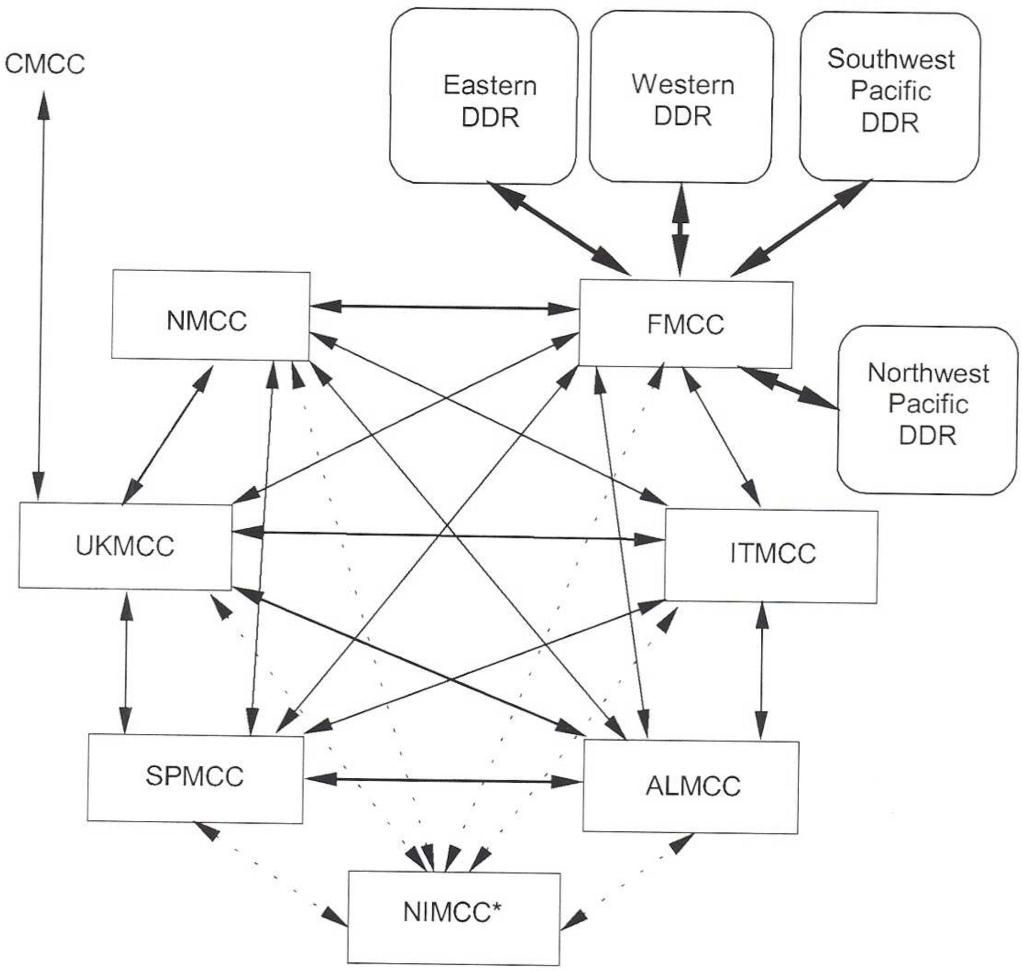


Figure III / A.3 : Central DDR Network Diagram

Note: * - Under development.

Appendix D.8

Chart giving the positions of naval vessels on 15th January 2004

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Brest, le 21 janvier 2004

PRÉFECTURE MARITIME DE L'ATLANTIQUE

COMMUNIQUÉ DE PRESSE

NAUFRAGE DU BUGALED BREIZH POINT DE SITUATION N°4

A PROPOS DES NAVIRES DE SURFACE ET SOUS-MARINS ENGAGES DANS L'EXERCICE ASWEX 04

En complément d'information du communiqué de presse du vendredi 16 janvier dernier, la carte donnant la position précise de tous les bâtiments engagés dans l'exercice multinational ASWEX 04 au moment du naufrage du chalutier *Bugaled Breizh* est disponible sur le site Internet de la préfecture maritime de l'Atlantique :

www.premar-atlantique.gouv.fr

NOTA :
- les carrés représentent les navires de surface,
- les **U** représentent la position des sous-marins. Le sous-marin DOLFIJN naviguait en surface au moment du naufrage.
- à l'exception des moyens maritimes français, ces différentes positions ont été transmises par les autorités militaires britanniques à la préfecture maritime de l'Atlantique.

