REPORT
ON THE WRECK OF THE
SS RICHARD MONTGOMERY

Maritime and Coastguard Agency
Spring Place
105 Commercial Road
Southampton
SO15 1EG

May 1999

CONTENTS

EXECUTIVE SUMMARY ..... Page 3/4

PART 1 THE 1998 SURVEY OF THE WRECK OF THE SS RICHARD MONTGOMERY

Introduction ..... Page 5
Conduct of the Survey ..... Page 5
Scope of Work ..... Page 5
Analysis of the Survey Data ..... Page 5/6
Comparison with 1996 and 1997 Data ..... Page 7
Conclusions ..... Page 8

PART 2 CONSIDERATIONS FOR THE FUTURE

Introduction ..... Page 9
Risks ..... Page 9/10/11
Effects ..... Page 11/12
Solution ..... Page 12/13/14
Conclusions for the way Forward ..... Page 14/15

PART 3 RECOMMENDATIONS

Masts and Derricks ..... Page 16
Recommendation 1 ..... Page 16
Continual Observation of the Wreck ..... Page 16
Recommendation 2 ..... Page 16
Survey of the Wreck ..... Page 16
Recommendation 3 ..... Page 16
Assessment of Risk ..... Page 17
Recommendation 4 ..... Page 17
Policy of Openness ..... Page 17
Recommendation 5 ..... Page 17

EXECUTIVE SUMMARY

i. The SS RICHARD MONTGOMERY, with a cargo of munitions, grounded and split in two off Sheerness in 1944. No explosions occurred either at the time of the grounding or since and a significant part of the cargo was succesfully removed immediately following the grounding.

ii. It is probable that some of the munitions remaining on board are still capable of detonation but the likelihood of a major explosion is remote. Experts have consistently advised that the best way to keep the risk to an absolute minimum is to leave the wreck alone. The site is therefore designated a prohibited area under the Protection of Wrecks Act 1973.

iii. Whilst the risk of a major explosion is remote, it is considered prudent to monitor regularly the condition of the wreck. Therefore routine surveys have been undertaken to assess the condition of the wreck and to check for any new signs of possible danger.

iv. Until 1984 surveys were carried out by Ministry of Defence (MOD) salvage divers. More recently the surveys have been undertaken by commercial diving contractors, working under MOD supervision. Following the 1993 survey, in view of the limitations placed on such methods by the poor visibility under water at the site, and on the recommendation of the MOD Salvage Organisation, it was decided that full advantage should be taken of the major advances in sonar technology, in preference to the use of diving surveys.

v. This survey, in 1998, was the third of three annual surveys conducted on behalf of the Maritime and Coastguard Agency (an executive agency of the Department of Environment, Transport and the Regions) by Sonar Research and Development Ltd of Beverley. It was completed in August 1998 under the supervision of the MOD's Salvage Organisation.

vi The survey of the wreck shows that there has been no significant change in the structure below surface. There has been some movement in the debris overhanging the side of the wreck with one item less being detected.

vii A visual inspection of the masts and derricks showed that the eyes in the cargo blocks had wasted to less than 10% of their original thickness. The heavy lift topping blocks were well secured. The mast shrouds are either missing or no longer supporting the masts.

viii By pulling together the available knowledge from several reports the future of the wreck is considered. The risks associated with the wreck are identified as; collision by another vessel, capsize or significant movement of the wreck and the wreck breaking up. The effects of these risks are judged to be either a mass detonation of the remaining munitions or the distribution of munitions, with the possibility of some washing ashore.

ix Five basic scenarios to solve the problems are namely; do nothing; monitor with non-intervention; containment; entombment or removal. The risks associated with these are shown at annex E (page 32). The most promising solutions are monitoring with no

intervention (the status quo) or containment. However, a feasibility study is required before any intervention option is considered.

x The recommendations are as follows:

Recommendation 1. Masts and Derricks

That the masts, derricks and warning notices remain in situ, subject to ongoing inspection and that the cargo blocks are removed when convenient.

Recommendation 2. Continual Observation of the Wreck

That the continual close observation of the wreck is maintained.

Recommendation 3. Survey of the Wreck

To monitor the seabed around the wreck, an annual survey should continue with a new contract let in 1999 for one year with a further two year option.

Recommendation 4. Assessment of Risk

That a risk assessment study is undertaken to cover the following points:

- The effects of a mass detonation of the remaining munitions under a variety of wind and tide conditions
- The conditions required for a mass detonation to occur
- The likelihood of those conditions occurring
- The possibility of the wreck breaking up
- The likely distribution of any escaped munitions
- Feasibility of a containment or entombment solution
- Feasibility of removing ordnance
- Feasibility of totally sanitising the wreck site

Recommendation 5. Policy of Openness

That information about the wreck be placed in the public domain, and that the results of the risk assessment are published to form part of a consultation exercise regarding the way forward in the long term.

