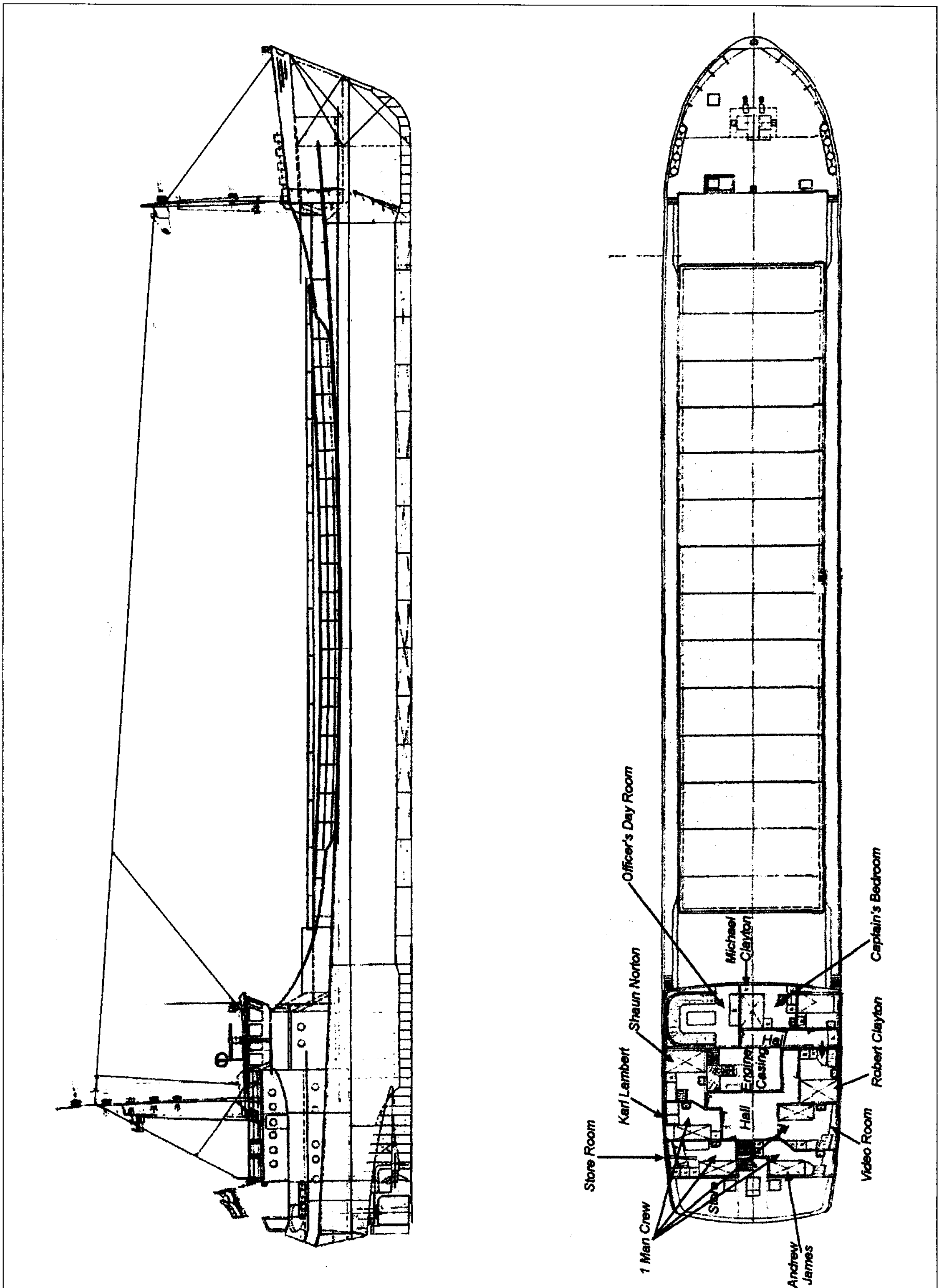
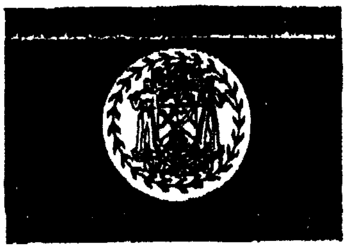
ANNEX 1

General Arrangement of *Rema*



ANNEX 2

Vessel Certification



INTERNATIONAL MERCHANT MARINE REGISTRY OF BELIZE
"IMMARBE"
REGISTRATION OF MERCHANT SHIPS ACT. 1989
PERMANENT PATENT OF NAVIGATION

NAME OF VESSEL
REMA

CALL LETTERS	REGISTRATION Nº
V3UD6	01961755

NAME AND ADDRESS OF OWNERS
HERBERT TRADING LTD. 50 SHIRLEY STREET CB 139737 NASSAU, BAHAMAS

DESCRIPTION OF VESSEL

TYPE OF VESSEL	MATERIAL OF THE HULL	GROSS TONNAGE	NET TONNAGE	UNDER DECK
DRY CARGO	STEEL	748.00	395.00	0.00

No. DECKS	No. MASTS	No. BRIDGES	No. FUNNELS	NAME OF BUILDERS	YEAR BUILT
1	2	1	1	VAN GOOR NV	1976

LENGTH	BREADTH	DEPTH	TYPE OF ENGINES	NAME OF ENGINES MAKERS	SPEED
59.50 METERS	9.40 METERS	3.80 METERS	BRONZ 440 KW	BRONZ	9.00 KNOTS

PREVIOUS NAME: FIVEL PREVIOUS NATIONALITY: HONDURAS (PRESENT) DUTCH WHEN BUILT.

TYPE OF RADIO EQUIPMENT: SKANTI

ENTITY RESPONSIBLE FOR RADIO ACCOUNTS: MARCONI HOUSE

COMPLETE ADDRESS OF ENTITY RESPONSIBLE FOR RADIO ACCOUNTS: MARCONI HOUSE NEW STREET CHELMSFORD ESSEX CM1 1PL ENGLAND

RESIDENT AGENT: HALCYON SHIPPING LTD.

DATE OF ISSUANCE	DATE OF EXPIRATION
MAY 19, 1997	MAY 18, 2002

The Registrar of the International Merchant Marine Registry of Belize, by the powers vested thereupon by Registration of Merchant Ships Act, 1989 and amendments thereto, hereby authorizes and issues the present Provisional Patent of Navigation.

INTERNATIONAL MERCHANT MARINE REGISTRY OF BELIZE • IMMARBE •

INTERNATIONAL MERCHANT MARINE REGISTRY OF BELIZE
IMMARBE
HEAD OFFICE

by
JOHN E. WAIGHT Registrar

CONTROL Nº 04 - 000653

INTERNATIONAL MERCHANT MARINE REGISTRY OF BELIZE
"IMMARBE"

MINIMUM SAFE MANNING CERTIFICATE

Issued in accordance with Regulation V/13(b) of SOLAS taking into account the Principles of Safe Manning as contained in IMO Resolution A. 481(XII)

NAME OF VESSEL:	**REMA**	CALL LETTERS:	**V3UD6**
REGISTRATION NO.	**01961755**	GROSS TONNAGE:	**748.00**
IMO NO.:	**7519438**	HORSE POWER:	**600.00**

MANNING COMPLEMENT

FOR SHORT VOYAGES*

OFFICERS	RATINGS	ENGINEERS	RATINGS
One Master	**Two Able Seamen**		
One First Mate	**One Ordinary Seaman**		

CONDITIONS:

***Short Voyages as defined in SOLAS Regulation III/3.16.**

One Deck Officer must hold a general or restricted certificate as radiotelephone operator.

Owner is responsible to ensure compliance with the provisions of the STCW 95 Convention, in particular Regulations VIII/1 and VIII/2 and Sections A-VIII/1 and A-VIII/2 regarding Fitness for Duty and Watchkeeping arrangements and principles to be observed.

Issued at **Belize City** this **19** day of **February, 1998**

Certificate expires **18** day of **February, 2000**

CONTROL Nº 19- [illegible]

Deputy Registrar
IMMARBE

ANNEX 3

Coastguard SAR Operational Report

INCIDENT ACTION REPORT

Part 1 - Incident Prologue

UIIN BT0092	**District** HUMBER MRSC			**Duration (hours)**	85.37
Start date 25/04/19	**Start time** 02:21	**Initial Position**		**Found Position**	
Finish date 28/04/19	**Finish time** 15:43	5442N	00008W		

Part 2 - Casualty

Call sign	Name	Port of registry	Nationality	Length	GRT
V3UDG	REMA		NOT KNOWN	63	748

Part 3 - Details of Casualty

Casualty Type	Details of activity	Nature of incd to vessel
MERCHANT VESSEL	ON PASSAGE	SUNK

Mode of propulsion	Preliminary Evaluation of Incident
INBOARD DIESEL	OTHER

It is stressed that the evaluation at Part 3-E of this form is made entirely for internal purposes of The Coastguard agency. It is of initial and preliminary nature and reflects the subjective assessment of the Officer concerned made on the basis of information available to him/her at the time. It is not intended to be final or definitive, or to anticipate in any way the decision of any Court or Tribunal.

COPY

Part 4 - Nature of incd to person

Part 5 - Weather conditions on scene

Wind force 3 **Wind dir** 210 **Sea state** 3 **Sea swell** 1 **Visibility** 4 **Civil twilight** 20:00

Part 6 - Incident Classification

ASSISTANCE RENDERED

Part 7 - Type of distress / urgency signal

DISTRESS(MAYDAY/SOS)VHF

Part 8 - Distress picked up initially by CG or Aux

MRCC/MRSC HUMBER MRSC

Part 9 - Distress picked up initially by non-UK

Part 10 - Distress received by co-ordinating MRC

VHF RADIO

W. N. LINDSAY (STEVEDORES) Ltd.

DIRECTORS
A. Irving, F.I.C.S.
I. S. Dougal, C.A., G. A. Lindsay
J. N. Lindsay, B.A.
J. A. Scott, M.A., F.C.A.

REGISTERED IN SCOTLAND No. 43806
at
GLADSMUIR GRANARY
TRANENT EH33 1EJ

LLOYD'S AGENCY

1 DOCK ROAD TWEEDMOUTH
BERWICK-UPON-TWEED
TD15 2BG

TELEX 53588
FAX No. 01289 306101

TELEPHONE NUMBERS
01289 306209

After Business Hours
A. Irving
01289 308741

DUTY MOBILE
0370 651156

AI/PNR

The Captain.
m.v. 'REMA'
Berwick-upon-Tweed.

23rd April, 1998.

Dear Sir,

m.v. 'REMA' - BERWICK/TERNEUZEN

We would be obliged if you would sign the attached duplicate letter acknowledging that your vessel's cargo has been loaded, stowed and trimmed according to your instructions and you are satisfied with the stability of the vessel throughout the forthcoming voyage, also receipt of One Original Bill of Lading, Form TC12 and a copy of the manifest and Pro-Forma Invoice.

Yours faithfully,
For W.N. LINDSAY (STEVEDORES) LTD.

Master.............................

Part 11 - Coastguard facilities

Type of Assistance	Station	Assisted	Rescued	Bodies Recovered
MF DSC	HUMBER MRSC	0	0	0
MF RADIO	HUMBER MRSC	0	0	0
VHF DSC	HUMBER MRSC	0	0	0
VHF D/F	HUMBER MRSC	0	0	0
VHF RADIO	HUMBER MRSC	0	0	0
COASTGUARD SM	WHITBY	0	0	0
COASTGUARD BURT	SCARBOROUGH	0	0	0
COASTGUARD CRV	SCARBOROUGH	0	0	0
VHF RADIO	SCARBOROUGH	0	0	0
VHF RADIO	WHITBY	0	0	0

Part 12 - Non-coastguard facilities

Type of Assistance	Assisted	Rescued	Bodies Recovered
MERCHANT VESSEL	0	0	0
RAF SAR HELO	0	0	0
RNLI AWB	0	0	0
BT CRS	0	0	0
POLICE	0	0	0
CIVIL FWA	0	0	0

Part 13a - Survivors

Male	0-12	13-19	20+	Female	0-12	13-19	20+	Total	Post Town
	0	0	0		0	0	0	0	

Part 13b - Lives lost

Male	0-12	13-19	20+	Female	0-12	13-19	20+	Total	Post Town
	0	0	4		0	0	0	4	CASTLEFORD/

Staff hours

RMT	DRC	DC	DDC/OM	WM	WO	CWA	SM	ACG
0.00	0.00	20.00	2.00	30.00	40.00	40.00	8.00	8.00

Resources

Service	Called	Tasked	Proceeded	On Scene	Released	Returned
LB 47008	251752	251752	251752	******	252019	
LB 47008	251003	251003	251003	251201	251549	******
MPCU 405	251339	251351	251358	251358	251438	
MV LAWT4	251421	251421	251421	251643	251800	
MV LDCV	251417	251417	251417	251626	251831	251831
MV MWVV6	251420	251420	251420	251800	251934	
MV V2LQ	251427	251427	251427	251619	252035	
R128 AIR	250718	250718	250744	250755	251113	251508
R128 AIR	250240	250240	250244	250331	250524	250557
R131 AIR	250448	250448	250448	250512	250752	250854
SC BURT	250342	250342	250351	250355	250712	250712
SC LB	250414	250414	250427	250603	251424	251623
TEES ALB	251353	251353	251400	251514	******	252019
WY LB	250239	250242	250305	250355	******	252019

Summary Narrative

At 0221 the Belize registered MV Rema broadcast a Mayday on VHF ch16 its position approximately 22 miles NE of Whitby. A search of the area using RNLI lifeboats, RAF helicopters and several Merchant vessels located the wreck of the vessel but its 4 crew were not found and considered to have perished with the vessel.

Incident Narrative

A Mayday call was heard at MRSC Humber at 250221 from the vessel giving callsign and position only, with no indication of what the distress situation was.The call was immediately answered . but no response gained from the vessel.The position of 54 42N 008 00W was plotted and checked against a DF bearing from the Whitby aerial. The position determined was approximately 21nm North East from Whitby. Mayday relays were promulgated from MRSC Humber but no response was forthcoming.

Investigations revealed that the vessel's name was REMA, a coaster on passage from Berwick to Terneuzen in Holland, carrying a cargo of redstone (an aggregate used in road making). The crew numbers were difficult to ascertain but probably four or five.

Whitby lifeboat and Rescue 128, sea king from Leconfield, were tasked to the incident arriving on scene at 0355 and 0331 respectively. On arriving on scene R128 reported an object in the water, which when investigated turned out to be an overturned liferaft. There was also a number of lifebelts and a large oil slick in the area. The lifebelts were left in the water to give an indication of drift. Scarborough Coastguard were tasked to man the landing site for the helicopter in case any survivors were located.

As initial searches were proving fruitless Scarborough Lifeboat was tasked to join the search and a second helicopter to relieve R128 requested from RCC Kinloss. The Mayday relay was constantly updated and broadcast on VHF, MF(2182), VHF DSC and MFDSC but still no response was made by any vessels. Search areas were calculated on SARIS and checked against known data from the positions of the lifebelts.

During the search various pieces of debris were located and taken on board the lifeboats, but no personnel were located.

Rescue 131 from Boulmer relieved R128 and contiued the search in concert with Whitby and Scarborough Lifeboats. Although the Mayday relays were frequently broadcast no further assistance was offered. MAIB and MPCU were informed of the incident and frequent Sitreps and a POLREP sent. CGHQ Press office informed of a major incident and kept updated as the search progressed.

The area surrounding the oil slick and lifebelts was thoroughly and effectively searched by the helicopters and lifeboats. Atlantic 405 the MPCU aircraft also assisted to ascertain the extent of pollution.

R131 was subsequently relieved by R128 with a new crew on board and the helicopter search continued until the end of the third assest's fuel endurance at 1113. Various pieces of debris were located including a survival suit marked M/S Fivel. Investigations revealed that this was a previous name of the REMA.

Further lifeboats were tasked to the search area, one 47-008 on passage and Teesmouth lifeboat. At 1407 in response to another Mayday relay four merchant vessels responded Rolf Buck, Sydstraum, Bikanes and Asperity. These were all taasked to the area to assist in the search.

Throughout the search various objects that had come from the sunken vessel were being located including mooring ropes, cabin doors, lifebelts, a gemini, and the liferaft.

The search was continued until twilight when after consultation with Regional Management the search was terminated, and all units were released. During the day liaison was maintained with the Police regarding the missing crew members who were English and with Clare Chappel at the press office. Problems were encountered regarding the number of crew members as the crew lists did not seem to tally with information received from relatives, however this was resolved during the day.

Altogther some 17hrs were spent searching for the missing crew members in water temperatures where survival was estimated at three hours.

On the 26th THV PATRICIA located a wreck in approximately the given position but was unable to confirm whether it was the REMA. Atlantic 405 checked for further pollution. As SAR involvement had ceased the incident was passed to MAIB for further investigation in liaison with the Belize authorities

M / SMC	DDC / OM	DC	RMT
CLOSED 28/04/1998 Mike Bill	CLOSED 29/04/1998 Tony Ellis	CLOSED 01/05/1998 Keith Vardy	CLOSE 07/05/1998 D HARDING

ANNEX 4

Copies of Cargo Shippers Comments

INSPECTORATE

Inspectorate Griffith Ltd
Grange Dock South Grangemouth Stirlingshire FK3 8UB Scotland
Tel: 01324 656029 Telex: 777980 Fax: 01324 474400

CERTIFICATE No. 7365

CERTIFICATE OF INSPECTION OF VESSEL'S HOLDS

Ref. No. 343.00766 **Date:** 24 April 1998

In pursuance of an order received, requesting us to carry out the instructions summarized as under:-

HOLD INSPECTION

of a consignment designated as:-

Description of goods	: 2-5mm 'Harden Redstone Chippings' 349.920 Tonnes in bulk
	: 5-8mm 'Harden Redstone Chippings' 572.560 Tonnes in bulk
Loaded to	: M.V. "REMA"
Loaded at	: Berwick-Upon-Tweed
On/Between	: 23 April 1998
Destination	: Terneuzen
Total Bill of Lading Weight	: 922.480 Metric Tonnes
Previous Cargo	: Malting Barley

We certify as follows:-

In accordance with instructions we attended on board the above mentioned vessel prior to commencement of loading and at the time of our inspection the holds were found to be clean, free from extraneous matter, suitable for the transportation of "Harden Redstone Chippings".

INSPECTORATE GRIFFITH LTD.

This Certificate is issued pursuant to an inspection carried out within the scope of the Principal's instructions and with the due care and skill in conformity with the General Conditions of Business of the International Federation of Inspection Agencies.

Claims in respect of this Certificate will be considered only if based upon failure to take due care proven by the Principal. Liability shall in no circumstances whatsoever exceed a total aggregate sum equal to ......10......times the amount of the fee or commission paid for the service the subject of this Certificate.

This certificate is not intended to relieve the parties to any relevant sales contract from their contractual obligations.

MEMBER OF THE WORLDWIDE INSPECTORATE GROUP – DEDICATED TO THE ELIMINATION OF RISK
Inspectorate Griffith Ltd. Registration No. 638315 Registered address 2 Perry Road, Witham, Essex CM8 3TU

HALCYON SHIPPING LIMITED
Shipbroking, Chartering, Port and Offshore Agents
Company Member of the Institute of Chartered Shipbrokers

VICE CONSULATE DENMARK

REGISTERED OFFICE:-
EUROPA HOUSE.
40 SOUTH QUAY.
GT. YARMOUTH.
NORFOLK NR30 2RL
Tel: (01493) 856831
Telex: 97188 (Agency)
Telex: 97477 (Chartering)
Fax: (01493) 857533

ALSO AT:-
LOWESTOFT SILO AND STORAGE,
COMMERCIAL ROAD,
LOWESTOFT,
SUFFOLK NR32 2TE
TEL: (01502) 567615
TELEX: 97476
FAX: (01502) 539288

TO: M.A.I.B. SOUTHAMPTON

FAX NUMBER: 01703 232459

ATTENTION: MR. A. RUSHTON

NO. OF PAGES (INCL. THIS PAGE): 4

FROM: TIM BETTS

DATE: 15-9-98 TIME: 1115

M.V. "REMA" SINKING 25TH APRIL 1998

FURTHER TO YOUR REQUEST FOR INFORMATION CONCERNING HOLD INSPECTIONS ON THE VESSEL. AS MENTIONED, PRIOR TO LOADING CARGO SUPERINTENDENTS APPOINTED BY CARGO OWNERS CHECK AND APPROVE THE SHIP'S HOLD PRIOR TO AUTHORISING COMMENCEMENT OF LOADING. IN MOST CASES THIS USUALLY IS A VERBAL AUTHORITY, A REPORT OF THE HOLD CONDITION IS NOT NORMALLY GIVEN.

WE HOPE THEREFORE THAT THE THREE ENCLOSED DECLARATIONS MAY BE OF USE. WE HAVE OBTAINED THESE FROM THREE MOST REGULAR USERS OF THE VESSEL :(I.E. CLAY, MALTING BARLEY, FLAKING GRITS FOR CEREAL MAKING) BECAUSE WE KNOW THAT THESE SHIPPERS ETC. WOULD BE IN THE BEST POSITION TO COMMENT ON HER CONDITION.