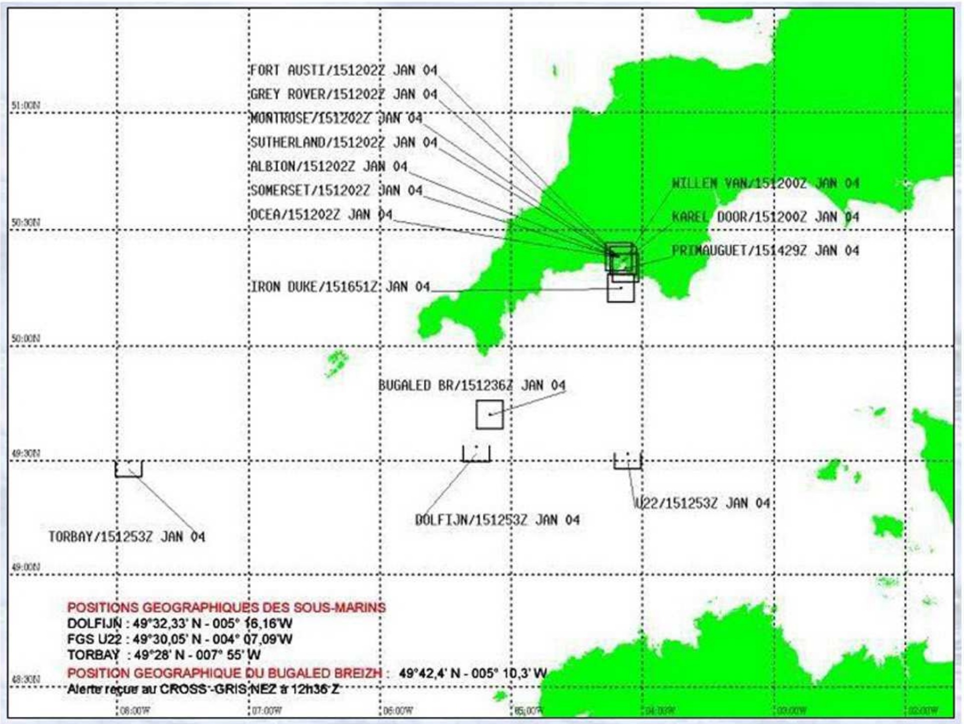
Préfecture maritime de l'Atlantique
Tel : 02.98.22.11.78
Fax : 02.98.22.07.56
Web : http://www.premar-atlantique.gouv.fr/

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Brest, le 21 janvier 2004

PRÉFECTURE MARITIME DE L'ATLANTIQUE

COMMUNIQUÉ DE PRESSE



Préfecture maritime de l'Atlantique
Tel : 02.98.22.11.78
Fax : 02.98.22.07.56
Web : http://www.premar-atlantique.gouv.fr/

Appendix E

Analyses and tests carried out on the vessel

E.1 Metallurgical analysis of the breach at the port echo sounder

E.2 Assessment of the forces required to open the breach at the echo sounder

E.3 Analysis of the structure

E.4 Stability calculations

E.5 Metallurgical analysis of the warps

The reports of the metallurgical analysis of the area around the starboard echo sounder, the assessment of the forces required to open the breach at the echo sounder, the analysis of the structure, the stability calculations and the metallurgical analysis of the warps carried out by the LCPC are available on request from the *BEA*mer.

The reports of the metallurgical analysis of the breach at the port echo sounder and the metallurgical analysis of the warps carried out by the LNE fall under the judicial inquiry and cannot be divulged by the *BEA*mer.

Appendix F

Photographs

F.1 Breach at the port echo sounder

F.2 Deformation of the bows

F.3 Winches and controls

F.4 Trawl rig

F.5 Engine controls

Appendix F.1

Breach at the port echo sounder

View of the breach at the port echo sounder seen from outside the vessel. The flap-like plate has pivoted into the engine room. The vertical crack in way of frame 18 can also be seen.