HOPE THIS IS OF ASSISTANCE TO YOU.

BEST REGARDS,

[signature]

Registered No. 1029848 England Directors M.J. Brooks (Managing) A. Garner (Secretary) A.C. Serruys (Dutch)
Bankers: National Westminster Bank PLC, 3 Hall Quay, Great Yarmouth–Sort Code 55-81-45–A/C No: 04928504

S & T SHIPPING LTD.

SHIPPING, CHARTERING & FORWARDING AGENTS | SHIPS AGENTS
5 ST. ANNS FORT, KING'S LYNN, PE30 1QS
TELEPHONE: 01553 772661/2/3 & 774849 | TELEX: 81669
A.O. 01553 761777 & 671451 | FAX: 01553 691074
KING'S LYNN

Our Ref: Your Ref: Date:

BCL/CH 3rd September, 1998

Halcyon Shipping Ltd.,
Europa House,
40, South Quay,
GREAT YARMOUTH,
Norfolk NR30 2RN

TO WHOM IT MAY CONCERN - WITHOUT PREJUDICE

Re: M.V. REMA at King's Lynn 14.01.1998 and 25.03.1998

With reference to the above vessel which loaded cargoes of Brewing Malt at King's Lynn on the above dates, on both occasions we acted as ships agent but also, as part of our service to the Shippers, we inspected the hold before loading commenced.

In view of the foregoing, we can confirm that the hold was kept in a good and clean condition free from any obvious obstructions or debris. The brewing malt is dried and prepared to a very high specification and therefore we would not allow loading to commence if the hold was found to be unfit and not watertight.

Yours faithfully,
for. S & BT SHIPPING LIMITED

Bridget Lascelles (Mrs)
Ships Agency Manager.

* LOADING MALT KINGS LYNN/BREMEN 27TH MARCH 1998

CCT-FAX +49 421 2045691 > +49 421 392187

K U R T A. B E C K E R

G m b H & C o. K G
GRAIN TRADE & PROCESSING DIVISION

KURT A.BECKER - Postfach 103247 - D 28032 BREMEN

MERAM - SCHIFFAHRTSKONTOR
ROLF HANKIEWICZ GMBH
POSTFACH: 10 33 66
LLOYDSTRASSE 1

D 28033 BREMEN

Bremen, 10.09.1998

Person in Charge Mr Osterloh
Telephone 0421/20456-43
F A C S I M I L E

re: MV "REMA"

With reference to your today's request we herewith would like to confirm that the loaded Maize Flaking Grits which were bound for Goole were in usual good condition prior loading. Before loading we (SGS was not ordered by us) have inspected the hold and found it in good order and condition to carry those goods. Of course, we didn't check any technical items of the vessel.

If you need further assistance please let us know.

* LOADING FLAKING GRITS BREMEN/GOOLE 11TH/13TH MARCH 1997

ECC INTERNATIONAL EUROPE – ECC PORTS
HOLD INSPECTION REPORT

VESSEL ...Roma............ INITIAL INSPECTION Date ..16-4-96...

Time ..16:35......

LOAD PORT ....Par............ DISCHARGE PORT ....

PASSED CLEAN FOR LOADING: Date ...16.4.96..... Time ....17.05.....

TYPE OF VESSEL: Singledecker/Shelter decker/Tween decker/Boxhold

NUMBER OF HOLDS .....one..................

HOLD CONDITION:	Good Clean Paint	Yes/~~No~~
	Cleaned free from previous cargo residue, loose rust, loose paint etc.	Yes/~~No~~
HATCH CONDITION:	Good Clean Paint	Yes/~~No~~
	Cleaned free from previous cargo residue, loose rust, loose paint etc.	Yes/~~No~~
CEILING CONSTRUCTION:		~~Wood~~/Steel
CEILING CONDITION:	Good Clean Paint	Yes/~~No~~
	Cleaned free from previous cargo residue, loose rust, loose paint etc.	Yes/~~No~~

SPECIFIC WORK INSTRUCTED BY HOLD INSPECTORS ....

....

If not passed for loading, estimated time/date for readiness:

....

Previous Cargo ..Pallets of Shotblast..........

COMMENTS: Passed for bags but looks a good ship for bulk

INSPECTOR ..P. Wilkinson......................

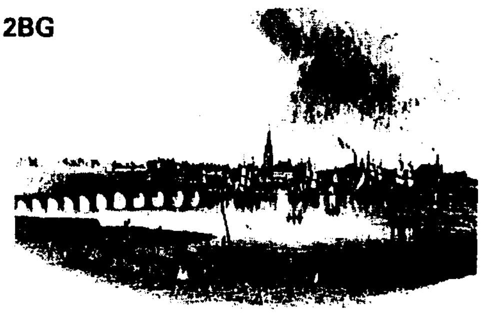
ECC INTERNATIONAL EUROPE undertake and report Hold Inspections as an advisory service only and do not relieve the shipowner of responsibilities for the preparation of the cargo space for the safe carriage of the cargo as required by the Charter Party.

DISTRIBUTION:
Top Copy (White) - ECCI Europe, Distribution Department
1st Copy (Blue) - South Coast UK

* LOADING CLAY PAR/ANTWERP 16TH APRIL 199[illegible]

W. N. LINDSAY (STEVEDORES) LTD.

1 Dock Road, Tweedmouth, Berwick-upon-Tweed TD15 2BG
Telephone : 0289 306209 Telex : 53588



TIME SHEET / STATEMENT OF FACT

Vessel : m.v. 'REMA'

Voyage From : BERWICK-UPON-TWEED To : TERNEUZEN Cargo : REDSTONE CHIPPINGS

Arrived :	22.4.98	1330 Hrs
First High Water after Arrival :	23.4.98	0036 Hrs
Berthed :	22.4.98	1350 Hrs
Notice Given :	22.4.98	1400 Hrs
Time Commences to Count :	As per C/P	
Commenced ~~Discharging~~ : Loading :	22.4.98	1500 Hrs
Completed ~~Discharging~~ : Loading :	23.4.98	1115 Hrs
Quantity ~~Discharged~~ / Loaded :	922.480 tonnes	
Sailed :		

WORK ANALYSIS

DAY :	DATE :	FROM :	TO :	REMARKS :
Wednesday	22.4.98	1500 Hrs	1700 Hrs	
Thursday	23.4.98	0700 Hrs	1115 Hrs	

W. N. LINDSAY (STEVEDORES) LIMITED.
BERWICK-UPON-TWEED.

MASTER..
m.v.

CODE NAME: CONGENBILL . EDITION 1994

Shipper

Tilcon (North) Limited.
P.O. Box 5,
Fell Bank, Birtley,
Chester-le-Street,
Co. Durham.

BILL OF LADING

TO BE USED WITH CHARTER-PARTIES

B/L No.

Reference No.

W. N. LINDSAY (STEVEDORES) LIMITED
1 DOCK ROAD, TWEEDMOUTH
BERWICK-UPON-TWEED
ENGLAND UK. TD15 2BG

Telephone: 01289-306209
Telex: 53588
Fax: 01289-306101

Consignee

to 'ORDER'

Notify address

'De Hoop' BV.
Terneuzen,
Holland.

COPY

Vessel: m.v. 'REMA'

Port of loading: BERWICK-UPON-TWEED

Port of discharge: [illegible]EN

Shipper's description of goods	Gross weight
A Cargo of 2 - 5 mm 'Harden Redstone Chippings' in bulk of	349.920 tonnes
A Cargo of 5 - 8 mm 'Harden Redstone Chippings' in bulk of	572.560 tonnes
	922.480 tonnes

(Nine Hundred and Twenty Two point Four Eight Zero Tonnes)

'CLEAN ON BOARD'

(of which on deck at Shipper's risk; the Carrier not being responsible for loss or damage howsoever arising)

Freight payable as per CHARTER-PARTY dated ....

FREIGHT ADVANCE.
Received on account of freight:

....

Time used for loading .... days .... hours.

SHIPPED at the Port of Loading in apparent good order and condition on board the Vessel for carriage to the Port of Discharge or so near thereto as she may safely get the goods specified above.

Weight, measure, quality, quantity, condition, contents and value unknown.

IN WITNESS whereof the Master or Agent of the said Vessel has signed the number of Bills of Lading indicated below all of this tenor and date, any one of which being accomplished the others shall be void.

FOR CONDITIONS OF CARRIAGE SEE OVERLEAF

Freight payable at	Place and date of issue: Berwick-upon-Tweed 23.4.98
Number of original Bs/L: 2/Two	Signature: Master.

C.15 Printed and sold by Witherby & Company Limited, 32/36 Aylesbury Street, London EC1R 0ET. Tel. No. 0171 251 5341 Fax No. 0171 251 1296 by authority of The Baltic and International Maritime Council, (BIMCO) Copenhagen.

SHIP LOADING RECORD. 2

TILCON
TILCON (NORTH) LTD

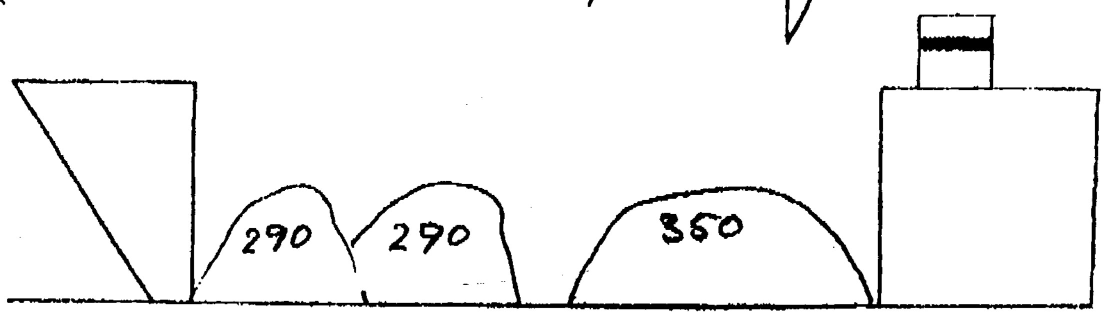
BERWICK - SHIP

VESSEL......REMA

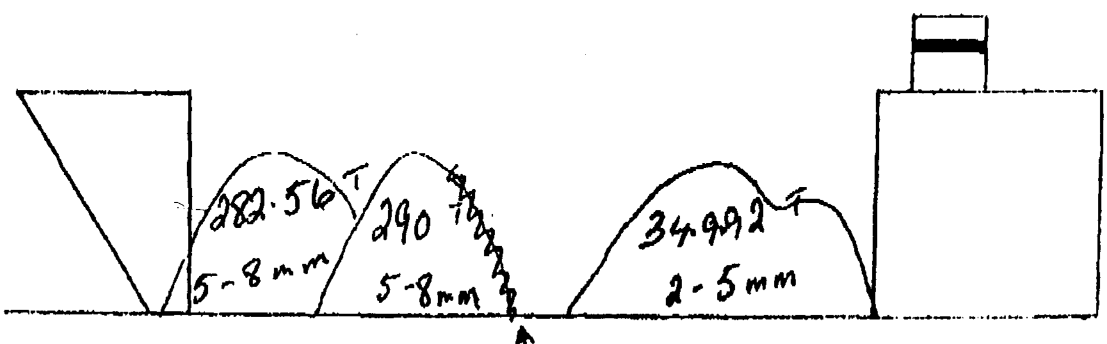
CUSTOMER......DE HOOP

DATE LOADED......23:4:98

AGREED LOADING PATTERN. SIGNED......[signature]...... AGENT
(IN ORDER OF SIZE I.E: 1-3/2-5/5-8)



ACTUAL LOADING. SIGNED......[signature]...... FOR TILCON



SEPARATION......PLASTIC SHEET.

DIRECT LOADING: TONNES......112.36 / 24.78......GRADE......2-5mm / 5-8mm

DESTINATION......TERNEUZEN HOLLAND

DEPARTURE DATE......24:4:98

SIGNED......[signature]......

ANNEX 5

Salvage Association Report

THE SALVAGE ASSOCIATION
INCORPORATED BY ROYAL CHARTER 1867

INSTRUCTION DATE	:	22nd July 1998
CASE NO.	:	1430704
SURVEY REPORT NO.	:	NA/1107/1
DATE	:	11th November 1998

HEAD OFFICE
BANKSIDE HOUSE
107/112 LEADENHALL STREET
LONDON EC3A 4AP

PHONE: +44 (0)171 648 2800
FAX: +44 (0)171 648 2874
TELEX: 94017187 (SALV G)
CABLE: WRECKAGE

THIS IS TO CERTIFY

that at the request of the General Manager of The Salvage Association and on behalf of the Marine Accident Investigation Branch (MAIB) flooding calculations have been carried out to assist the investigation into the loss of the 748 GT general cargo vessel

"REMA"

which sank off the coast of England on 25th April 1998 whilst on passage from Berwick to Terneuzen, Holland, carrying a cargo of redstone chippings.

Flooding Calculations on the "REMA"

1. INTRODUCTION

An ROV diving survey carried out in June 1998 at the reported position of the wreck found the "Rema" lying upright and largely intact on a reasonably level mud sea-bed in about 60m depth of water. Obvious damage to the hull included the crushing of the upper portion of the bow, two indents on the bulwark above the transom, and one indent on the starboard side of the hull in way of the engine-room aft. Most of the cargo hatch pontoons had buckled inwards roughly at their mid-span, and it appeared that many of the vertical frames within the hold had been bent at their base and top in way of the tank-top and the main deck. The only other obvious damage noted was to the four-bladed propeller: about one-third of the span from the tips of three of the blades was broken off leaving jagged edges, the fourth blade being bent but less damaged than the others. No damage to the rudder could be seen.

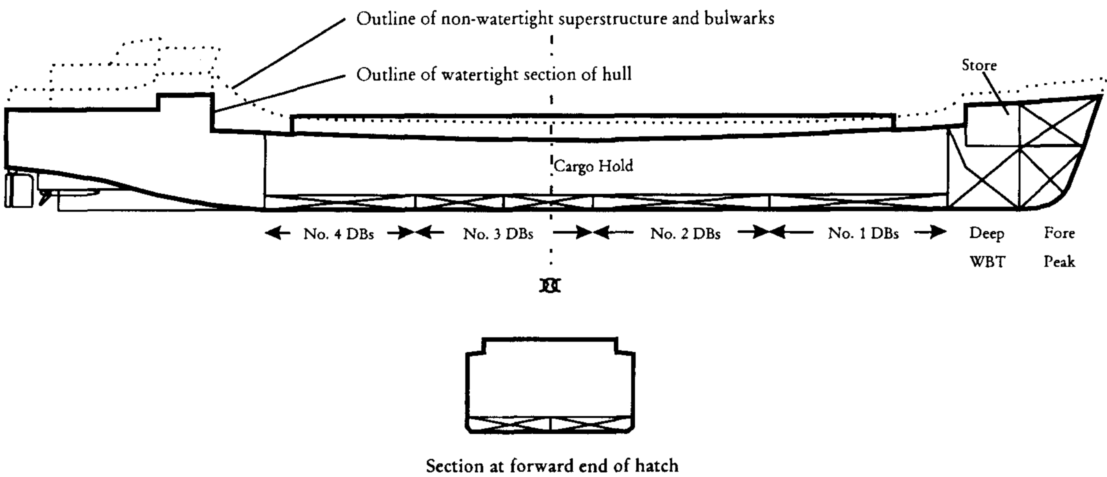
Most of the cargo had spilled out of the cargo hold. Evidence suggested that this had poured through the forward hatch pontoons (these being the only pontoons that were obviously out of position) whilst the vessel had been inclined very steeply to the horizontal. With mud found on the stem bar of the bow at forecastle deck level and behind the anchors, it appeared that the "Rema" must have plunged by the head, digging the bow into the bottom mud whilst the stern was kept at or near the surface for some unknown length of time by temporary residual buoyancy. With most of the hatches in their correct positions, there was no indication of capsize having occurred during the sinking process.

The crushing of the bow, the indents at other locations, and the collapse of the hatch pontoons were considered most likely to have been caused either directly or indirectly by implosion due to pressure of water. Some interplay with suction effects whilst cargo ran out of the hold may have been involved in the collapse of the hatch covers. These damages, therefore, appeared to be consequences rather than causes of the sinking. The damage to the propeller blades, on the other hand, had this occurred during the final voyage, could indicate that the "Rema" had touched the ground at some point. It is possible, therefore, that her bottom shell could have been breached although this could not be seen.

The purpose of this investigation was to perform calculations to explore the extent of flooding that would be necessary to sink the "Rema" in a manner that was consistent with the known circumstances of the casualty and the evidence available from the wreck. If possible, the investigation was to attempt to narrow in on the position and extent of damage that, at least on the balance of probabilities, is likely to have been involved.

2. "REMA" - PRINCIPAL CHARACTERISTICS

The "Rema" was a single hold 748GT, low air-draught bulk carrier / dry cargo ship, built in Holland in 1976. Figure 1 shows her general arrangement in terms of main compartments.



Length BP	59.80m
Breadth	9.40m
Depth	3.80m
Draught (S)	3.12m

Figure 1. Main Arrangements of M.V. "Rema"

It can be seen that "Rema" had a substantial ballast capacity. This was of the order of 500m^3, 270m^3 of which was in the form of double bottom tanks lying entirely below the cargo hold.

3. SOFTWARE USED

Hull modelling, hydrostatics, damage stability and progressive flooding calculations have all been carried out using the WOLFSON UNIT software which is widely used in the industry. During the course of this investigation some "bugs" were discovered in the software in certain modes of calculation. These could affect the descriptions of the stability characteristics GM and GZ for a vessel as presented in the programs' output once the equilibrium condition had been found, but do not affect the underlying balancing algorithms. These problems were reported to the Wolfson Unit who are presently de-bugging their code. Extensive discussions with them, however, indicated that the results presented in this report are not likely to have been affected, and even if they were then only small numerical differences in the calculated values of GM and GZ would be involved which would not affect the overall conclusions.

4. GENERATION OF BODY-PLAN

Only a limited amount of documentation was available for the vessel. Unfortunately this did not include a body plan, lines plan, or table of hull offsets. Some structural drawings were available that gave a reasonable definition of the fore-end. However, no drawings were available giving the shapes of sections at the aft end, and it was therefore necessary to deduce the likely shape from the General Arrangement drawing. A body plan was generated and is shown in Figure 2. Checks against the available hydrostatic data were made and it was considered that the generated body plan would be sufficiently accurate for the purposes of this exercise.

5. CHECKING ACCURACY

A grain stability booklet was available. This gave details of the lightweight of the vessel and normal operating conditions, but only provided information on weights, vertical centres of weights and resulting mean draughts. No information was available on longitudinal centres of weights and resulting trim. A diagram of cross-curves of stability was available, but no table of hydrostatics.

The cross curves of stability were checked against the corresponding computer program output for three different displacement conditions. The maximum error in the cross-curve parameter KN was found to be 2%. The displacement error for a light draught condition of 1.3m was found to be 3%, corresponding to approximately 16 tonnes in 540 tonnes; for a deep draught condition of 3.2m the displacement error was found to be 1.5%, corresponding to approximately 22 tonnes in 1490 tonnes.

6. ANALYSES & RESULTS

6.1 Estimating Vessel Condition at Time of Initiation of Flooding

The condition of the "Rema" at the time of the initiation of flooding was assumed to be the same as the departure condition from Berwick since the effects of use of fuel and water would have been slight. Unfortunately, there was some ambiguity in the available description of the actual departure condition. It was understood that before leaving Berwick the master verbally declared a draught of 3.3m to the Assistant Harbour Master and that the trim at that time may have been about 10cm by the head. However, no-one ashore officially witnessed or recorded the draught and trim and thus it was not clear whether the draught declared was the *mean* draught or the *maximum* draught. To cover this ambiguity, in this study both possibilities have been considered as discussed below.

(a) Possible Departure Condition:- Mean Draught 3.3m / Trim -0.1m

The hydrostatics software provided the total displacement and longitudinal centre of buoyancy for the vessel corresponding to this first interpretation of the departure condition which assumes the declared draught to be the mean draught and imposes a trim by the head of 10cm. Knowing the total weight of cargo loaded (923 tonnes), and estimating the height of the centre of gravity of the cargo from consideration of its likely geometry when stowed in the available hold space at a stowage factor of 0.71m^3 per tonne, it was possible to deduce a "constant" for the ship's condition which would summarise the weight and vertical centre of any unknown items on board. This overall calculation and the deduced position of the vessel's centre of gravity is shown in Table 1a.

It can be seen that if the declared draught was the mean draught then there could have been of the order of 95 tonnes on board that has not been identified. Without longitudinal centres for the lightship and other items it was not possible to home in on where this weight would have been centred longitudinally. If this unknown weight was ballast, as a single tank this could correspond roughly to the capacity of the deep tank forward (capacity approx. 102 tonnes sea-water). Alternatively it could correspond to one set of double bottom tanks plus the lower fore-peak tank (total capacity approx. 70 tonnes plus 27 tonnes). For the purposes of the subsequent stability calculations carried out for this investigation the vertical centre of gravity of this unidentified weight was assumed to lie at 0.6 of the depth of the main hull from the keel.

If the mean draught was in fact 3.3m then the vessel would have been deeper than her summer marks. With this in mind, and in view of the fact that the Harbour Master would probably have been more concerned with available water under the deepest part of the keel, it was considered more likely that the declared draught was actually the *maximum* draught of the vessel on departure. Such a condition is examined below.

(b) Possible Departure Condition:- Mean Draught 3.12m / Trim -0.36m

A maximum draught of 3.3m could be achieved by a range of combinations of mean draught and trim. If it is assumed that the vessel was not over-loaded and that her mean draught was equal to her summer marks at 3.12m then this would result in the minimum trim condition for the lighter displacement options, i.e. 0.36m by the head. This was considered to be the most likely of the range of possible alternative interpretations of the declared departure condition and a similar analysis summary for this condition is given in Table 1b. It can be seen that in this case the corresponding "constant" is small (actually negative) and does not raise the suggestion of pre-filled or pre-flooded spaces.

(c) Assumed Casualty Condition

For the purposes of presentation in this report the former deeper condition (a) summarised in Table 1a has been taken as the casualty condition. The reason for this was because this condition exhibited weaker hydrostatic stability characteristics (although both conditions are actually very strong in this respect) and presented the more pessimistic results - in the sense here of requiring lesser quantities of flood water to submerge down-flooding points and to reach the point of sinking. All tables of results and diagrams of floating attitudes, therefore, are based on this deeper intact condition of the vessel and brief discussion of the typical differences in the results of calculations using the lighter possible departure condition is given in section 6.4.

Figure 3, then, shows pictorially the floating attitude and resulting transverse stability of the "Rema" in the departure/casualty condition described in Table 1a. It can be seen that the vessel would have had appreciable stability, and this would have been largely influenced by the comparatively low centre of gravity of the cargo. Since stone chippings tend to have a large angle of repose (of the order of 55 degrees) and as a cargo is not liable to liquefy, it was considered very unlikely that shifting of cargo would have been involved in any initiating process in the casualty or, indeed, that it would have contributed in any way to the sinking sequence until the trim and/or heel had become large.

Figures 1 and 3 show the extent of main hull that was considered water-tight in the calculations. For trimming by the bow the first positions for possible rapid down-flooding was identified as the forward corners of the cargo hatch lying at 5.175m above the keel line, ±3.75m from the centre-line and 19.35m forward of amidships. In the assumed condition at the time of the initiation of the flooding it can be seen that the free-board to these down-flooding points would have been 1.84m and the heel angle required to immerse these points would have been 26 degrees.

6.2 Flooding Scenarios

In this investigation the following combinations of flooding were examined:-

(i) Flooding of the cargo hold;

(ii) Flooding of different combinations of the double bottom tanks, always pessimistically including the flooding of the lower fore-peak tank and the forward deep ballast tank;

(iii) Flooding of (i) and (ii) together.

No flooding of spaces aft has been considered in view of the evidence from the wreck that indicated that the vessel had plunged by the bow. Similarly, flooding of the forward store space and the upper fore-peak tank (see Figure 1) was not considered in the flooding scenarios since the evidence from the wreck suggested strongly that these spaces imploded during the sinking, therefore indicating that they were largely dry before the final plunging[1].

[1] Note that the absence of any obvious implosion damage in way of the lower forward tanks does not necessarily imply that these spaces, conversely, *did* fill by flooding at the surface. For it could be that there was implosion damage to these spaces *internally* in way of the deck or bulkhead connections to the spaces above.

6.3 Flooding Calculations

Table 2 summaries the salient flotation and stability characteristics for four cases (A to D) of symmetrical flooding involving progressively worse (and arguably less likely) extents of damage to the bottom of the "Rema" whose intact condition is illustrated in Figure 3. For each case of free-flooded bottom damage the cargo hold was then progressively flooded to two identifiable "critical" conditions: (i) the point where the forward end of the cargo hatch just became submerged (at which point rapid down-flooding could have occurred had the cargo hatches been disturbed - see section 6.1); and (ii) the point where the computer program predicted that the vessel sank. In the latter case the table records the floating attitude, etc., in the time-step just before the sinking was recorded.

Table 3, similarly, summaries the flotation and stability characteristics for three cases (E to G) of asymmetrical bottom damage followed by the same progression of cargo hold flooding as in cases A to D above.

In both tables of results "Flooding Time Indices" are included. For each case of bottom damage these figures represent the time it would take, in hours, to flood the hold space *from the tanks-flooded condition* to each of the two critical conditions described above with flooding taking place from the sea to the hold through a 25cm^2 aperture located at the forward end of the hold on the starboard side at tank-top level. Obviously this hole size and position is notional and for reference only since no actual holes have yet been identified in the hull. However, using these Flooding Time Index figures the actual flooding times for smaller or larger holes can be determined[2]. Regarding the sensitivity of this Flooding Time Index to *position* of the hole, the most significant factor here is the initial "head" of water from the sea into the hold. To illustrate the effect of this the overall Flooding Time Index for CASE A[3] was recalculated positioning the hole near to the original waterline and in this situation the Flooding Time Index increased from 24 to 36.

6.4 Results & Discussion

Examining Tables 2 and 3, the first result to note is that none of the simulations involving bottom damage alone (i.e. without flooding of the hold) led to the loss of the ship. With progressive flooding of the hold occurring thereafter, however, all simulations ended up with the vessel sinking. Similarly, flooding of the hold alone, without any flooding of the bottom tanks, led to the vessel sinking in simulation. It may be inferred, therefore, that in order for the "Rema" to have sunk within the range of possible flooding scenarios (see section 6.2) flooding of the hold at least must have been involved.

[2] As flooding time is inversely proportional to the hole area, the time needed to flood the hold through a hole of actual area "A" (in cm^2) can be scaled from the Flooding Time Index by multiplying by the factor (25/A).

[3] For all other cases it should be noted that the Flooding Time Index does not include the time taken to flood the tank spaces.

In all flooding simulations carried out it can be seen that the mean draught progressively increased (as expected of course), as did the trim by the head since most of the flooding was centred forward of amidships. Figures 4 and 5 show pictorially the progressive change in attitude of the vessel for CASE A and CASE G through to the point of sinking. These were considered to be the most likely flooding scenarios of those considered since they involved the minimum extents of bottom damage.

For cases of symmetrical damage it can be seen that the heel angle remained zero throughout the flooding simulations since the total free-surface effects generated were insufficient to destroy the upright stability of the vessel to the extent of causing a loll. Generally, though, the stability index GM did tend to reduce as flooding proceeded: however, some cases showed a slight recovery in GM in the latter stages and this would be where tanks or compartments approached their filling points such that the free-surface losses partly disappeared.

An indication of the resilience of the vessel's transverse stability to flooding was given by the GZ values at 20 degrees. It can be seen that in all cases the vessel exhibited a significant range of residual stability even at the point of potential down-flooding, indicating that whatever was the actual extent of flooding suffered the vessel was unlikely to have capsized during the sinking. Indeed the progressive flooding program indicated in all cases that the final sinking of the vessel occurred by over-trimming and that in the final time-step prior to the sinking the GM value was positive. This was all in keeping with the physical evidence from the wreck which indicated that the "Rema" plunged by the head without capsizing.

Looking at specific results it can be seen that if flooding of the hold alone was involved (CASE A) then it would have taken of the order of 700 tonnes of water ingress to sink the vessel. If such ingress had taken place through a hole equivalent to 5cm x 5cm square at tank-top level then this would have taken of the order of 24 hours to occur. It can be seen that of all the damage extents modelled this, unsurprisingly, required the most water to sink the vessel. The conditions requiring the least amount of water were CASE C and CASE G and of these CASE G involved flooding of the least number of tanks, namely, the two forward tanks plus the starboard side of the No. 1 double bottoms. It can be seen that to sink the vessel in simulation in these circumstances still required a total ingress of water of the order of 500 tonnes, although with such damage the total time for sinking to occur with inflow through a 5cm x 5cm hole was now of the order of 13 hours taking account of the time taken to flood the tanks as well as the hold.

Addressing the ambiguity surrounding the condition of the "Rema" at the time of the casualty (see section 6.1), similar calculations to those above showed that for each case of bottom damage approximately 5% more total flood water would be required to sink the vessel had the lower displacement departure condition of Table 1b more closely matched the actual condition at the time of the casualty.

Finally, looking at the floating attitude of the vessel for each damage scenario at the point where the hatch edge just became submerged (i.e. the point where, potentially, more rapid down-flooding could have commenced), shows that the trim angles[4] predicted were not severe. It is plausible, therefore, that only relatively small changes in trim occurred during the flooding which may have contributed to the crew not being alerted to there being a problem until it was too late. The comparatively larger heel angles developing in CASE E and CASE F, however, could reasonably have been expected to have alerted the crew earlier, at least giving them time to abandon ship; since they did not manage to escape, these scenarios involving severe asymmetrical flooding can probably be discounted. Being representative of the remaining scenarios, figures 4 and 5 show that prior to the point of possible down-flooding the main deck would have become awash. It might be expected that this would have alerted the crew in time to take some action even though low freeboard vessels of this size would regularly take seas onto their decks in normal operation. However, on the night in question there was no moon and conditions would likely have been very dark. Furthermore, the seas were slight and any change in the "feel" of the vessel's motions (such as sluggishness in response to waves) may not have been discernible.

[4] For this length of ship and the range of angles considered the trim angle in degrees roughly equals the corresponding trim expressed in metres between perpendiculars.

7. CONCLUSIONS

Possible damage scenarios considered have included combinations of flooding of the double bottom tanks, the forward deep water ballast tank, the lower fore-peak tank, and the cargo hold. The flooding of the forward store and the upper fore-peak tank have been excluded from consideration since evidence of implosion suggests that these were largely empty prior to the final plunging. On the basis of flooding simulations performed the following conclusions were made:-

- Breaching of any combination of bottom tanks alone would not have caused the "Rema" to sink. Flooding of the hold must also, or alternatively, have been involved.

- Flooding of the hold alone, without damage to any of the bottom tanks, would have led to plunging by the head and would have required the ingress of about 700 tonnes of water to do so.

- The calculated simulations of sinking support the physical evidence from the wreck in that, whatever the actual extent of initiating damage to the hull within the scenarios considered possible, the "Rema" would have sunk by plunging by the head without capsizing.

- Overall, it would appear that the "Rema" would have to have taken on board of the order of at least 500 tonnes of flood-water to overcome her buoyancy and result in her sinking. If a nominal breach (or number of breaches) in the outer skin having a total area of $25cm^2$ is considered for reference purposes, flooding to cause sinking could have taken in the region of 12 to 36 hours depending on the location of the hole(s) and the number of compartments breached.

- Of the flooding scenarios considered, those involving severe asymmetrical damage are considered less likely since the heel angles developing early could reasonably have been expected to have alerted the crew in time for them to have taken some action.

- It is plausible that the flooding leading to the sinking of the "Rema" involved no heeling and only relatively small changes in trim in the early stages which, when combined with the conditions on the night in question, may have contributed to the crew not being alerted until it was too late.

Report Prepared By:-

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Staff Naval Architect

Item	*Weight (tonnes)*	*VCG (m)*	*Vmom*	*LCG (m)*	*Lmom*
Lightweight + basic	536.35 [SB]	3.190 [SB]	1710.957		
Cargo	923.00 [K]	2.000 [E1]	1846.000		
Constant	**94.65** [C]	2.280 [E2]	215.802		
Departure Condition	1554 [H]	2.428 [C]	3772.759	0.869 [H]	1350.426

[SB] From Stability Booklet [H] From hydrostatics [K] Known [C] Calculated
[E1] Estimated from likely distribution of cargo in hold
[E2] Estimated at 0.6 x depth of hull to main deck

Table 1a. Estimated Casualty Condition:- Mean Draught 3.3m, Trim -0.1m

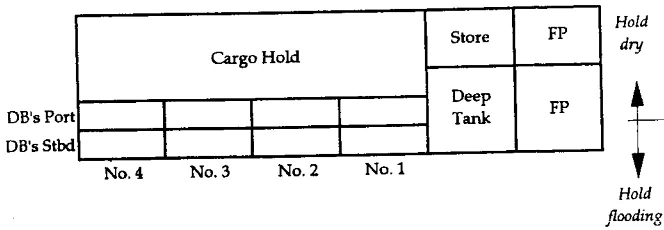
Item	*Weight (tonnes)*	*VCG (m)*	*Vmom*	*LCG (m)*	*Lmom*
Lightweight + basic	536.35 [SB]	3.190 [SB]	1710.957		
Cargo	923.00 [K]	2.000 [E1]	1846.000		
Constant	**-7.35** [C]	2.280 [E2]	-16.785		
Departure Condition	1452 [H]	2.438 [C]	3540.199	1.477 [H]	2144.604

[SB] From Stability Booklet [H] From hydrostatics [K] Known [C] Calculated
[E1] Estimated from likely distribution of cargo in hold
[E2] Estimated at 0.6 x depth of hull to main deck

Table 1b. Estimated Casualty Condition:- Mean Draught 3.12m, Trim -0.36m

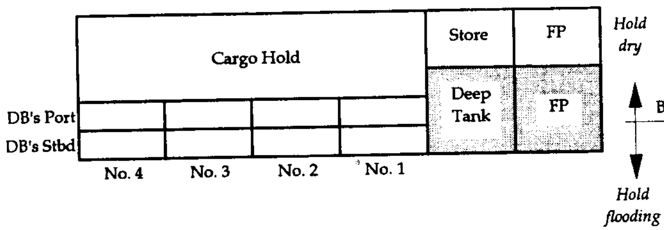
TABLE 2. SYMMETRICAL FLOODING OF BOTTOM TANKS FOLLOWED BY PROGRESSIVE FLOODING OF HOLD

CASE A



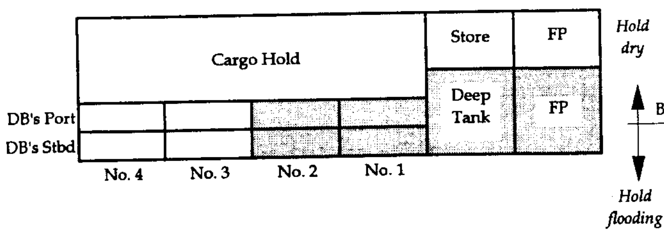
	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at 20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Hold dry	0	3.30	0.10	0.0	1.77	0.56	1.84	26.1	3.05	0.0
Hatch edge at waterline	660	4.64	1.73	0.0	0.57	0.14	-0.02	0.0	0.87	20.0
Vessel at point of sinking	769	4.99	2.44	0.0	0.64		-0.61		0.15	24.0

CASE B



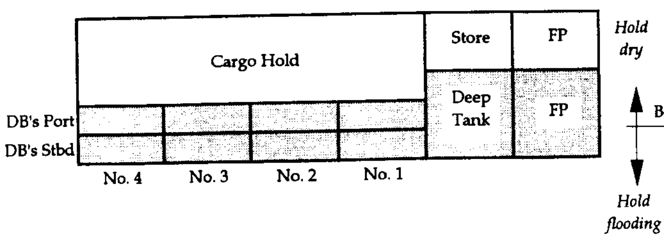
	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at 20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Bottom tanks flooded as shown	124	3.55	1.37	0.0	1.85	0.54	1.18	17.5	2.14	0.0
Hatch edge at waterline	483	4.32	2.74	0.0	0.60	0.14	-0.03	0.0	0.67	9.0
Vessel at point of sinking	592	4.85	4.45	0.0	0.29		-1.12		-0.75	12.0

CASE C



	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at 20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Bottom tanks flooded as shown	266	3.83	2.10	0.0	1.55	0.59	0.67	10.1	1.49	0.0
Hatch edge at waterline	420	4.20	3.14	0.0	0.95	0.32	-0.05	0.0	0.58	3.3
Vessel at point of sinking	537	4.91	5.66	0.0	0.61		-1.56		-1.43	6.3

CASE D

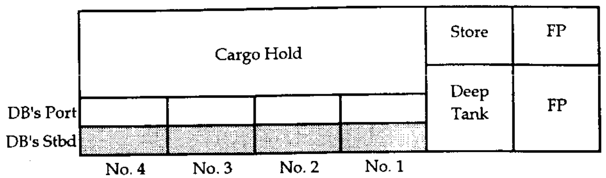


	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at 20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Bottom tanks flooded as shown	400	4.09	1.88	0.0	1.84	0.65	0.47	7.2	1.34	0.0
Hatch edge at waterline	504	4.35	2.61	0.0	1.16	0.44	-0.02	0.0	0.70	2.3
Vessel at point of sinking	626	5.54	6.61	0.0	0.58		-2.51		-2.55	5.0

** This index approximates to the number of hours taken to flood the hold <u>from the free-flooded tanks condition</u> through a 25cm^2 apperture to the hold from the sea located at the forward end of the hold on the starboard side at tank-top level*

TABLE 3. ASYMMETRICAL FLOODING OF BOTTOM TANKS FOLLOWED BY PROGRESSIVE FLOODING OF HOLD

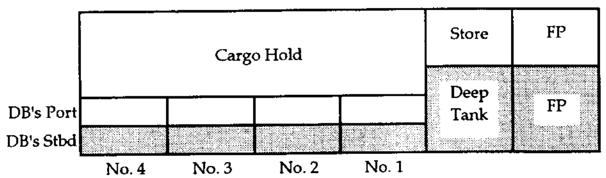
CASE E



Hold dry ↑ … ↓ *Hold flooding*

	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at +20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Bottom tanks flooded as shown	135	3.55	0.31	5.4	1.92	0.60	1.16	17.2	2.68	0.0
Hatch edge at waterline	373	4.04	0.94	12.6	1.05	0.36	-0.03	0.0	1.80	6.0
Vessel at point of sinking	709	5.38	3.59	30.0	1.19		-3.50		-1.25	15.5

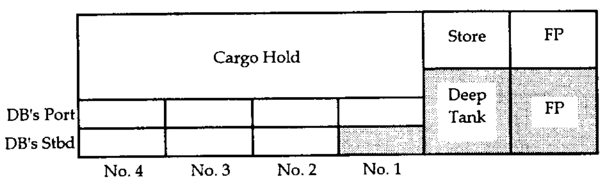
CASE F



Hold dry ↑ … ↓ *Hold flooding*

	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at +20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Bottom tanks flooded as shown	263	3.82	1.63	6.0	1.85	0.57	0.43	6.5	1.72	0.0
Hatch edge at waterline	320	3.96	1.98	8.7	1.57	0.51	-0.01	0.0	1.39	1.3
Vessel at point of sinking	586	5.43	6.40	25.9	0.81		-4.15		-2.64	7.5

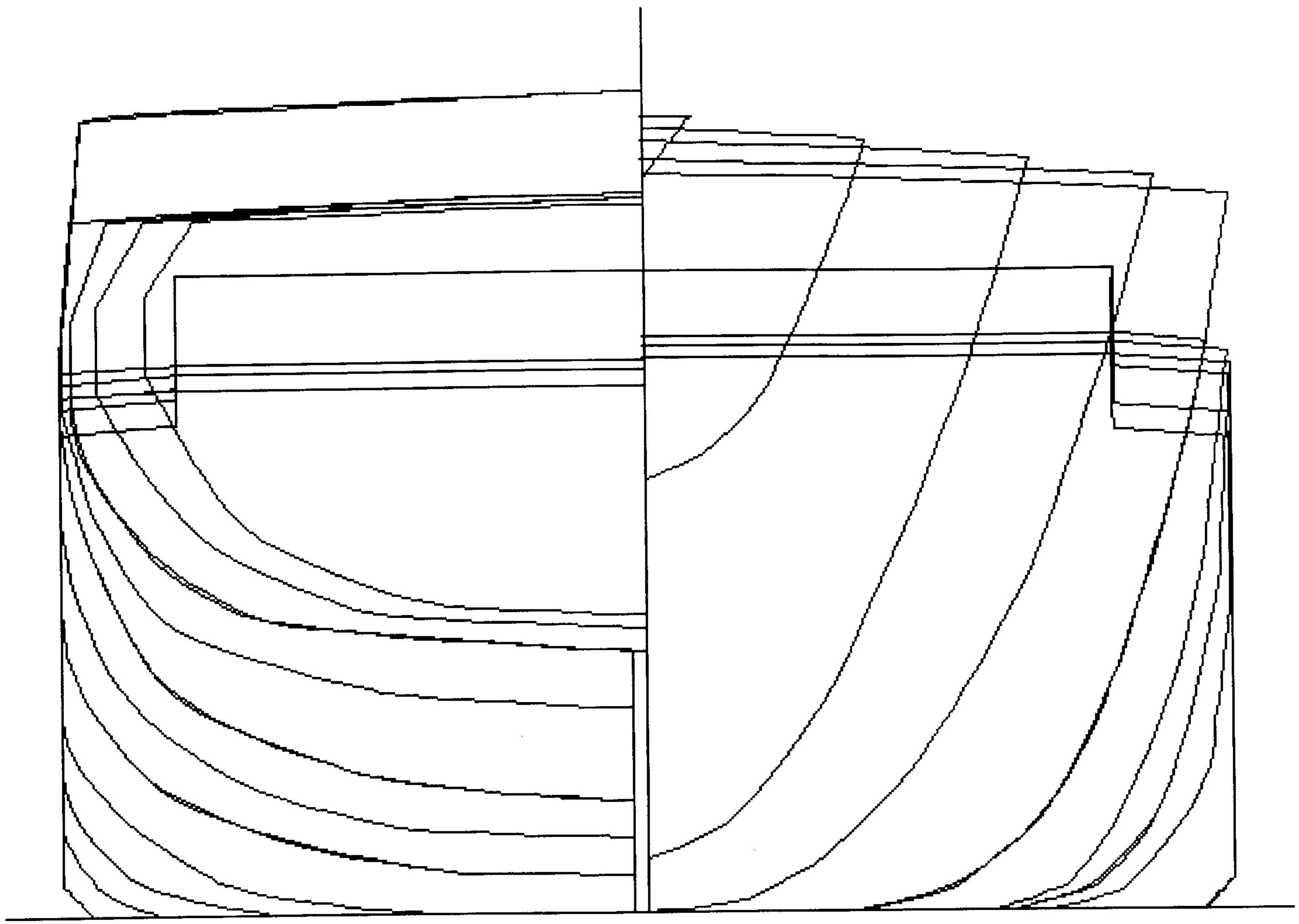
CASE G



Hold dry ↑ … ↓ *Hold flooding*

	Total Flood water (tonne)	Mean Draught (m)	Trim by bow (m)	Heel Angle (deg)	GM fluid (m)	GZ at +20 deg (m)	Freeboard to Hatch (m)	Angle to Hatch (deg)	Freeboard to Foc's'le (m)	Flooding Time Index*
Bottom tanks flooded as shown	156	3.61	1.60	1.2	1.90	0.55	0.97	14.5	1.97	0.0
Hatch edge at waterline	366	4.06	2.59	4.4	0.60	0.29	-0.02	0.0	0.99	5.0
Vessel at point of sinking	539	4.53	3.51	6.1	0.42		-0.90		0.05	9.5