View of the breach at the port echo sounder seen from inside the vessel. On the left of the photograph the broken cable conduit coupling can be seen. The part of the conduit rising towards the upper part of the engine room is visible on the right of the photograph.

Appendix F.2

Deformation of the bows

View of the deformation of the starboard side. The photograph shows the deformation in way of the fish hold and the double bottom below it. The bowing of the keel can also been seen.

Photograph looking aft showing the symmetry of the deformations.

View of the deformations of the forward part of the upper deck. The wheelhouse is located to right of the photograph.

View of the deformation of the main deck. The photograph was taken from the after end of the work room.

Deformation of the fish loading hatch on the the starboard side of the forward part of the work room.

Deformation of the double bottom tank top below the fish hold. The photograph was taken from the middle of the fish hold, looking forward.

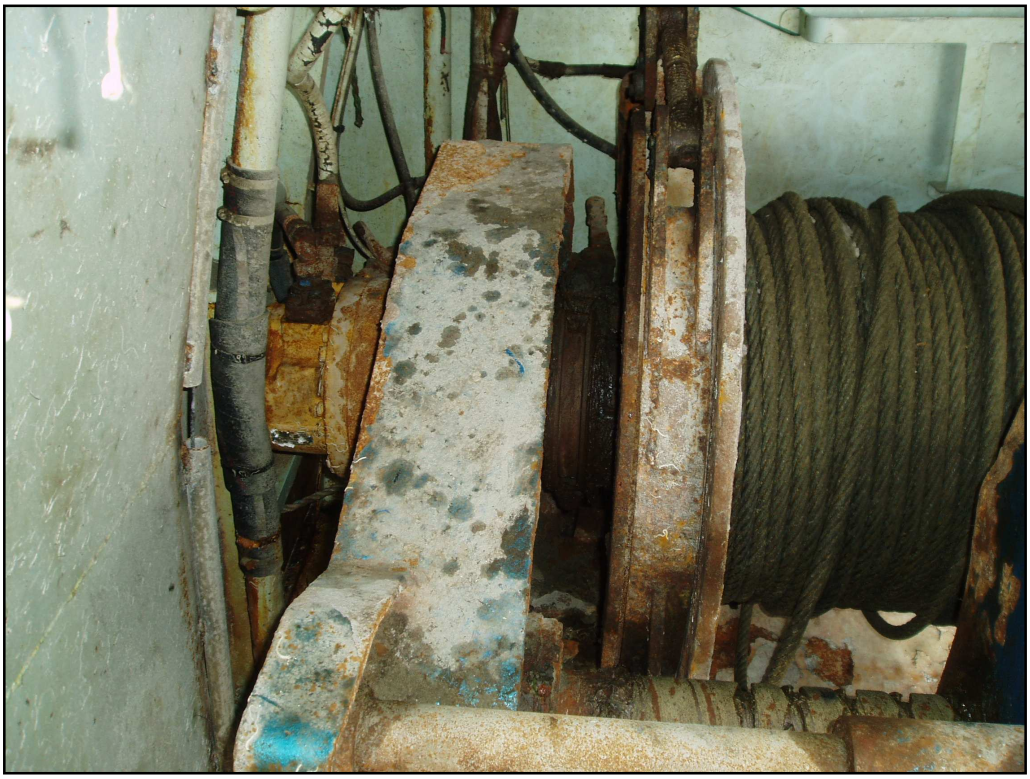
Deformation of the double bottom below the fish hold. Photograph taken in way of the bilge well.

Photograph showing the deformation of the side shell and frames of the starboard side of the fish hold.