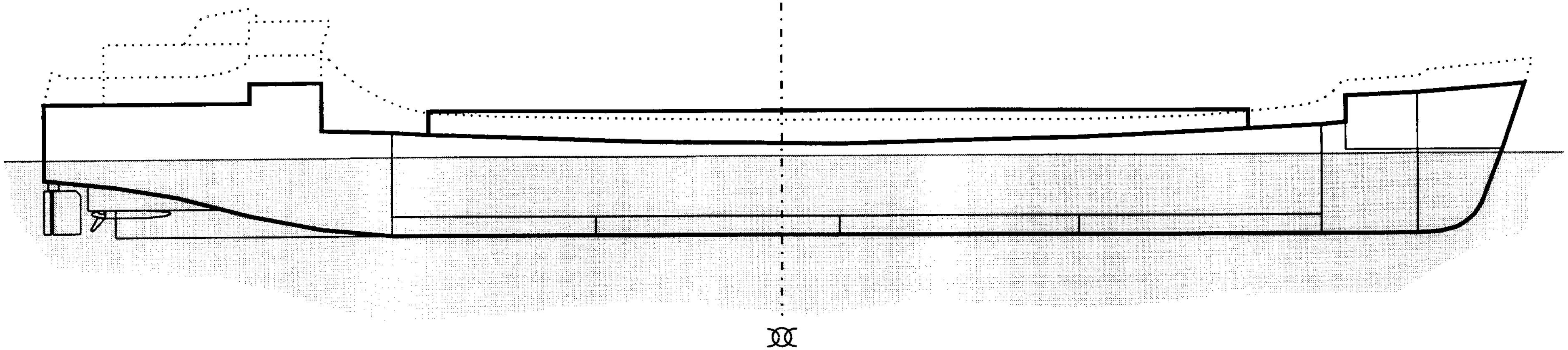
* *This index approximates to the number of hours taken to flood the hold from the free-flooded tanks condition through a 25cm² apperture to the hold from the sea located at the forward end of the hold on the starboard side at tank-top level*

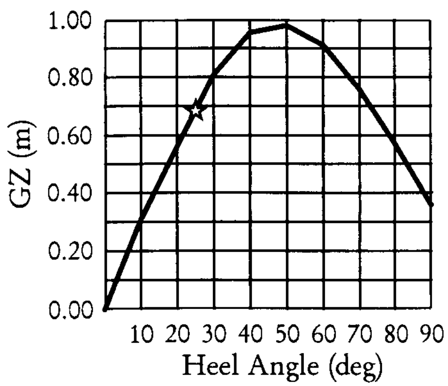


"REMA"

FIGURE 2. BODY PLAN GENERATED

Figure 3. "REMA" Departure Condition



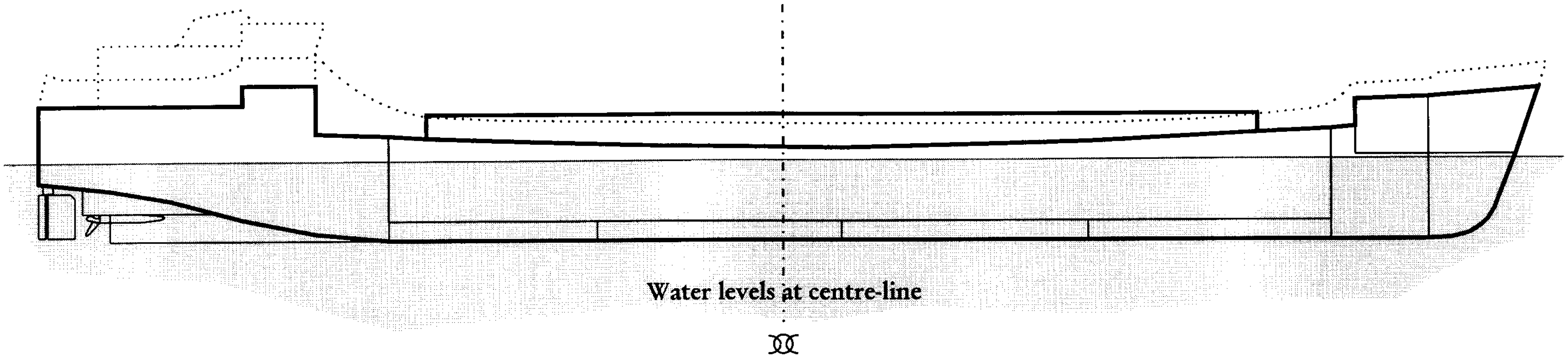


Draught Fwd: 3.35 m
Draught Aft: 3.25 m
Trim by bow: 0.10 m

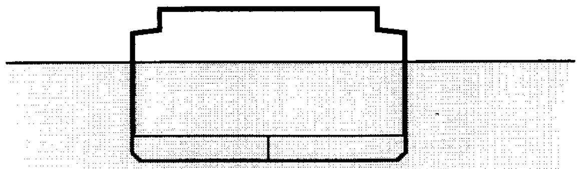
Equilibrium $GM_{(fluid)}$: 1.77 m

☆ *Angle for down-flooding at forward end of hatch*

Figure 4a. CASE A:- Starting condition - Hold Dry



Draught Fwd:	3.35 m
Draught Aft:	3.25 m
Trim by bow:	0.10 m
Heel angle:	0.00 deg
$GM_{(fluid)}$:	1.77m



Section at forward end of hatch looking aft

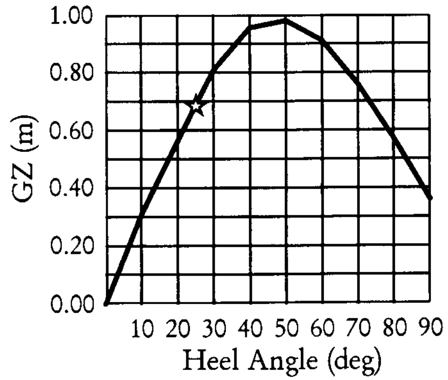
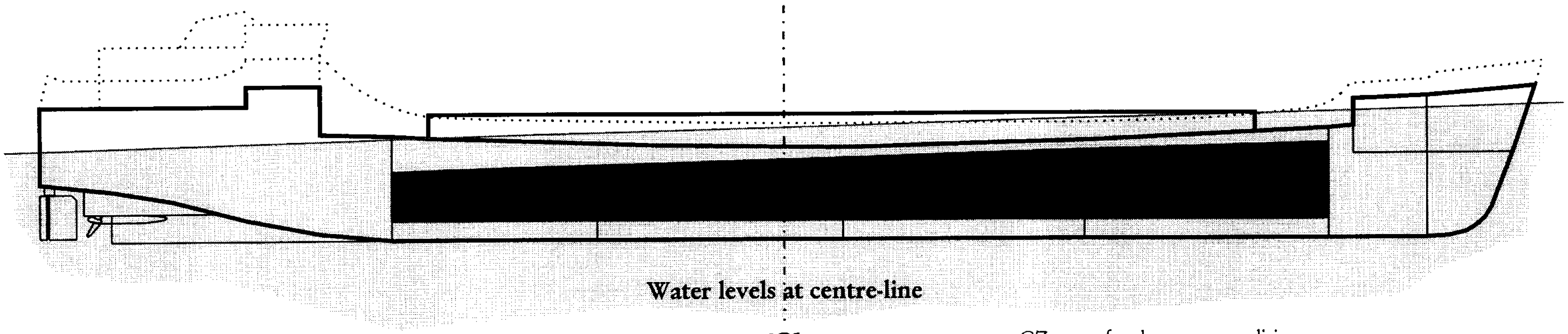
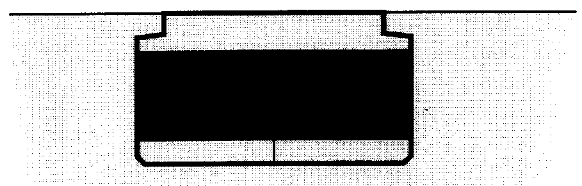


Figure 4b. CASE A:- Hold flooded to cause immersion of hatch edge



Draught Fwd:	5.51 m
Draught Aft:	3.77 m
Trim by bow:	1.74 m
Heel angle:	0.00 deg
$GM_{(fluid)}$:	0.57m



Section at forward end of hatch looking aft

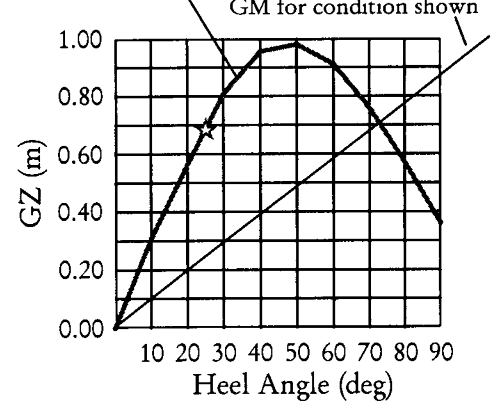
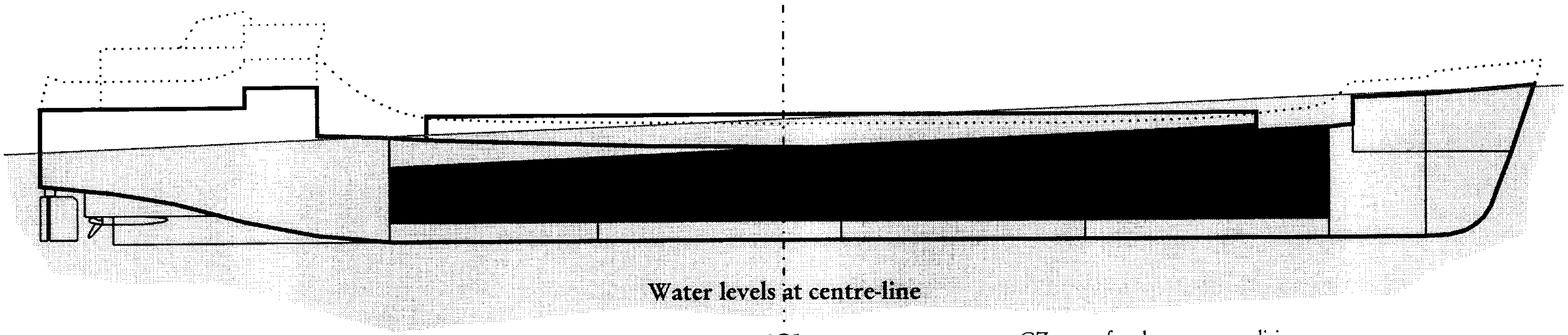
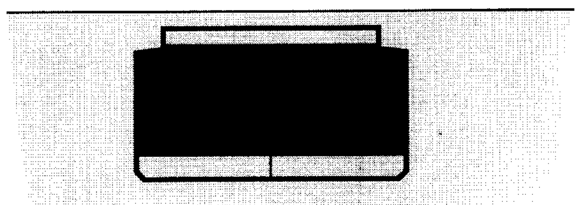


Figure 4c. CASE A:- Hold flooded to point of sinking



Draught Fwd:	6.21 m
Draught Aft:	3.77 m
Trim by bow:	2.44 m
Heel angle:	0.00 deg
$GM_{(fluid)}$:	0.64m



Section at forward end of hatch looking aft

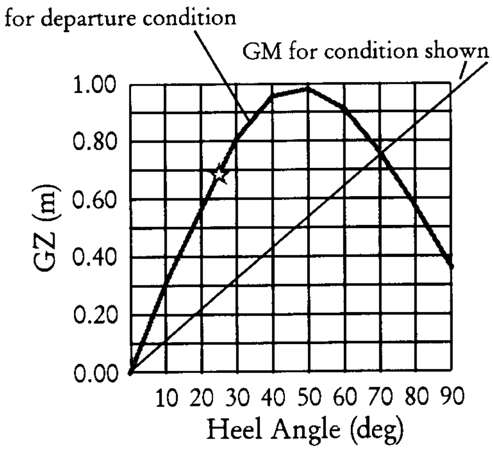
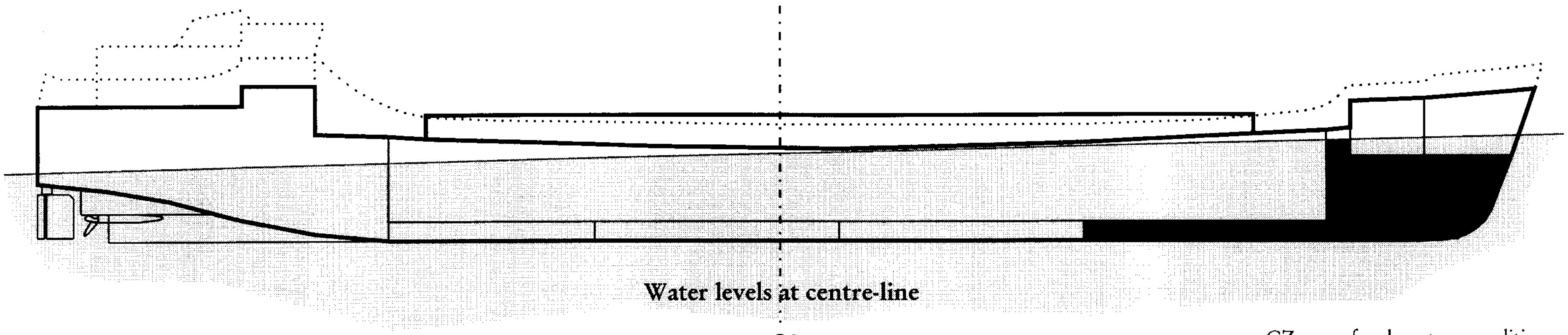
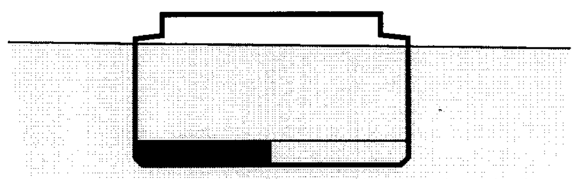


Figure 5a. CASE G:- Starting condition - Tanks free-flooded - Hold dry



Draught Fwd:	4.41 m
Draught Aft:	2.81 m
Trim by bow:	1.60 m
Heel angle:	1.20 deg
$GM_{(fluid)}$:	1.90m



Section at forward end of hatch looking aft

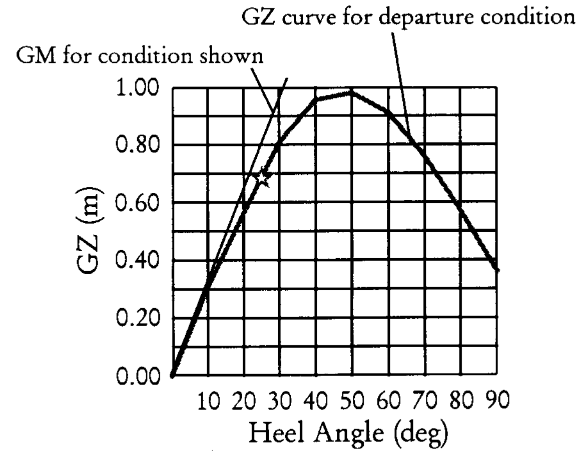
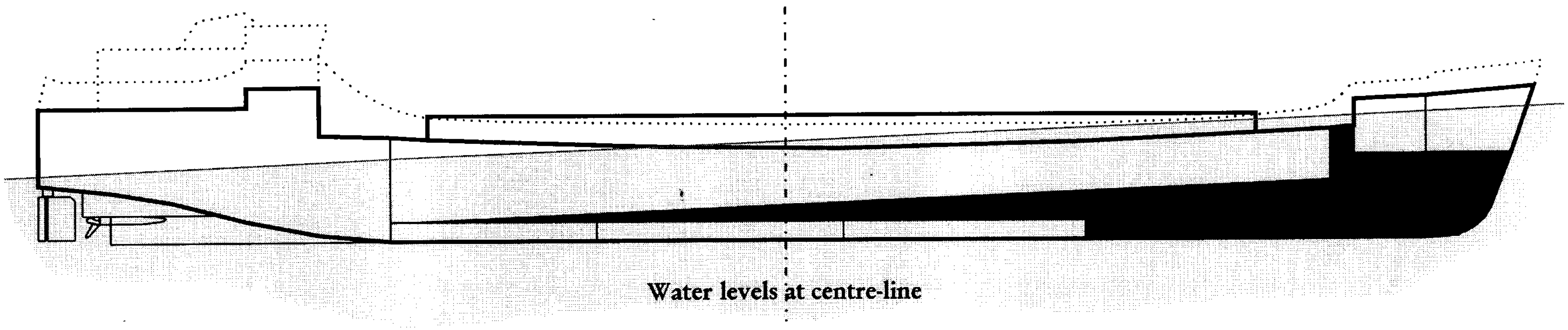
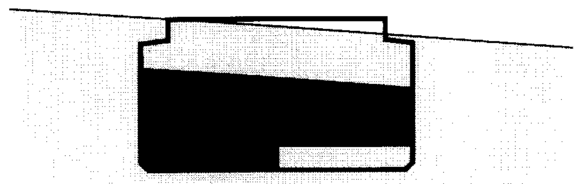


Figure 5b. CASE G:- Hold flooded to cause immersion of hatch edge



Draught Fwd: 5.35 m
Draught Aft: 2.76 m
Trim by bow: 2.59 m
Heel angle: 4.40 deg
$GM_{(fluid)}$: 0.60m



Section at forward end of hatch looking aft

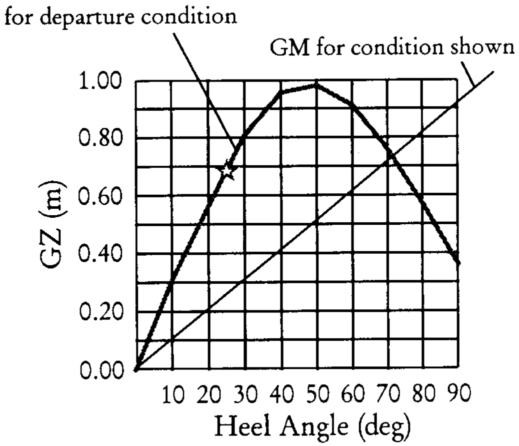
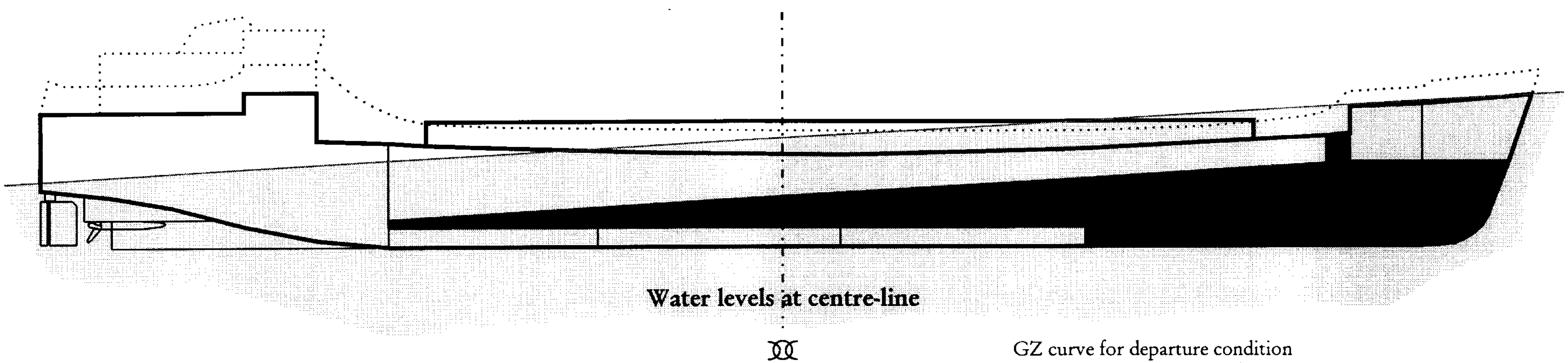
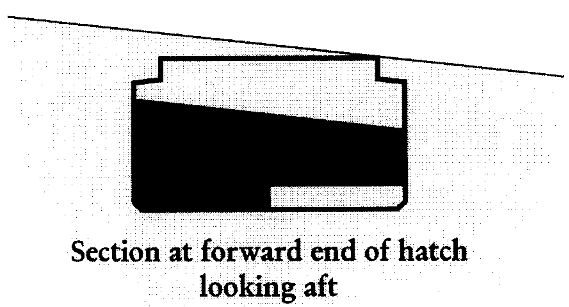
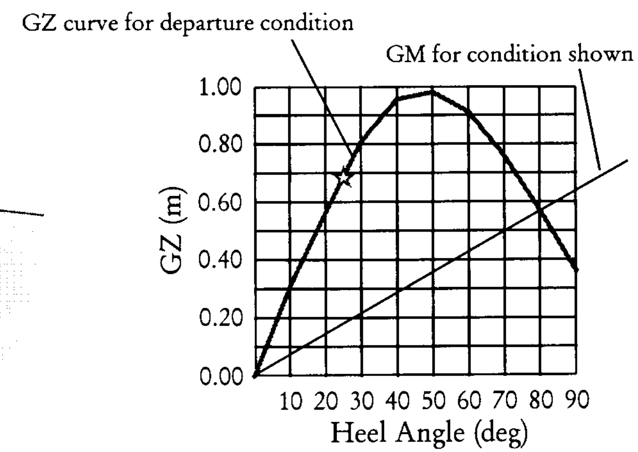


Figure 5c. CASE G:- Hold flooded to point of sinking



Draught Fwd: 6.26 m
Draught Aft: 2.76 m
Trim by bow: 3.50 m
Heel angle: 6.10 deg
$GM_{(fluid)}$: 0.42m





ANNEX 6

Photographs taken by ROV

Starboard bow of *Rema*

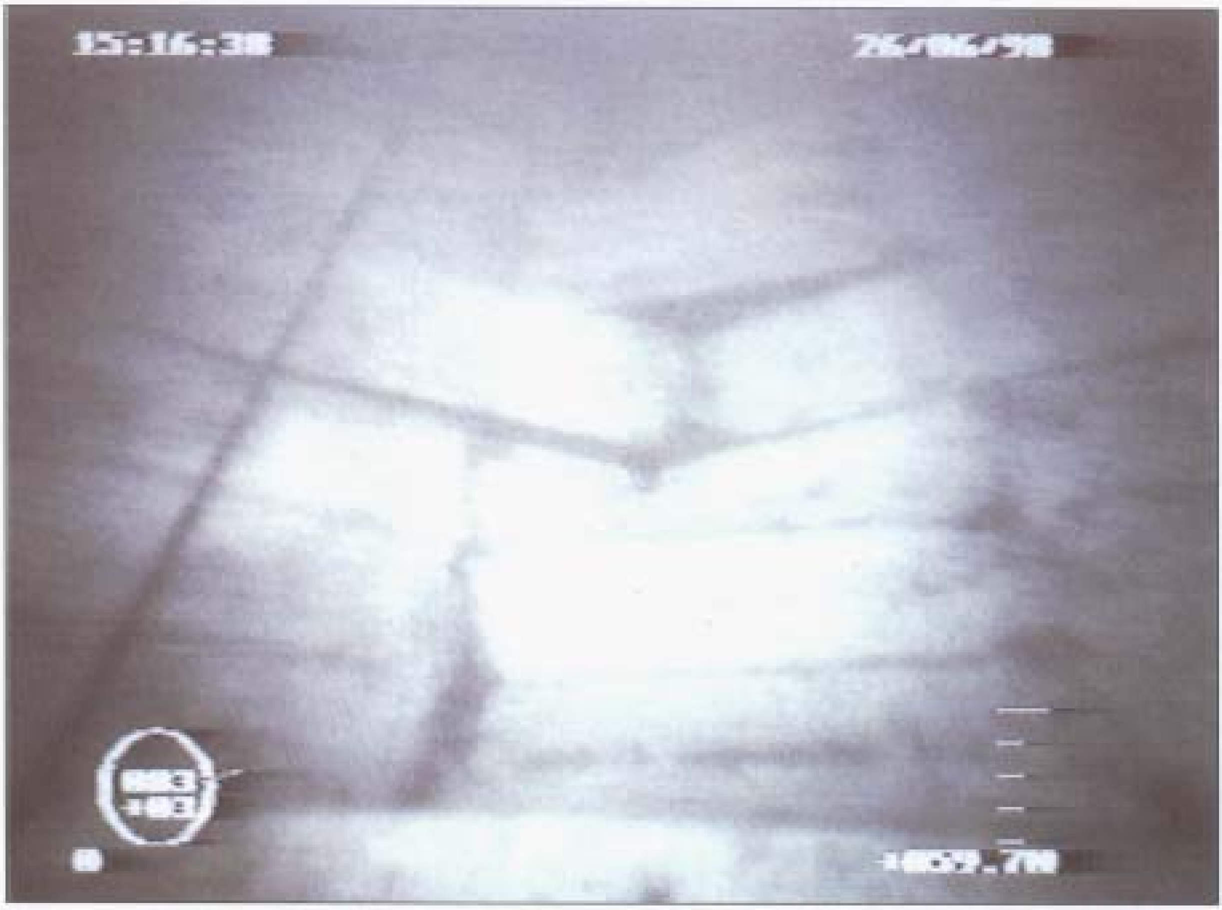
View of stem showing bulwark pushed right back and seabed mud on top of stem

Stem of *Rema* looking upwards from seabed — note deformation of bow plating on both port and starboard sides due to soft impact of stem on seabed

Starboard corner of main deck forward and forecastle — note residue of cargo

Access hatch to forecastle storeroom — note deformation of hatch sides and hatch cover forced into hatch space by water pressure

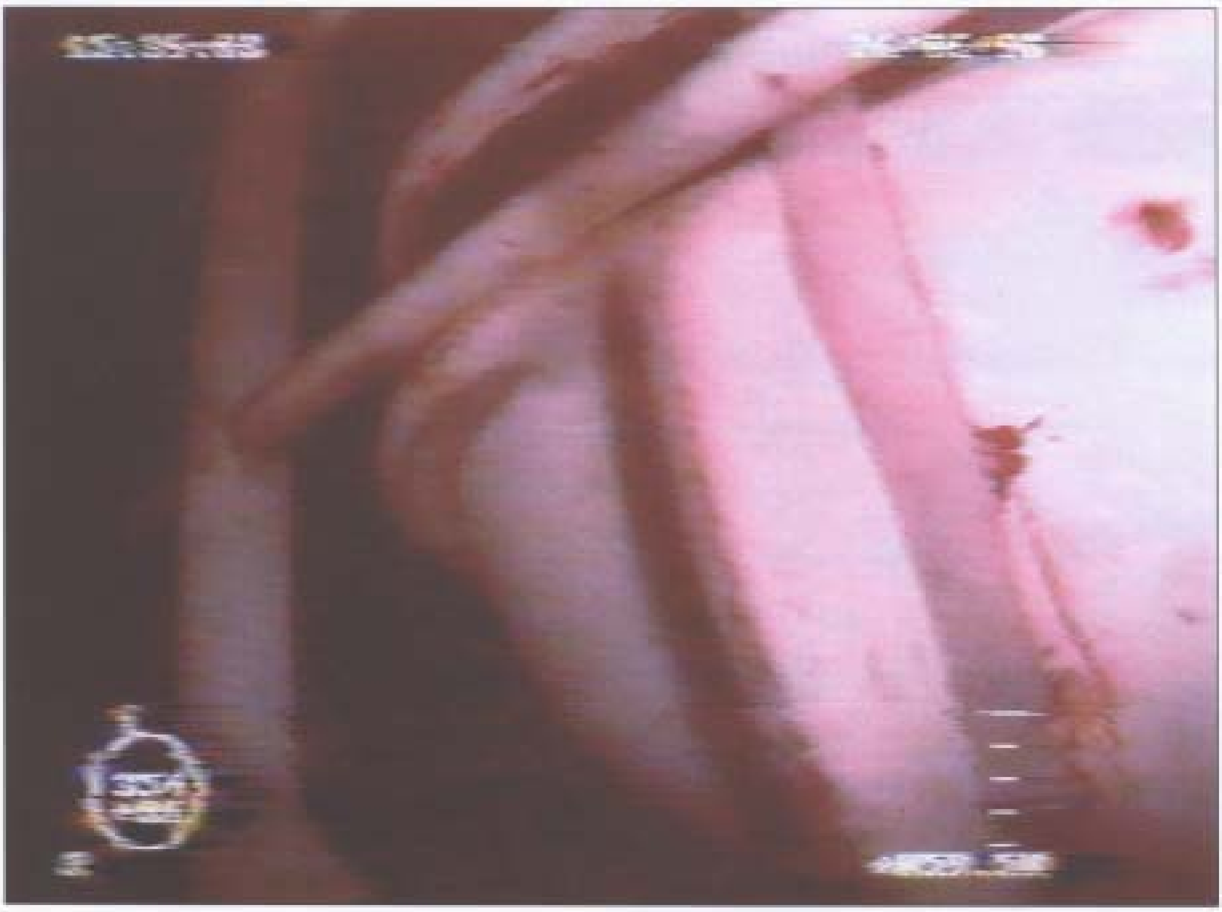
Close-up of fractured and distorted hatch cover beams due to water pressure



View of hatch covers looking forward from wheelhouse front — note fractures due to water pressure

Wheelhouse Front — note crushing of centre alloy portion due to water pressure

View of port aft poop deck showing damaged hatch and air vent due to implosion of store and fresh water tank below



View of port liferaft trapped under ships rails aft of liferaft cradle

Close-up of lower part of Bekker rudder showing absence of grounding damage

View of rudder and tail ends

View of hold aft bilge suction (starboard) next to engine bulkhead — note crumpled bilge hat cover

View of hold internal structure showing deformed side stringer due to water pressure

ANNEX 7

Summary and explanation of image enhancement techniques used in this report

Summary

The images presented in this report have been digitally captured from SVHS video tapes as single frames, or multiple and superimposed frames. They have been enhanced by an initial de-interlacing of the video scan lines, followed by despeckling and then contrast optimisation. Secondary enhancements of the image have attempted to extract contrast details within specific regions of interest in order to obtain the maximum information held by the images. Detailed enlargements have been made by extracting sub-regions from particular frames and expanding the images by resampling them at higher spatial resolution (typically between 300-600 pixels per inch). Line drawings are presented as a guide to features of particular interest within the images or their enhanced versions. Explanation of the images are given in text accompanying the images and their enhancements.

Explanation of image enhancement techniques

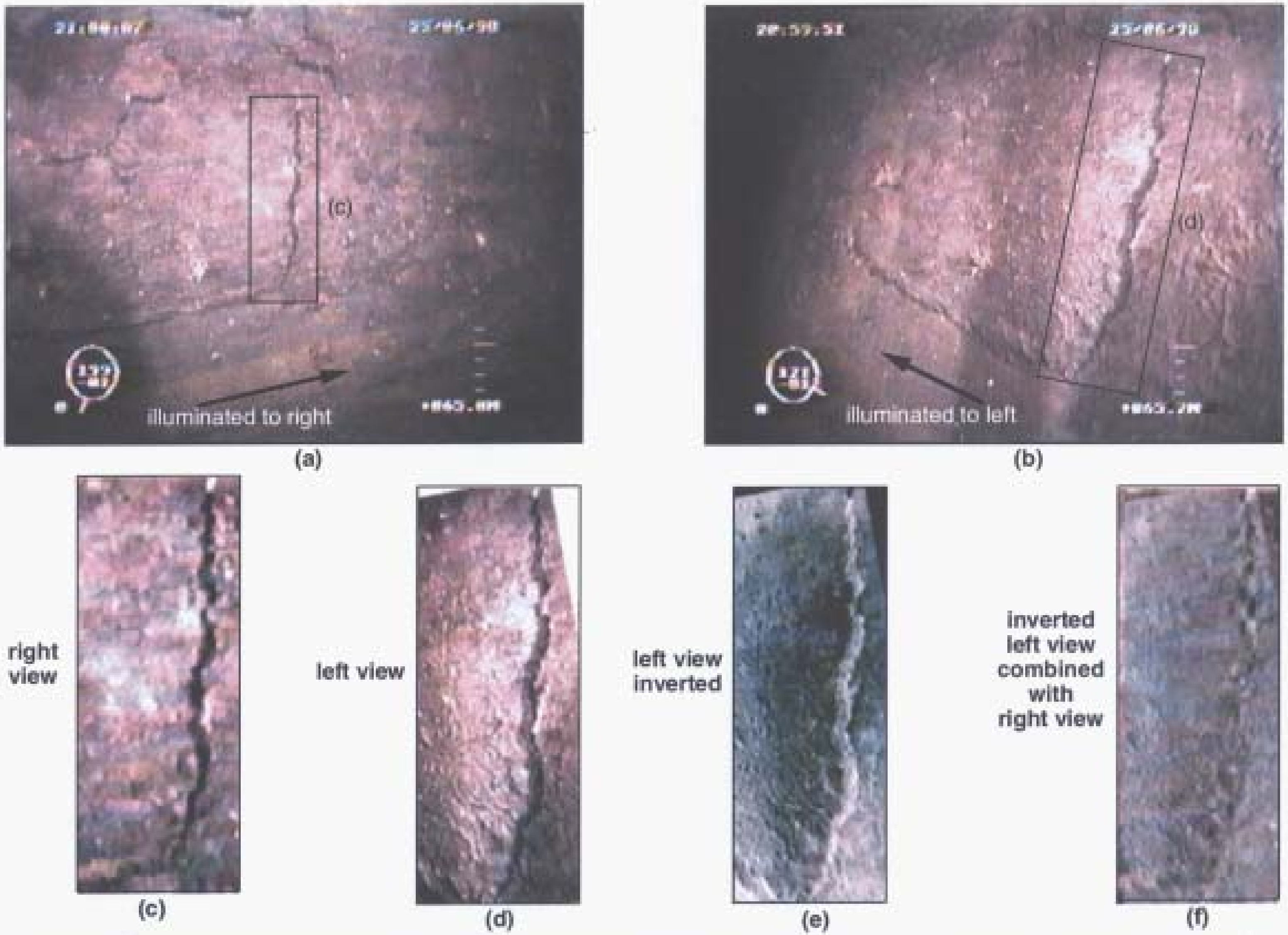
Three main enhancement techniques have been used in this report.

1. Contrast equalisation: alters contrast within images to maximise contrast gradients.

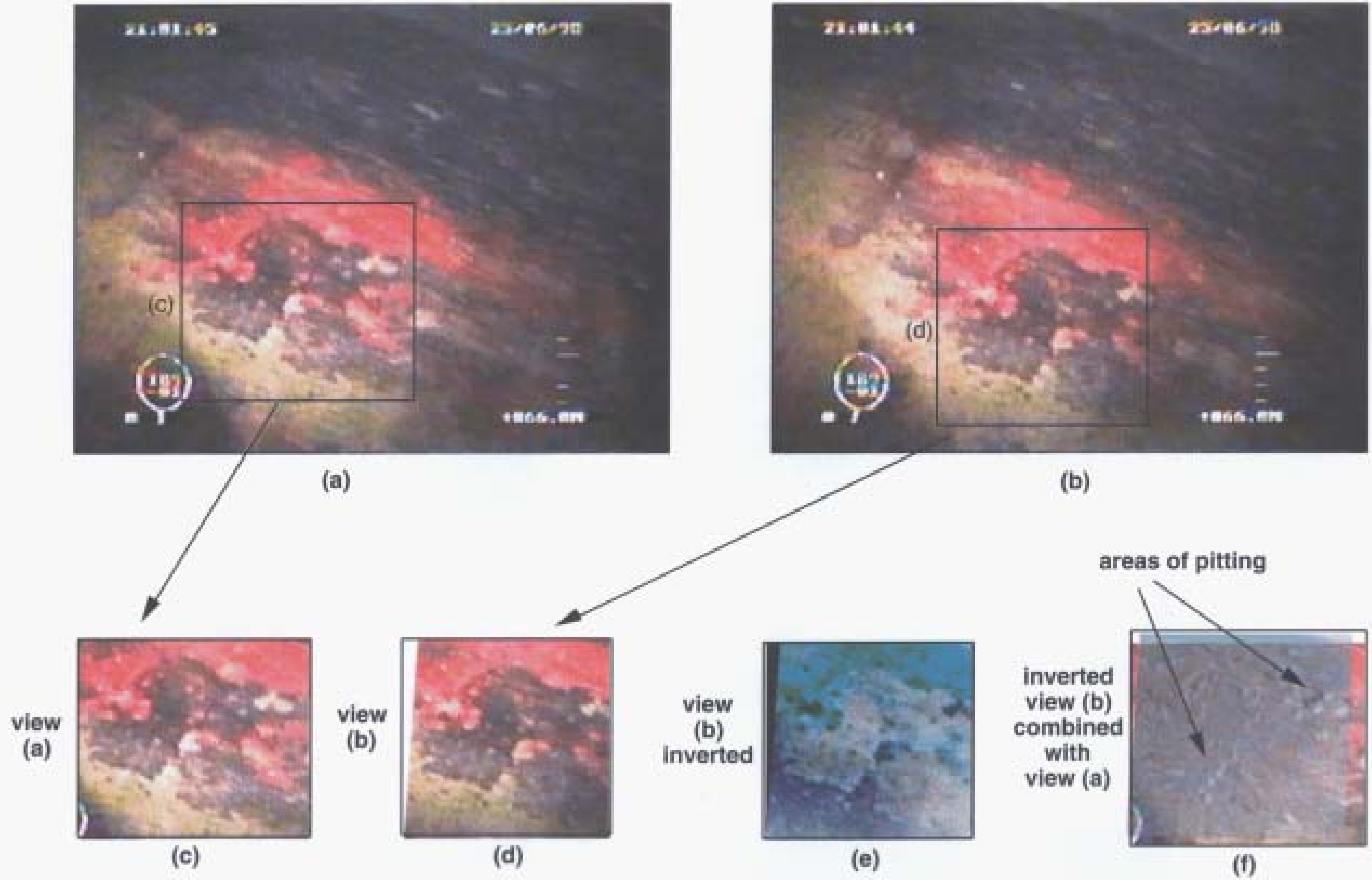
2. Edge detection: first order differentials highlight the maximum gradients in contrast: second order differentials highlight maximum changes in gradients between contrast. Both processes are used to contour edges, which highlight contrast differences within regions of interest.

3. Difference image: this is used when a region of interest is imaged and illuminated from adjacent positions, causing variation of lighting. Surface morphology casts shadows or causes bright reflections, which in turn vary under different lighting conditions. Comparison of different views of the same region of interest require those images to be similarly scaled and corrected for any possible perspective changes. Difference images of views of the same region of interest, but under differing lighting conditions, highlighting changes in surface morphology as bright or dark regions that persist when the two views are merged.