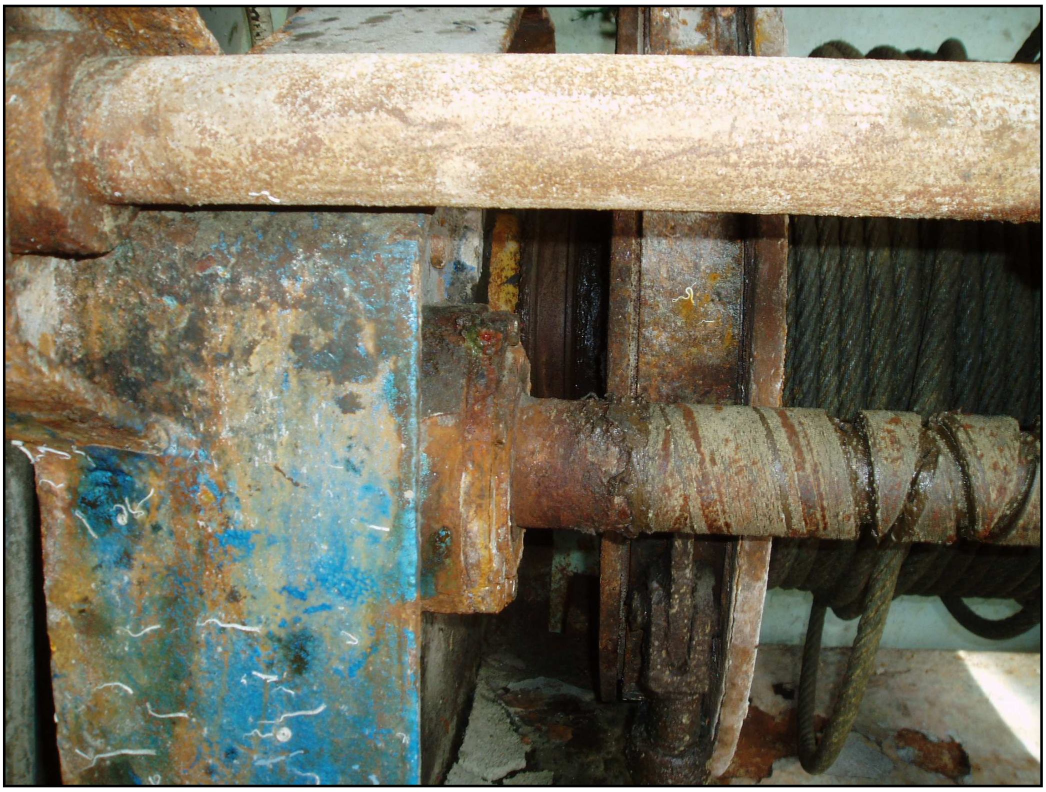
Appendix F.3

Winches and controls

View of the winch control console on the after starboard side of the wheelhouse. The port winch brake lever is located on the far right of the photograph.



View of the port warping winch showing that the warping head is declutched.



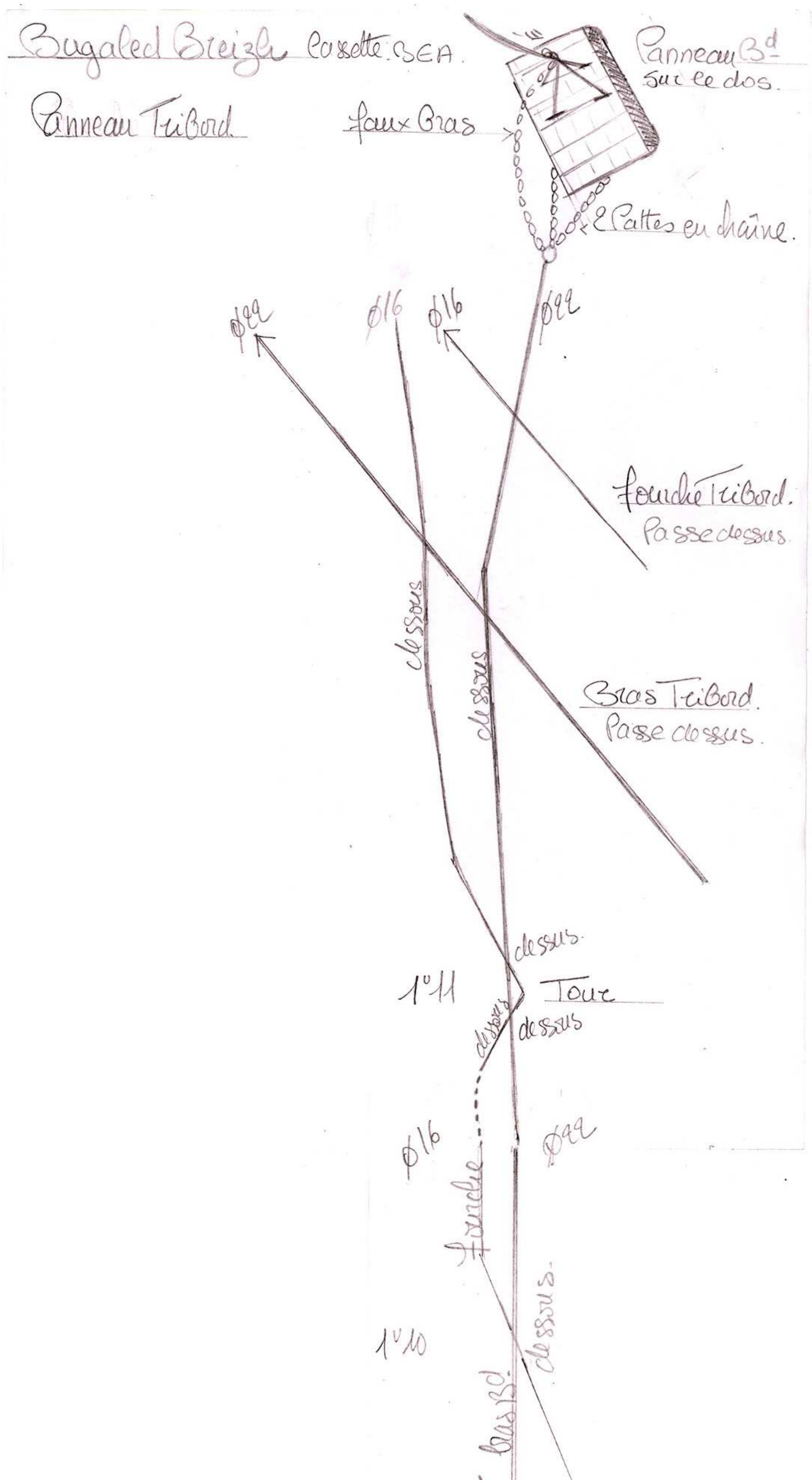
Detail of the port winch clutch jaw.