Dr Bramley J. Murton
Consultant image analyst

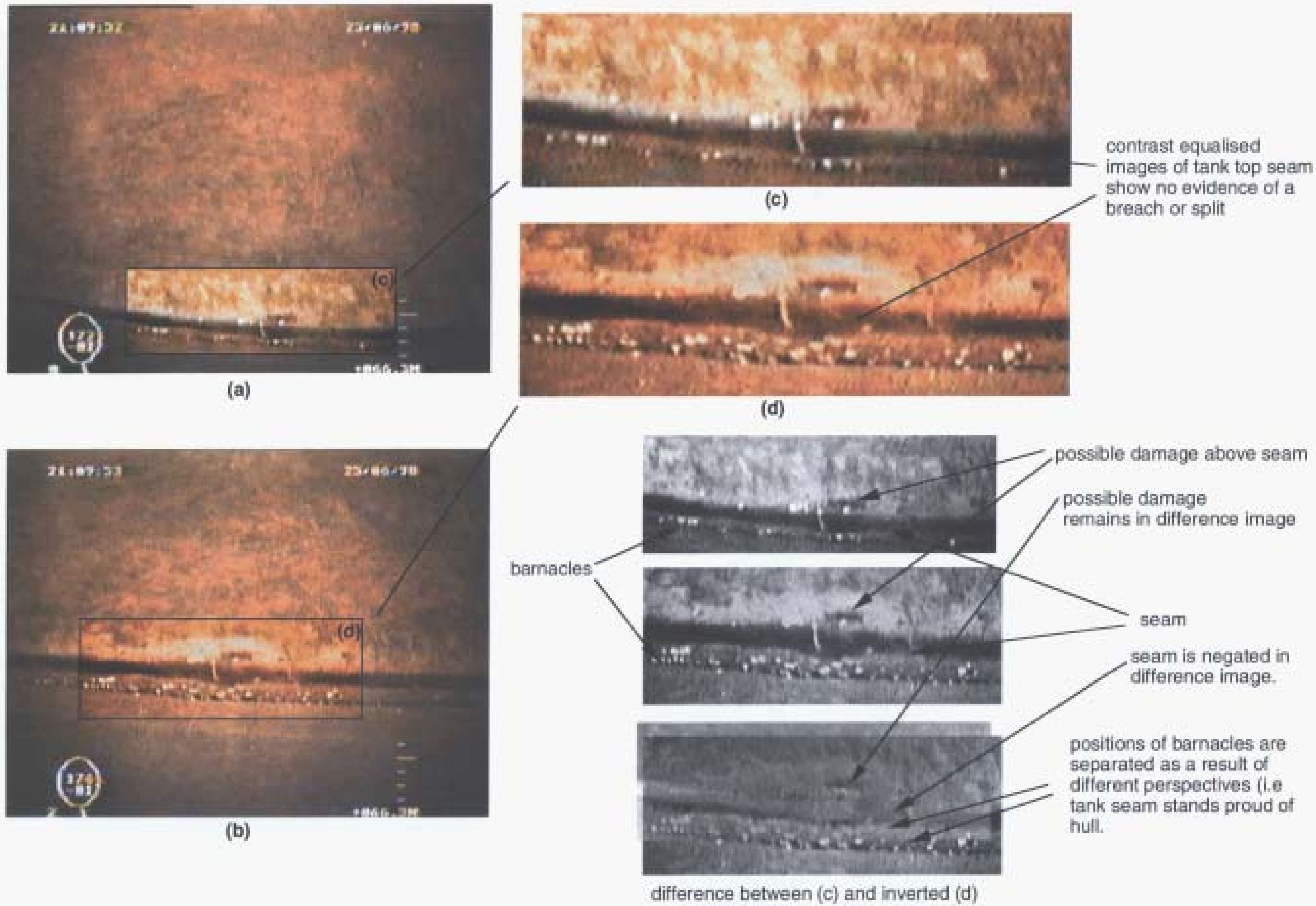


View of damaged area and posssible "vertical crack". Image (a) is viewed and illuminated from the right, image (b) is viewed and illuminated from the left. Small images (c) and (d) are details of the "vertical crack", at the same scale and orientation, taken from (a) and (b) respectively. Image (e) is a colour-scale inverted version of (d). Image (f) shows the result of combining (c) and (e): if the vertical feature was a "crack" in the hull casting a shadow, then it would not appear equally, or simultaneously, in both left and right illuminated views. Image (f) shows the "vertical crack" is cancelled out by combining the inverted left view with the right view. This means the "vertical crack" is not a shadow cast by a parting in the plates, but a dark colouration of the hull, and probably damaged paint-work.

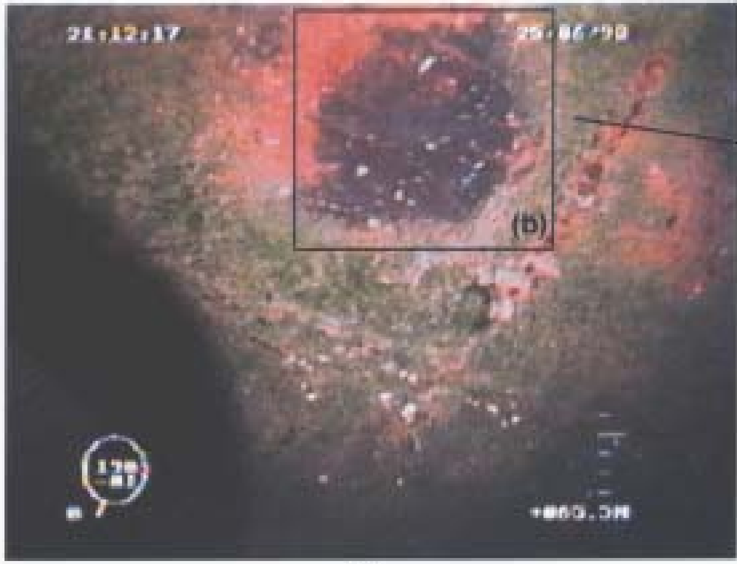


View of possible "corrosion wastage". Compared with image (a), image (b) is viewed and illuminated from ~50-100cm further to the right. Small images (c) and (d) are details of the "corrosion wastage", at the same scale and orientation, taken from (a) and (b) respectively. Image (e) is a colour-scale inverted version of (d). Image (f) shows the result of combining (c) and (e): if the "corrosion wastage" included pitting of the hull, casting shadows, then they would not be cancelled out when the inverted and positive images are combined. Image (f) shows two areas where small circular features remain, indicating vertical relief in the hull plating consistent with pitting damage. However, there is no evidence that these pits have penetrated the hull.

TANK TOP SEAM



"PIPE INLET"

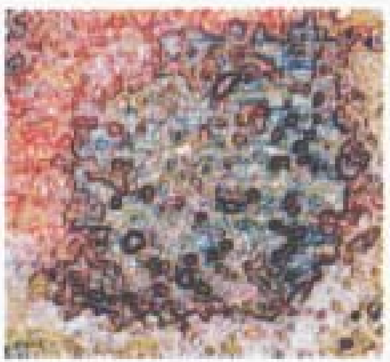


(a)

Image of circular mark possibly indicating seawater intake.

(b)

Contrast equalised image of circular mark showing interior features inconsistent with the presence of any inlet hole. Instead, the features show discoloration of metal platework which is continuous across the area.

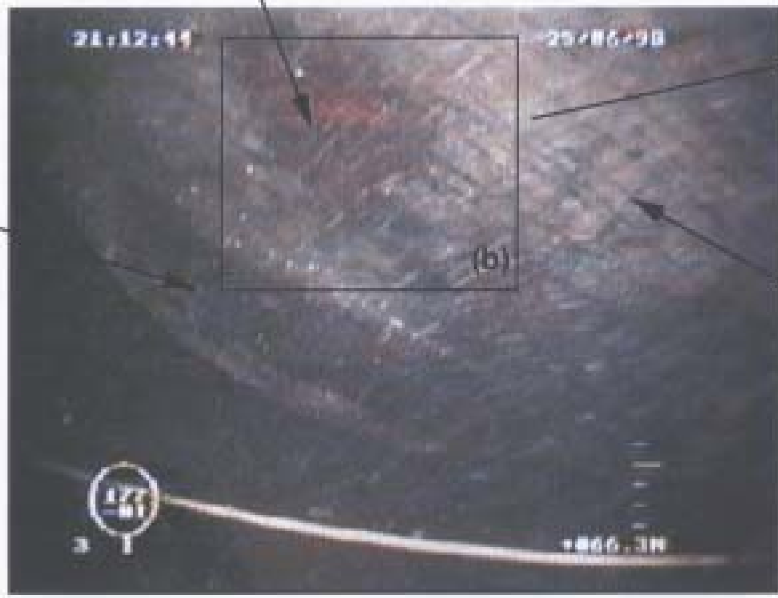


(c)

Contouring of contrast gradients within the equalised image of the circular mark showing interior features indicating plate work is continuous across the area of the discolouration.

Damage to paint work on bow post-dates diagonal scoring to plates

Indentation on bow



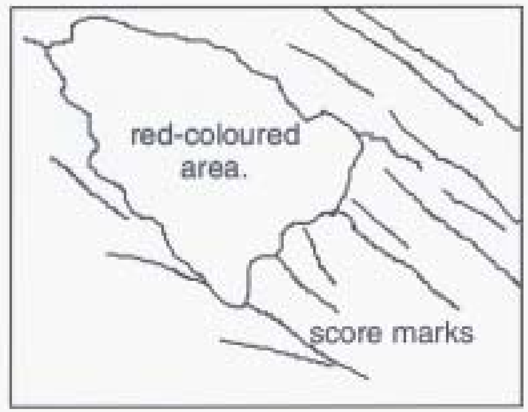
diagonal scoring to plates on bow

(a)

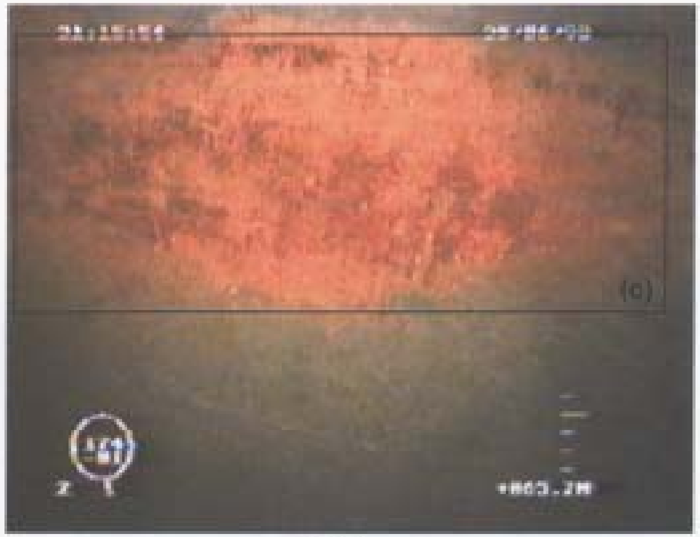
Area underside of bow where a damaged area has exposed red paintwork and where diagonal scores cross the plates.

(b)

Contrast equalised to enhance relationship between red area of damaged paintwork and diagonal scores.



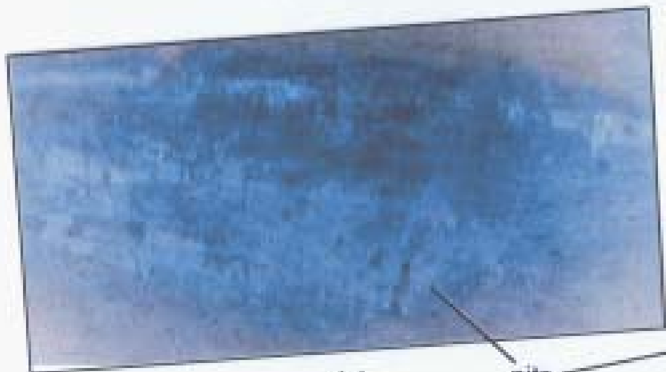
Score marks are clearly truncated by red-coloured area of damaged paint work.



(a)

(b)

Different images (a) and (b), one second apart and taken from different postions, showing a general area of possible corrosion or damage to the hull.

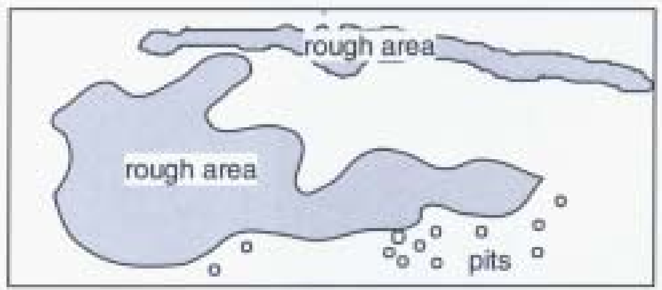


(e)

Inverted, rotated and scaled image (d) detail of possible corrosion area shown on (b).

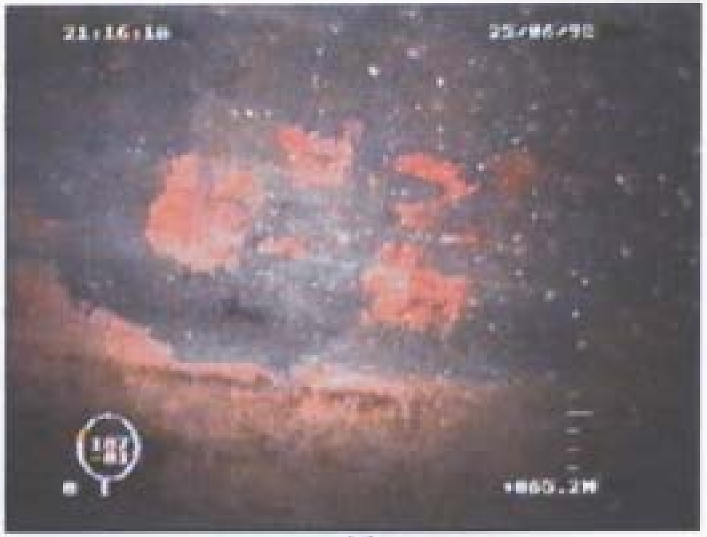
(f)

Difference image: comparison betwen (c) and (e). Rough and smooth areas (shown in sketch (g)) correspond to areas with more or less corrosion respectively. Small spots remain in difference image and are evidence of pitting of surface. But there is no evidence these pits penetrate the hull.



(g)

Interpretation and summary of corrosion area, showing rough and smooth areas and pits.



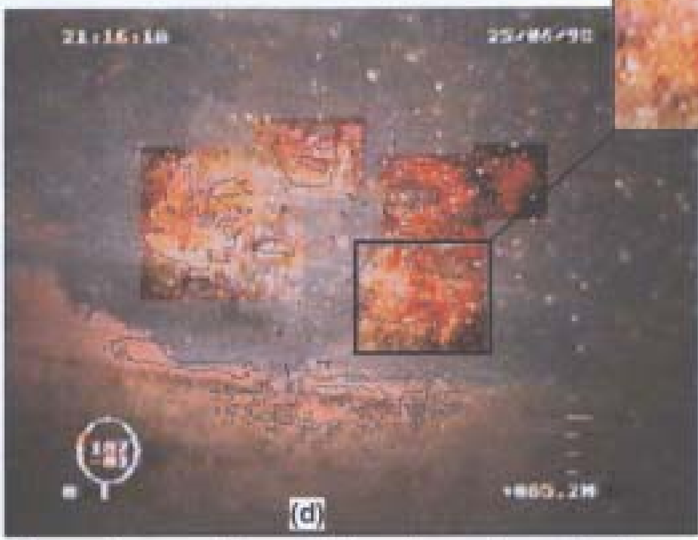
(a)

Area of general "corrosion", red paint exposed under black paint, plus linear, sub-horizontal marks.

(b)

Area of general "corrosion", outlined by contours of significant colour gradients.

(f)

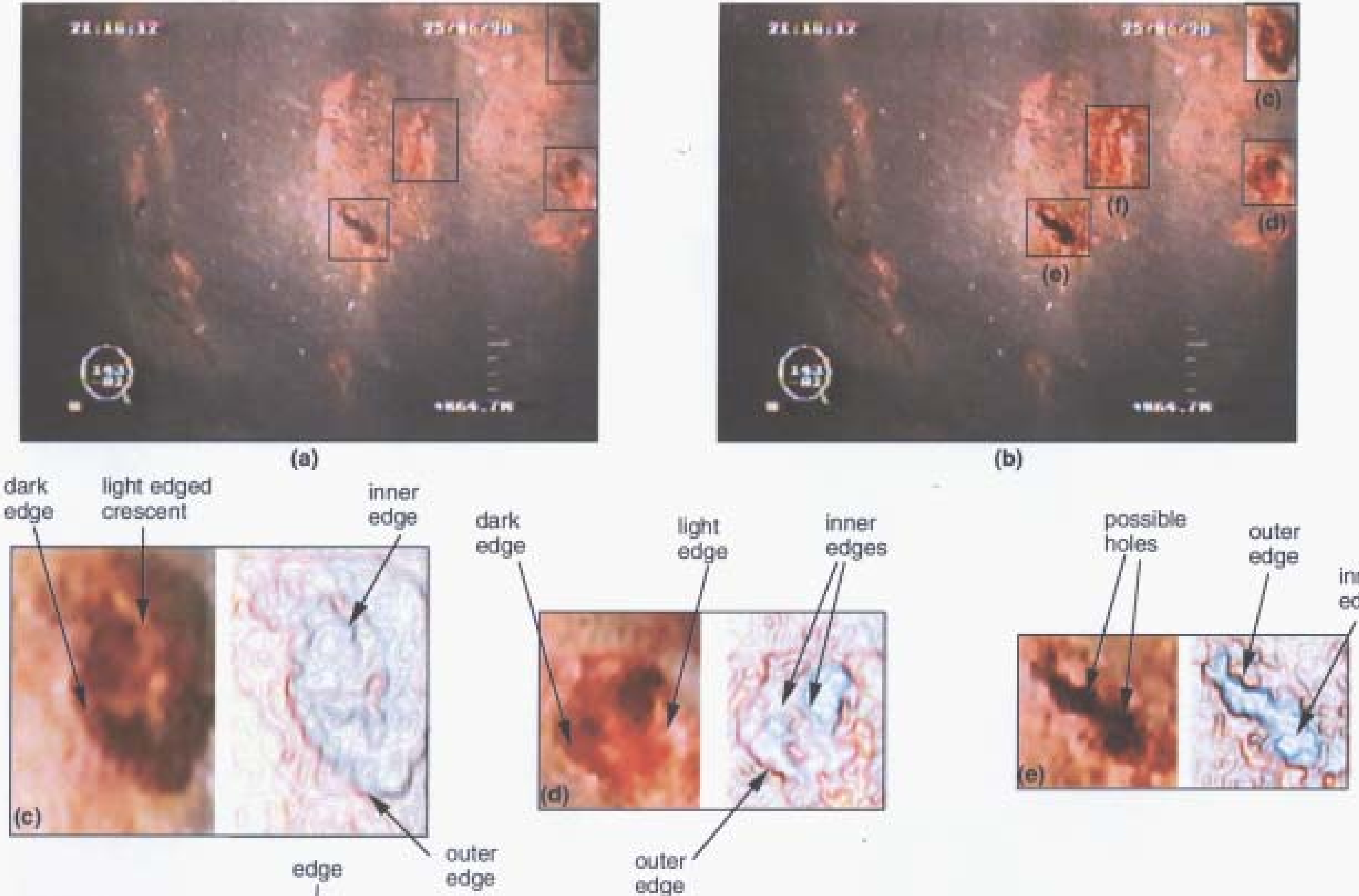


(d)

Areas of general "corrosion", enhanced by contrast equalisation (including inset detail (f)). Equalisation shows variations in paint colour, but no perforations in the plating which would otherwise appear homogeneous.

(e)

Difference between two images of the same area, offset by 10-20cm. The image does not show any significant textural differences coinciding with the areas of "corrosion" (outlined) indicating little irregularity of the surface



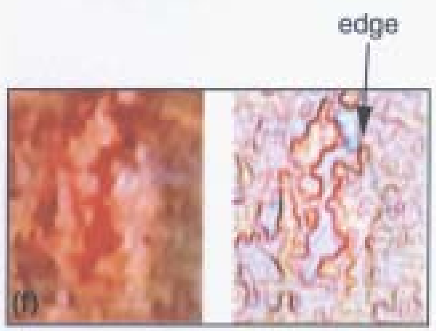


Image of area of "general corrosion" (a), and with contrast equalised details inset (b). The details are shown with gradients between light and dark areas contoured (i.e. showing second differentials in contrast between light and dark areas). The contrast equalised, detailed areas show light and dark edges, and inner and outer rims, consistent with the dark areas having a negative surface relief (i.e. they are indentations or perforations in the surface). By comparison, the dark area in detail (f) does not have light and dark edges, and probably does not have any significant relief.

(a)

Areas of "corrosion" on plating. Inset (c) is area of more significant changes in colouration and possible depth of wasting.

(b)

Areas of "corrosion" on plating imaged from a position ~50 cm to the left of (a)..

(d)

Details of areas of "corrosion" showing outlined edges between darker discolouration and lighter areas.

(e)

Details of areas of "corrosion". Equalisation of the image shows areas of darker discolouration bordered by dark and lighter edges, indicating surface relief.

(f)

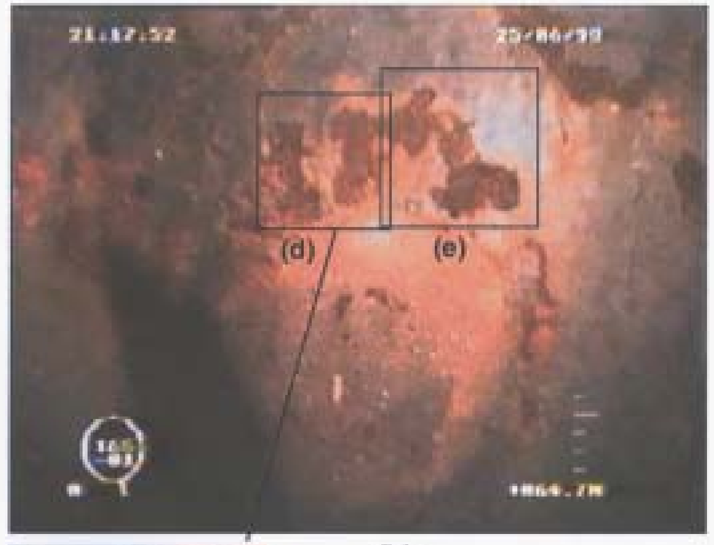
Differences between the two views of "corrosion" (inset (a) and (b) after perspective and scale corrections) showing light and dark edges to the darker areas. This indicates relief between the darker and lighter regions.

(g)

Sketch summary of the differences between the darker and lighter regions, with the darker regions (cross-hached) being deeper relative to the lighter regions (i.e. indicating areas of general corrosion and wasting).

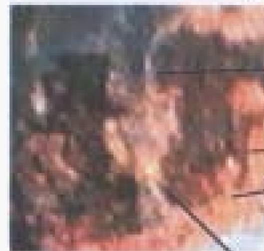
AREAS OF "GENERAL CORROSION"

(a)



(b)

(c)



(d)

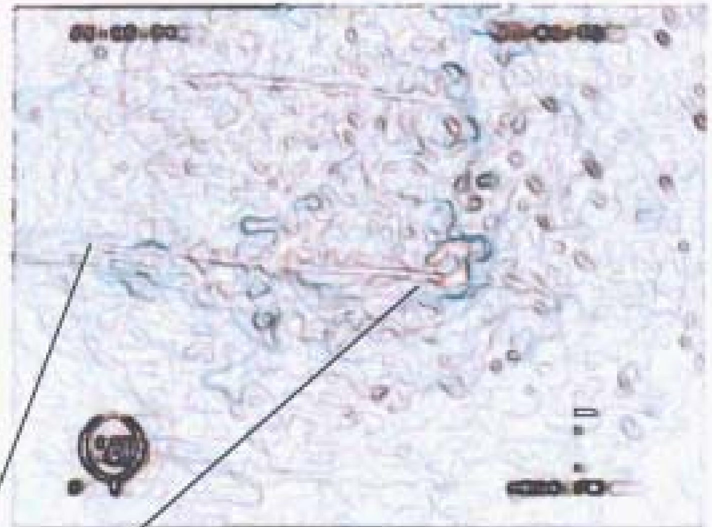
(f)

Areas of "general corrosion", (a) and (b) are views from different positions and perspectives. Views (c) and (d) are details, contrast optimised to show variations in illumination. The dark regions in views (c) and (d) are generally bordered by light rims to the left (reflective edges) and dark rims to the right (shadowed edges). Illumination is from the right, therefore the rims show relief between the dark and light areas such that the darker areas are depressed relative to the lighter areas. This difference in relief is demonstrated by the difference between the detailed areas (f) (after correction for perspective and scale) showing dark rims (i.e. shadow) on the right edge of the dark regions and light rims (i.e. reflective) on the left rims. This suggests the darker regions have lower relief compared with the lighter areas and are probably areas of general wasting of the plates.

PARALLEL SCORES ON HULL

(a)

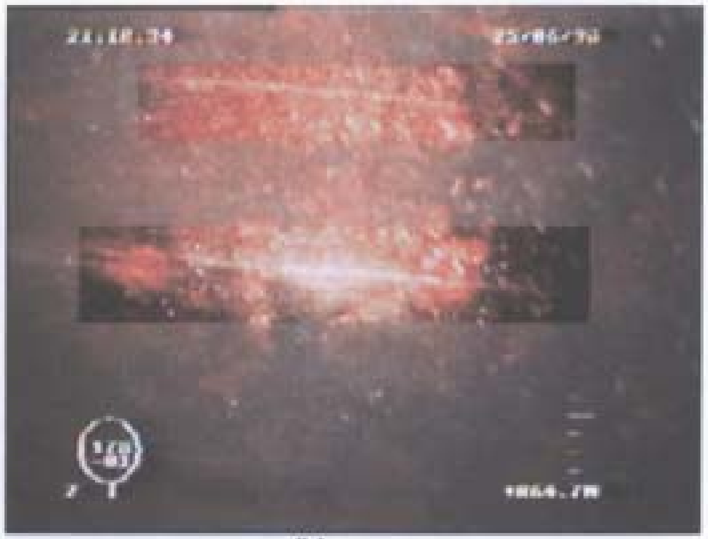
Image of parallel scratches on side of hull



(c)

scratches super-
imposed upon
rust patches

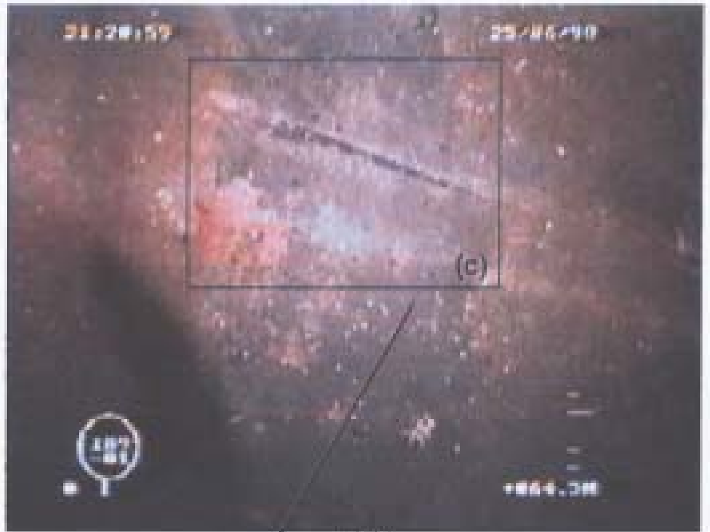
Contoured contrast gradients (c), showing the parallel lineations are dicontinuous, with the upper one being shorter than the lower one. Also shown, the lineations are superimposed upon, and hence younger than, the rounded rust patches.



(b)

Image of parallel scratches, contrast equalised, showing lighter colouration, and hence no evidence of penetration of plate surface.

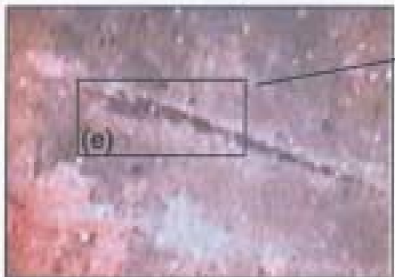
LINEAR DAMAGE



(a)

(b)

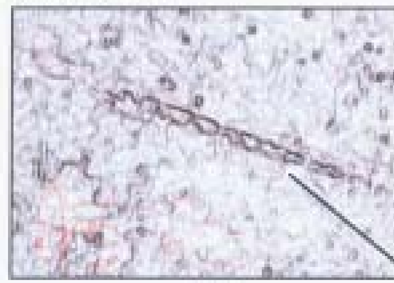
Different views (a) and (b) of a posssible "split" .



(c)

(e)

Inset, details of "split" (c) and (d), and enlargement (e) show colour variations within the "split" area, indicating the discolouration of the surface rather than perforation.



(g)

Contouring (g) of the contrast gradients between the light and dark regions in image (c) also show that the "split" actually comprises a series of dark areas aligned diagonaly across the image, and is not a linear rupture of the surface.

"split"

(f)

Image (f) is the contrast equalised version of detail (d), and shows the "split" to be an alignment of a series of dark regions.

(h)

Difference (h) between details (c) and (d) (after correction for perspective and scale) also shows the "split" as a line of light and dark regions but with no evidence of surface relief.

STARBOARD SIDE BOW DAMAGE

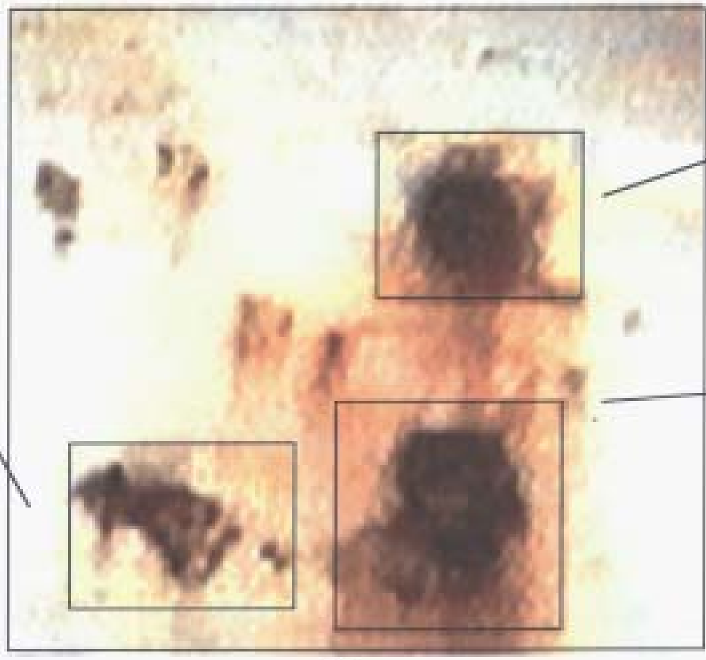
Parallel and sub-horizontal scratches truncated by large area of damaged paint work revealing red surface below white.

THREE RUST SPOTS ON TOP SIDE FORWARD AND MIDSHIPS

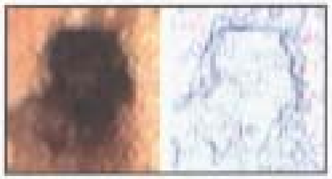
(a)

Inset details of rust spots including contoured contrast gradients (i.e. edges) showing details inside rust spots. Variations in contrast within the spots is evidence that the rust patches are regions of variable corrosion. Small dark spots within the rust patches are possible perforations of the plate surface.

(e)



(c)



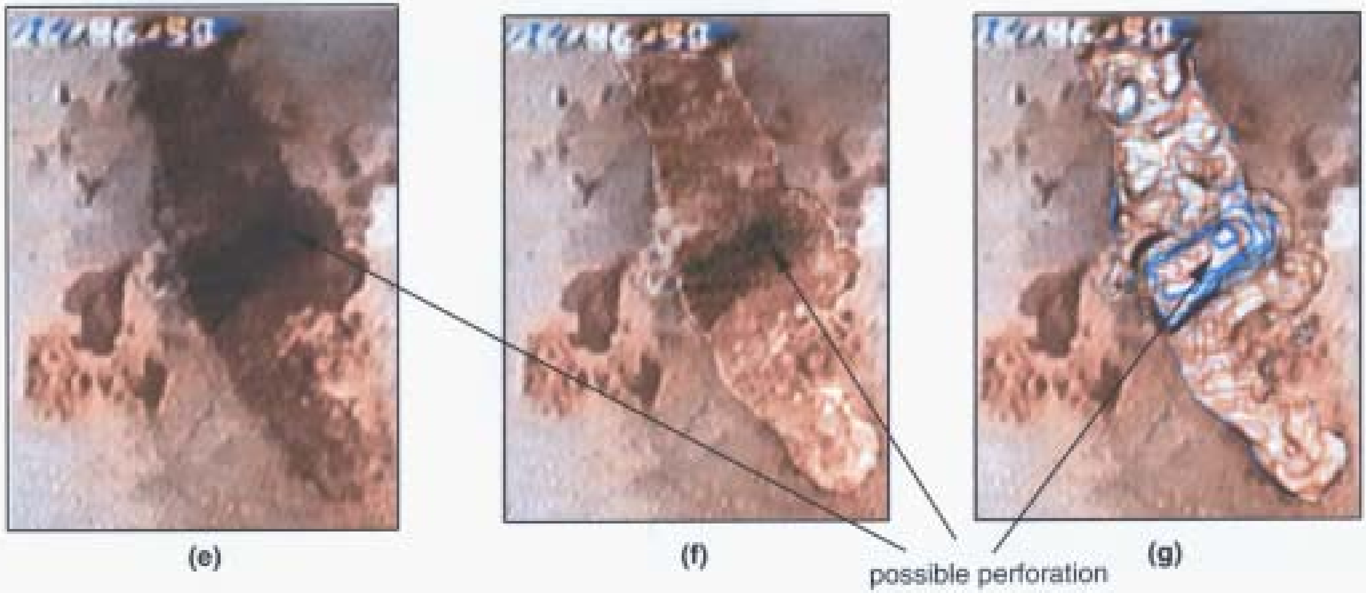
(d)

(b)
Three rust spots, contrast equalised, and details

POSSIBLE INDENTATION, RUST PATCH AND PERFORATION OF PLATES

(a) (b) (c)

Images of possible "indentation, rust patch and perforation" of plates on top side forward amidships. Image (a) is the image of the area of interest, (b) is the area after contrast equalisation, and (c) is contoured for edges (second order differential). Both (b) and (c) show complex structure in the area, with several concentric zones of increasing dark colouration. The darkest colouration is roughly rectangular in shape and elongated sub-horizontally and parallel to the length of the vessel.



(e) (f) (g)

Details of the rust patch: (e) after contrast optimisation, (f) after contrast equalisation and (g) after contouring of edges of different contrast within the area of interest. The darkest discolouration forms a rectangular shape, with several further concentric rectangular boundaries inside. The innermost and darkest rectangular patch contrasts with the red rust patch to the left, which is consistent with the presence of a perforation in the plate work.

POSSIBLE INDENTATION, RUST PATCH AND PERFORATION OF PLATES

(a)

(b)

(c)

Images of possible indentation, rust patch and perforation of plates. Image (a) is the image of the area of interest, (b) is the area after contrast equalisation, and (c) is contoured for edges (second order differential). Both (b) and (c) show complex variations in discolouration within the rust patches, indicating wasting, but not perforation, of the plate.

(e)

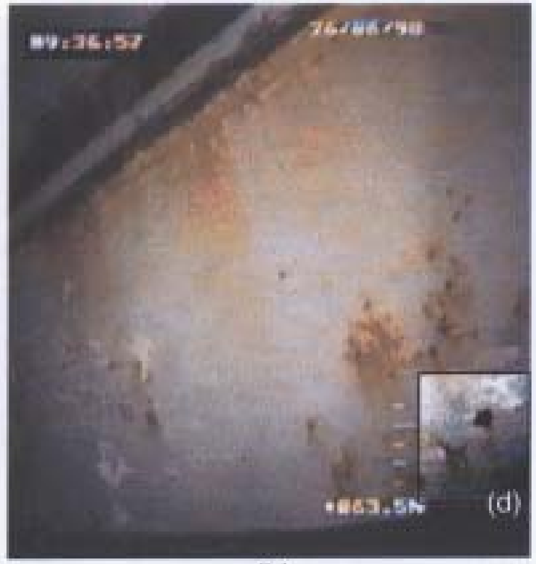
(f)

(g)

Details of the rust patch: (e) after contrast optimisation, (f) after contrast equalisation and (g) after contouring of edges of different contrast within the area of interest. Both the longitudinal area of damage and the more circular area comprises discoloured plate, but with no obviously very dark regions that would be evidence of perforation.

SMALL HOLE OR RUST SPOT

(a)



(b)

Images of possible "hole" in plates. Image (a) is the "hole", and (b) is the "hole" after contrast equalisation. Images (c) and (d) are enlargements of the areas of interest, and (e) is contoured for edges (second order differential). Both (d) and (e) show complex variations in discolouration within the "hole", indicating wasting. However, contouring of the contrasted edges (images (e) and inset) shows a possible hole, roughly circular in shape, that is consistent with the presence of a perforation of the plate.

(c)

(d)

(e)

Details of the "hole": (c) after contrast optimisation, (d) after contrast equalisation, and (e) after contouring of edges of different contrast within the area of interest. Inset detail of contoured edges shows no internal structure within the innermost concentric edge, and is therefore probably a perforation of the plate, roughly circular in shape.

HOLES OR SCUPPER DISCHARGE VENTS

(a)

(b)

Images of possible "holes or scupper discharge vents" in hull. Image (a) is the area of interest, and (b) is the area of interest after contrast equalisation. Images (c) and (d) are enlargements of the areas of interest, and (e) is contoured for edges (second order differential). Images (c), (d) and (e) show variations in discolouration within the "holes or scupper discharge vents", indicating wasting but no perforation of the plate.

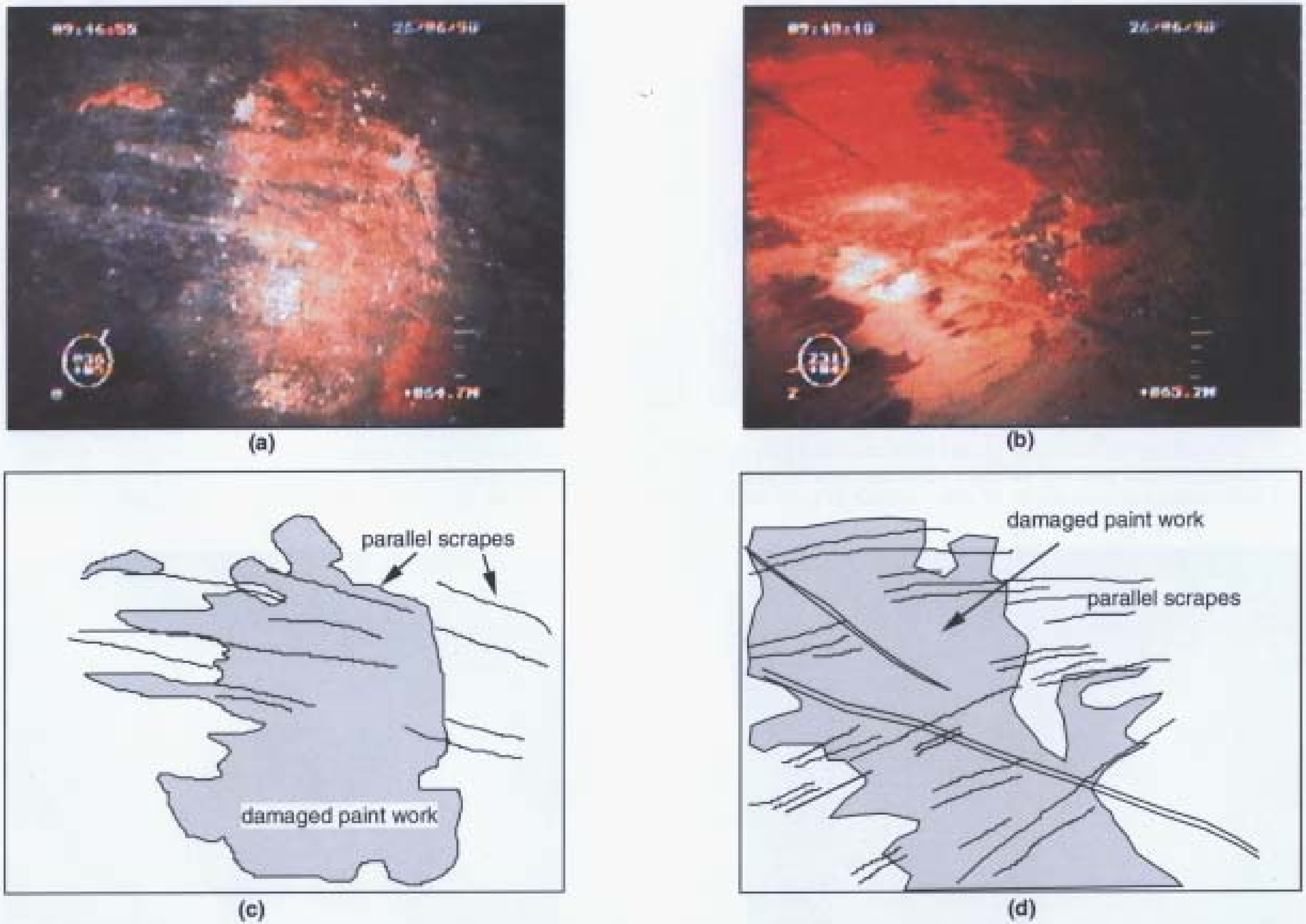
(c)

(d)

(e)

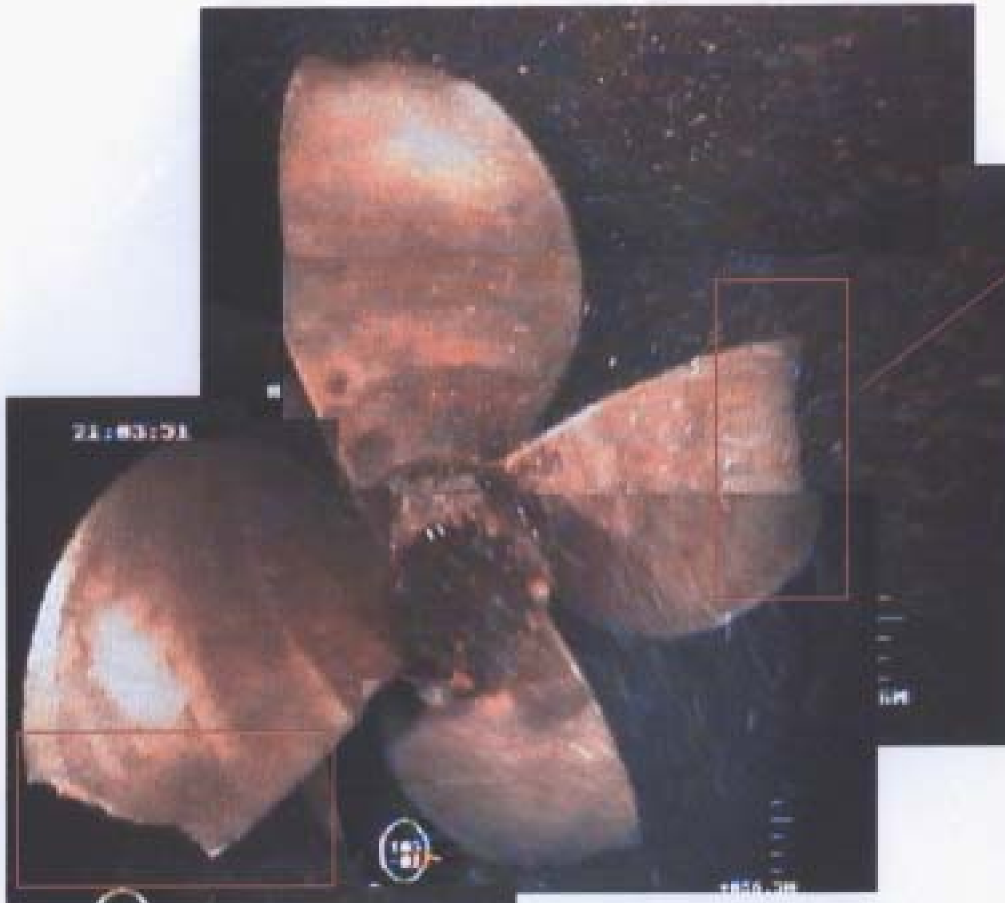
Details of the "holes or scupper discharge vents": (c) after contrast optimisation, (d) after contrast equalisation, and (e) after contouring of edges of different contrast within the area of interest. Internal structure within the "holes or scupper discharge vents", are evidence that there is no perforation in the plates.