View of the starboard winch cable guide.

View of the starboard winch showing that the warping head is declutched.

Appendix F.4

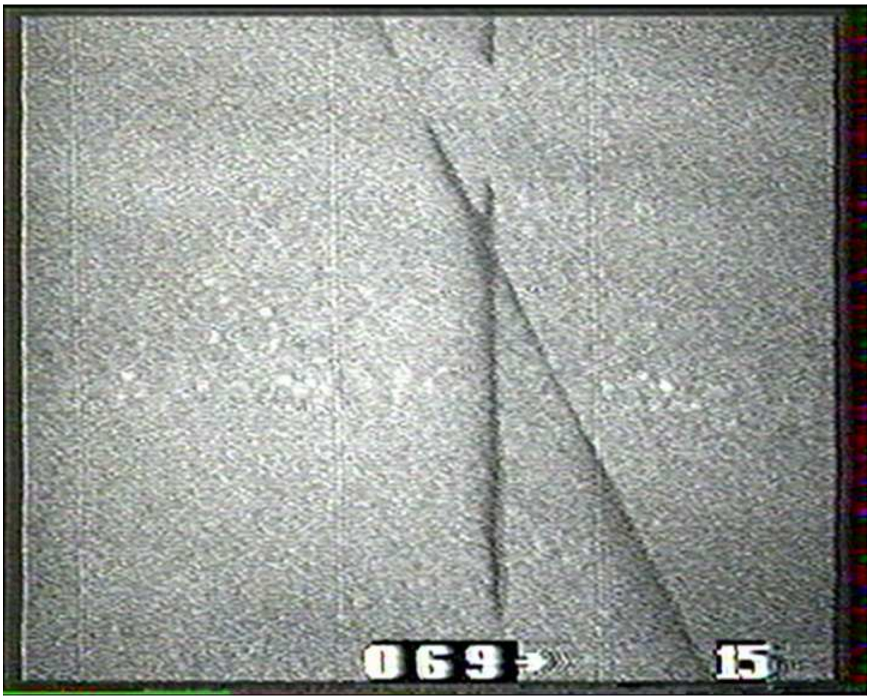
Trawl rig



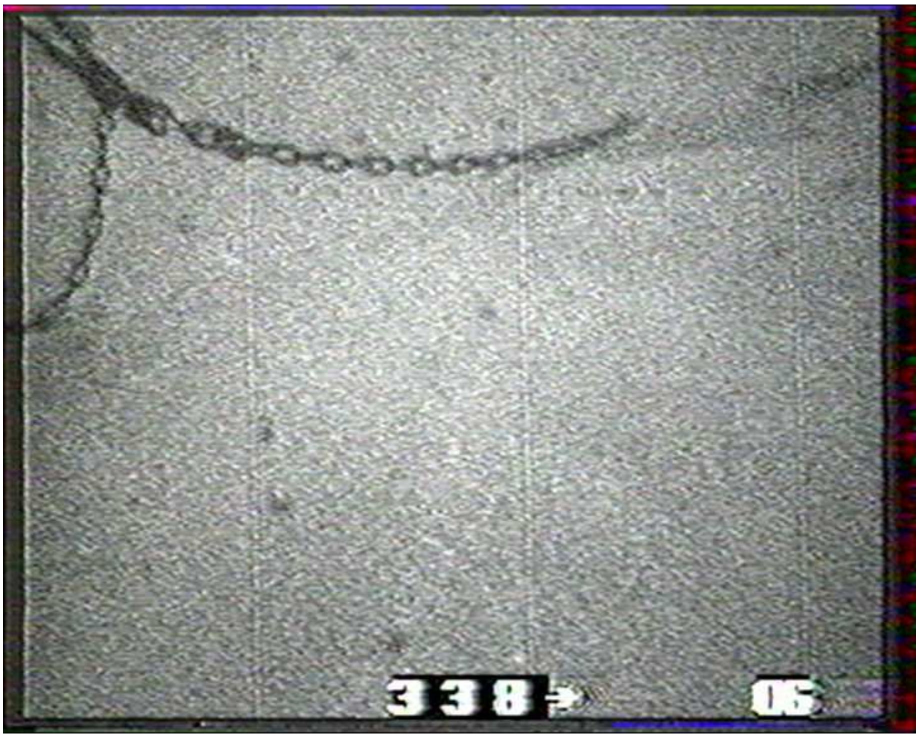
Summary diagram made from the video footage taken by the ANDROMÈDE showing the respective positions of the port and starboard bridles and fork legs.

View of the port fork leg passing under the lower port bridle in two places then running roughly