SCRAPES ALONG THE STARBOARD SIDE OF THE HULL



Images of scrapes along the starboard side of the hull. Images (a) and (b) are the areas of interest, and (c) and (d) are line drawings of the essential features in those areas of interest. Significantly, both areas show similar features: a large irregular area of damage to paint work, with parallel and subhorizontal scrapes superimposed upon them. The scapes clearly cross, and are hence younger than, the damaged paint work.

DAMAGED PROPELLER



Mosaic of propeller, showing broken tips to blades

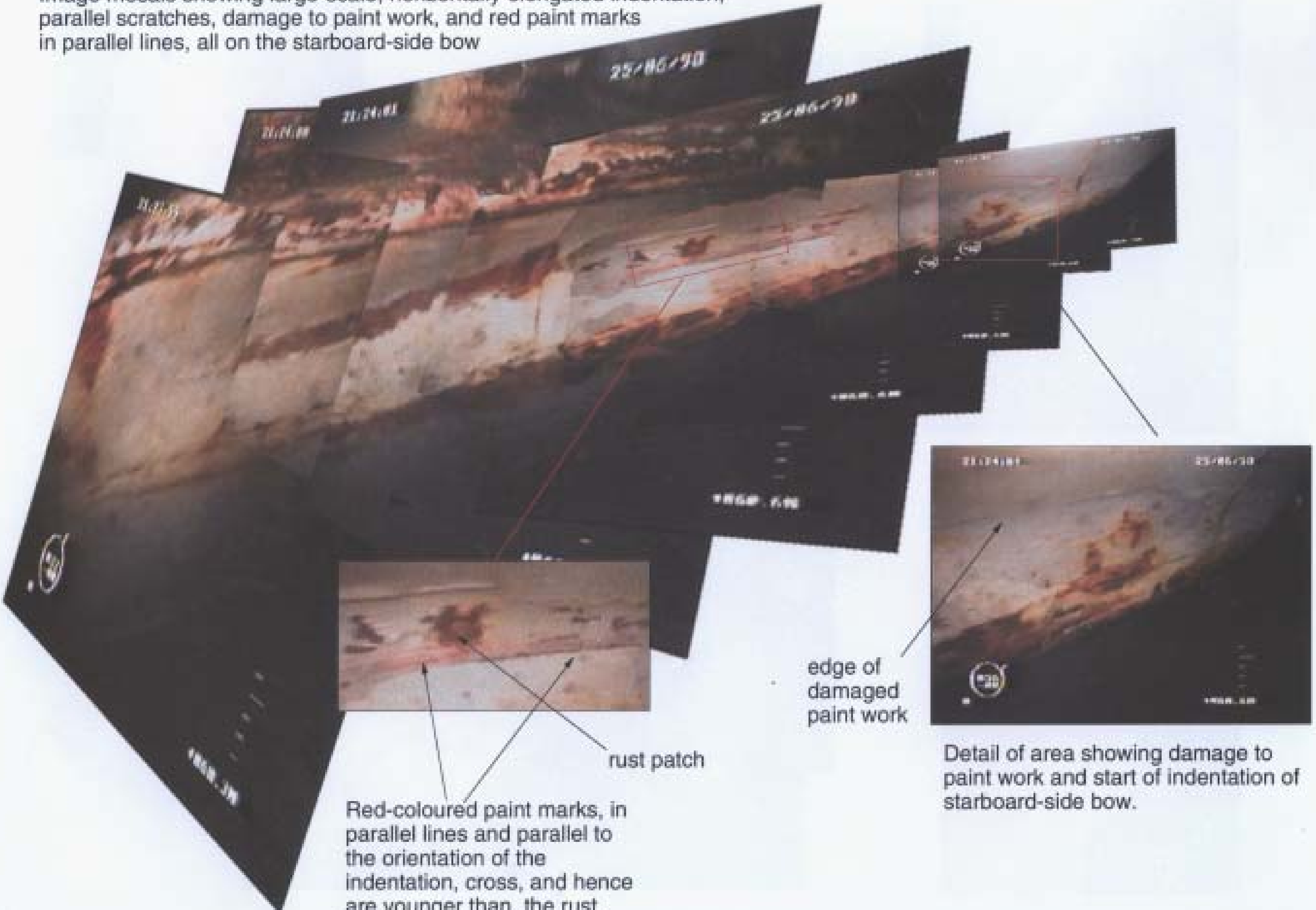
Detail of brittle-style fracture to propeller tip

Detail of brittle-style fracture to propeller tip

Mosaic showing side profile of propeller and broken blade tip

BOW DAMAGE

Image mosaic showing large-scale, horizontally elongated indentation, parallel scratches, damage to paint work, and red paint marks in parallel lines, all on the starboard-side bow



Detail of area showing damage to paint work and start of indentation of starboard-side bow.

EPIRB

EPIRB on boat deck attached to rail

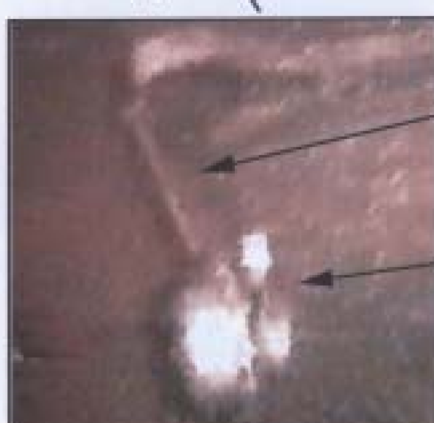
Detail of EPIRB showing catch and loop

Detail of EPIRB showing catch

HYDROSTATIC RELEASE

Hydrostatic release (a) and detail (b) showing attached line or strop.

(a)



(b)

STARBOARD LIFERAFT: DAMAGED SEAL

Images of the starboard liferaft showing: (a) contrast optimised image with a light-coloured mark in the centre of the black seal surrounding the external casing; (b) contrast equalised part of the image, showing the mark as a significant feature; and (c) enlargement of the mark on the casing seal, revealing it as an area of possible damage.

(a)

(b)

(c)

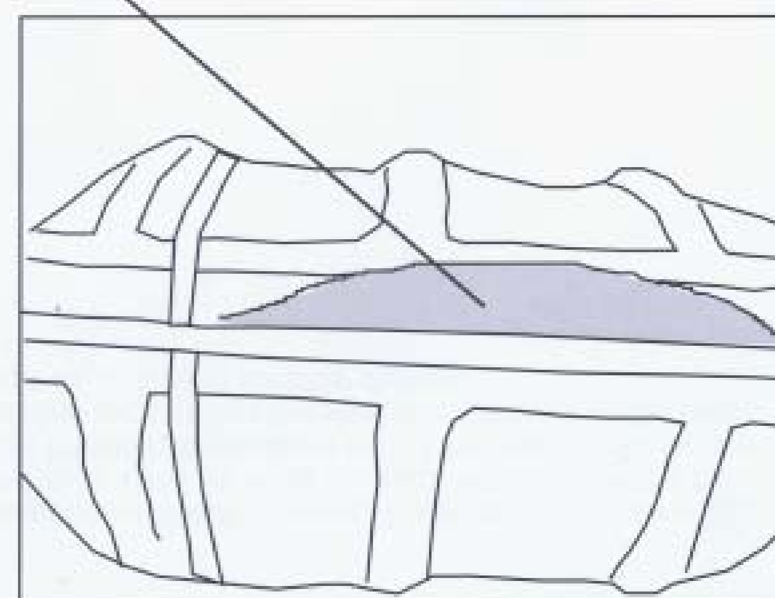
STARBOARD LIFERAFT

Images of starboard liferaft (a), showing exposed part of liferaft that has breached the casing seal and partially escaped the exterior casing. Same image as (a) but after contrast equalisation (b), showing more clearly the exposed liferaft material. Line drawing (c) showing main features of the external casing, the casing seal and the exposed liferaft.

(a)

exposed canopy or part of inflatable liferaft, breaching seal on external casing.

(b)



(c)

VIEW OF INTERIOR OF ROBERT CLAYTON'S CABIN

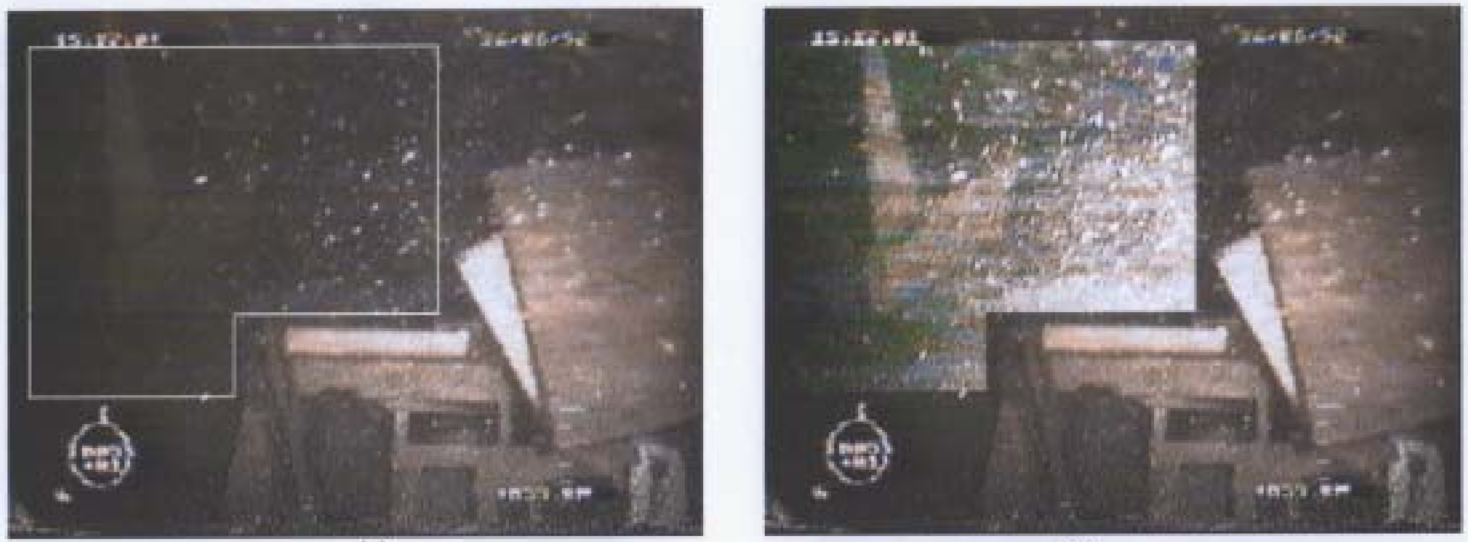
(a)

Mosaic of two images of interior of cabin.

(b)

Contrast equalised regions of image of interior of cabin: upper left object is floating life-jacket, lower areas are the floor of the cabin showing debris only.

INTERIOR OF BRIDGE



(a) (b)

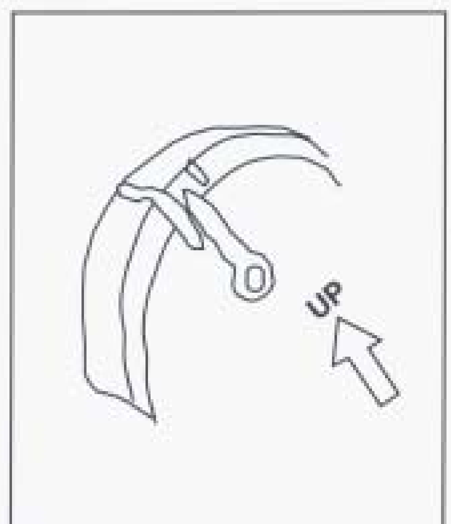
Interior of bridge (a), and (b) contrast equalised darkest regions showing general debris only.

ENGINE CONTROLS

(a)

Image (a) of interior of bridge showing possible "engine controls" (outlined). Below, detail of inset (b), enlarged and contrast optimised, showing cresent-shaped bright feature and linear feature extending from crescent centre to mid-point. Line drawing (c) showing prominent features of bright object: curved object with radial spar extending from centre to mid-point and pointing upwards.

(b)



(c)

SOCKET AND PLUG ATTACHED TO CABLE IN CREW ACCOMMODATION

Plug and socket with attached cable. The cable leads to the right of the image and is at an angle to horizontal. The plug and socket are rotated anticlockwise by ~15°.

Detail of plug and socket, showing rotation of socket relative to its wall box.

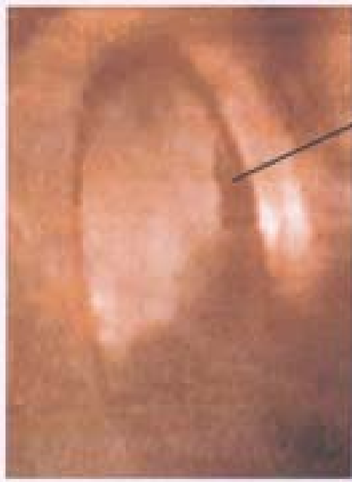
Detail of plug and socket, contrast equalised, showing rotation of socket relative to wall box, and switch in "on" position..

CREW ACCOMMODATION CLOCK

Crew accommodation clock (a), detail (b), and contrast equalised (c). Despite enhancement, the face and hands of the clock are not visible. Changes to the colouration of the face, which are probably the result of reflections from the glass cover, suggest the cover is broken.

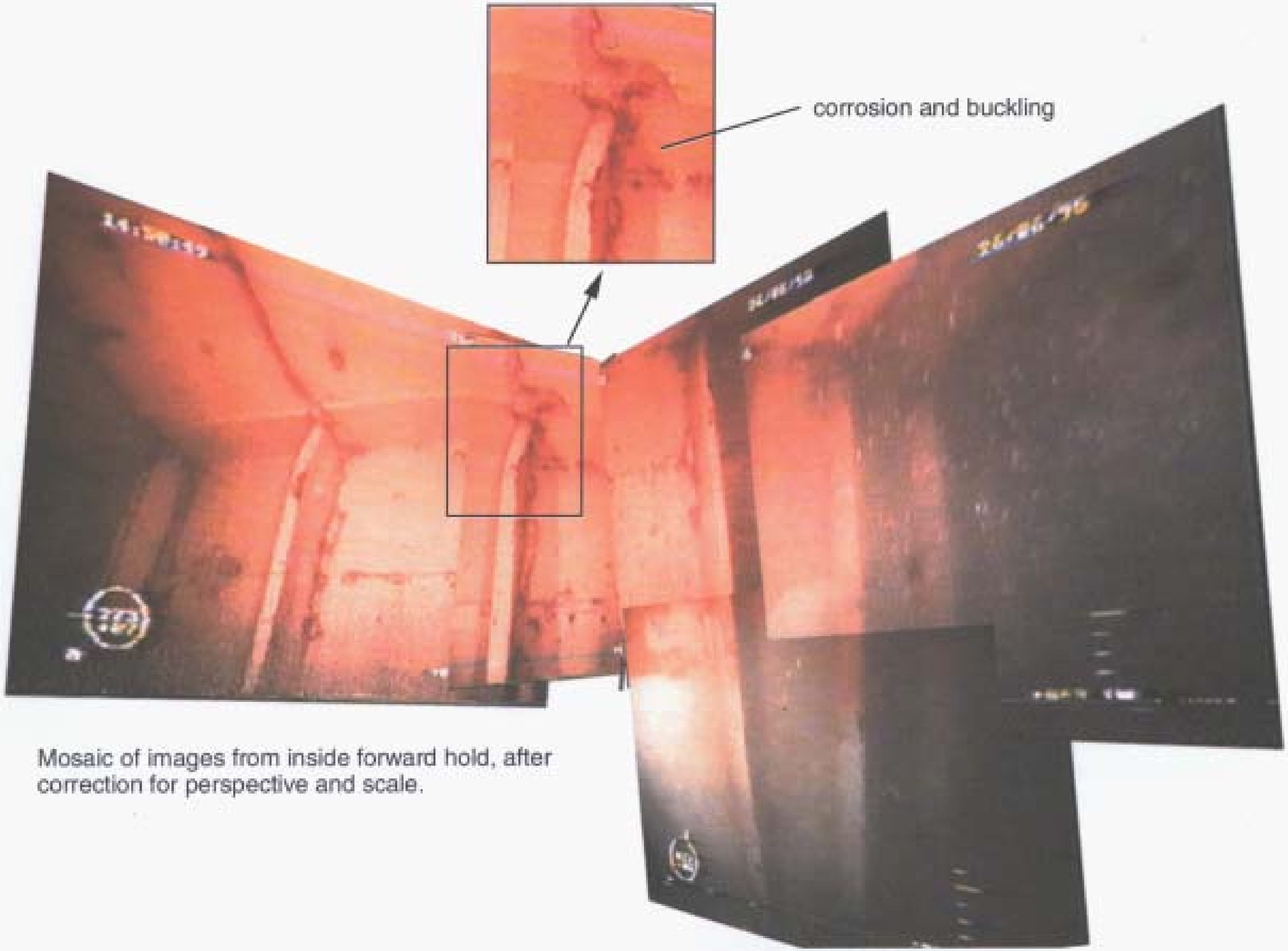
(a)

(b)



(c)

INTERIOR OF FORWARD HOLD, STARBOARD SIDE AND DECK EDGE



Mosaic of images from inside forward hold, after correction for perspective and scale.

AFT SIDE HATCH COVER CLEATS

(a)

(b)

Aft side of hatch cover with cleat in place (a). Detail (b) of inset showing cleat in place on hatch cover.

(c)

(d)

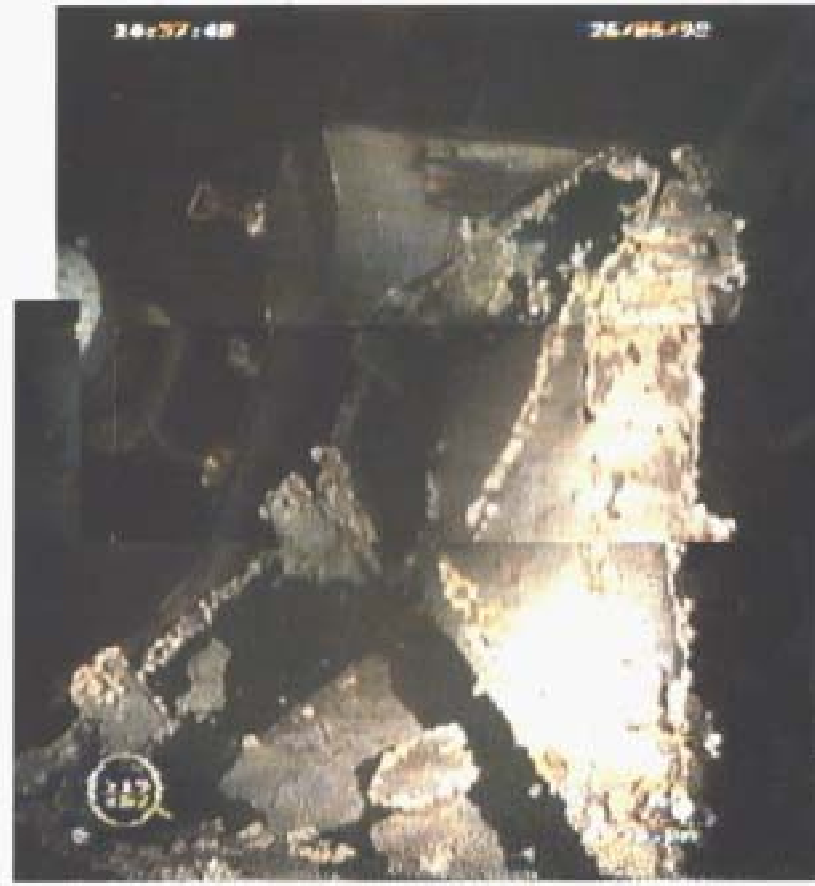
Second hatch cover forward from aft side with cleat in place (c). Detail (d) of inset showing cleat in place on hatch cover.

FORWARD, STARBOARD SIDE HATCH COVER

hatch cover partially open

cleat/dog in open position

FORWARD HATCH COVER



Mosaics of forward hatch and cover. Hatch cover has suffered pressure damage causing inward buckling of both cover and coving. A cable leads from under the forward hatch cover to a control device on deck.