parallel to it towards the trawl door (area 1 described in paragraph 6.4 of the main body of the report).

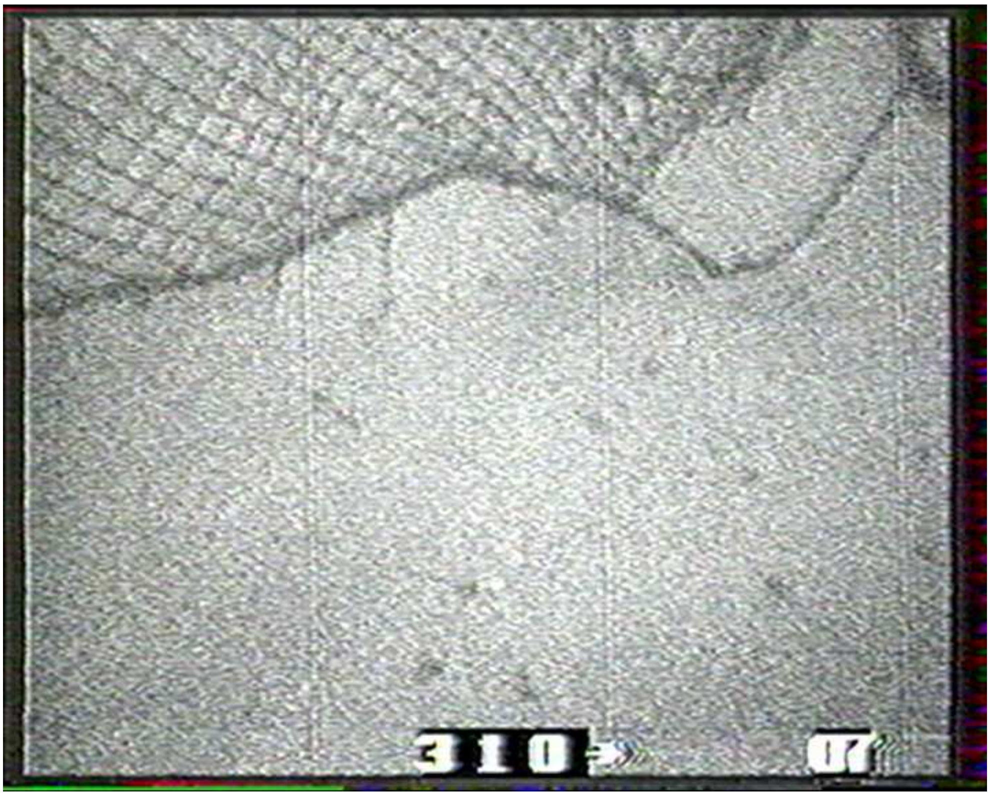
View of the starboard bridle passing over the port bridle. The shadow to the left of the starboard bridle shows the respective positions of the two cables and the presence of a concavity on the seabed (area 2 described in 6.4 of the main body of the report). The cable on the left of the photograph is the port fork leg.



View of the starboard fork leg passing over the port bridle (area 3 described in paragraph 6.4 of the main body of the report).

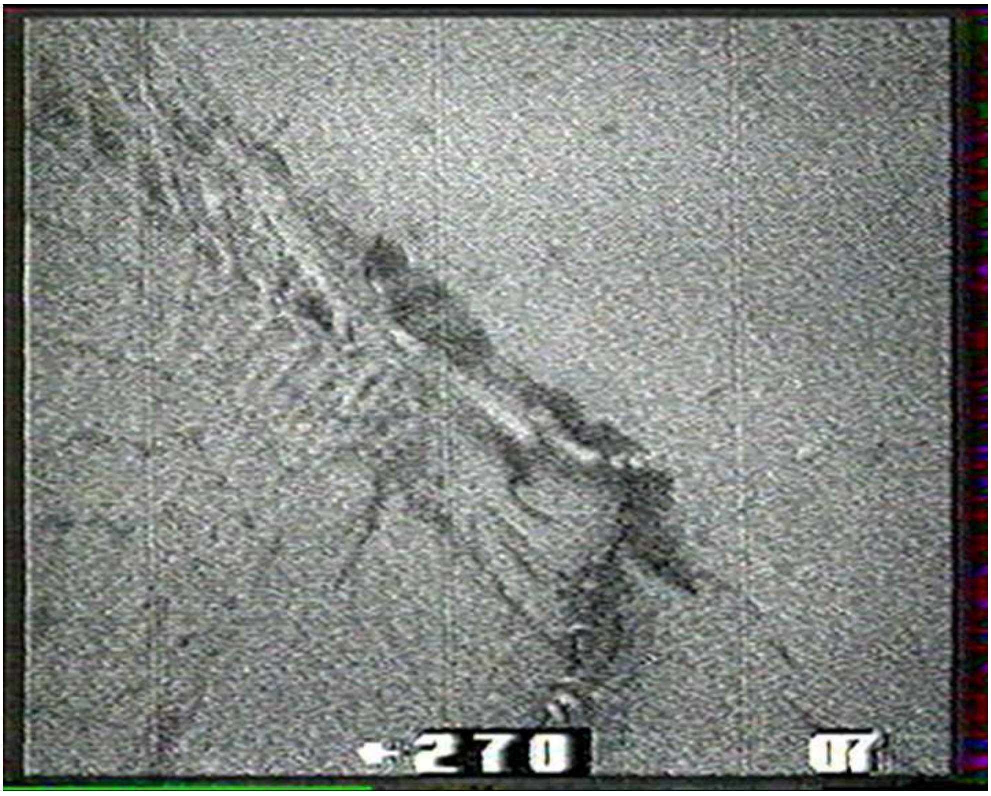


View of the portside three way connection at the top left of the photograph. The chain leading to the right of the photograph is the chain of the upper port bridle.



View of the headrope of the trawl on the port three way connection side.

View of the portside three way connection. The chain emerging from the sediment at the bottom of the photograph belongs to the lower bridle.



View of the portside three way connection. It can be seen that the webbing on the wing line is torn. The line of rock-hoppers is also visible.

View of the lower port ballast chain showing through the sediment.

View of the lower port chain showing through the sediment.

View of the lower port chain located near the starboard upper wing. The head line floats can be made out..

Appendix F.5

Engine controls

View of the engine control lever showing that it was engaged.

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