PART 1

THE 1998 SURVEY OF THE WRECK OF THE SS RICHARD MONTGOMERY

INTRODUCTION

1. From time to time over some 25 years, and on the recommendation of the Committee on Hazardous Wrecks[1], surveys of the wreck have been arranged in order to monitor conditions. The most recent survey was conducted in August 1998 by Sonar Research and Development (SRD) Limited under contract to the Secretary of State for the Environment, Transport and the Regions (DETR). The survey was organised by the Maritime and Coastguard Agency (MCA)[2] and was supervised by the Chief Salvage Officer to the Ministry of Defence (Navy). The survey made use of a high resolution electronic scanning sonar system developed by the contractor and linked to a microprocessor system to produce a detailed survey of the seabed, over a wide area in the vicinity of the wreck. Both the MOD and MCA were satisfied that the survey was properly and competently carried out in compliance with the contract.

CONDUCT OF THE SURVEY

2. The vessel "Humber Surveyor", owned by Associated British Ports (ABP), was used for the survey which was conducted on 11 and 12 August 1998. The technical description of the survey is at Annex A. The survey was carried out during a period of good weather. The survey area was in the lee of the Isle of Sheppey and sea conditions remained calm throughout the duration of the survey.

3. The survey area lies at the eastern extremity of Sheerness Middle Sand and is to the south of the Great Nore Anchorage and north of the Medway Approach Channel. During the course of the day there were several shipping movements which temporarily impeded survey operations. This did not cause any problems.

SCOPE OF WORK

4. SRD was contracted to survey the wreck of SS RICHARD MONTGOMERY and an area of 400 metres around the wreck. The company was required to locate, identify and map any loose wreckage and munitions on the seabed. The full work scope was completed. The wreck was examined in detail resulting in no noticeable deterioration

[1] The Committee on Hazardous Wrecks comprised experts from the Ministry of Defence, the Home Office and the Health & Safety Executive, together with the Port of London Authority and the Medway Ports

[2] MCA was formed on 1/4/98 by the merger of The Coastguard Agency and Marine Safety Agency

below the water line. An area of small contacts in the break of the wreck was re-examined

ANALYSIS OF THE SURVEY DATA

5. SS RICHARD MONTGOMERY ran aground on Sheerness Middle Sand in 1944. Since her grounding, the presence of the wreck has caused localised changes in the seabed topography. The most noticeable change was to the scouring that has occurred around the wreck. Scouring has caused the wreck to settle into the seabed, having the effect of making the wreck appear to "sink".

6. Hydrographic surveys have shown, in general, that sand banks are at their shallowest over neap tide periods. This survey took place over the spring tide period to ensure that the survey vessel could pass over the wreck in safety at high water.

7. The monochromatic gradient plots at Annex C reveal details of the ship's structure. These plots also reveal details of small seabed topographical features such as sand ripples over the area.

8. The following features within the survey area might be observed from the solid contour plot at Annex D:

- The Wreck Site
  The wreck site occupies the central part of the survey area. It is the area enclosed by the 9-metre contour and may be considered to be the area of seabed topography most influenced by the presence of the wreck.

- The Medway Dredged Channel
  The Medway dredged channel occupies the southern part of the survey area, which is orientated in the region of 072°/252° and is bounded by the southernmost 9-metre contour in the survey area. The edge of the marked channel is 200 metres from the nearest point of the wreck.

- The Sheerness Middle Sand
  The Sheerness Middle Sand occupies the central part of the survey area. This sand bank is most extensive in the western part of the survey area. It is broken by the wreck site and continues to the east of the wreck site. The 6-metre contour of this feature is continuous to the north, and to the south this feature is continuous along the 8-metre contour.

- The Great Nore Anchorage
  The Great Nore Anchorage forms a north eastern boundary to the survey area.

9. The survey shows that the 15-metre contour is more extensive than shown on the published chart. This contour now extends some 10 to 30 metres from the east side of the wreck into two elongation's to the west side of the wreck. On the east side, the contour is at its maximum distance from the wreck opposite the centre part of each section. The elongation at the bow of the vessel extends some 80 metres on a bearing of 238°, at the stern the elongation is shorter at only 25 metres to the south west.

From the colour contour plot at Annex D it can be seen that the shallowest parts of the wreck are at a similar depth to the shallow parts of the Sheerness Middle Sand.

10. When compared with the 1996 survey, which was also carried out at Spring tides, it can be seen that the scouring process which has effectively "sunk" the wreck over the last 54 years appears to be slowing down due to reaching the original river bed.

COMPARISON WITH 1996 AND 1997 DATA

Seabed Terrain

11. The detailed differences between this survey and those conducted in 1996 and 1997 are as follows:

- The average depth for the survey area has remained almost constant between the 1997 and 1998 surveys. The majority of differences of depth of the seabed were within 0.20 of a metre.

- Material has accumulated to the north of the wreck. There has been up to 1.1 metres of removal of material from the eastern face of the sand bar to the west of the wreck.

- All of the features visible in the last two surveys had been found again during the 1998 survey.

- The object 2 metres across, situated 190 metres from the wreck at a bearing of 347° has been identified as an artefact of the wreck but is not clearly identifiable. This object is exposed but does not give rise to concern. It is too large to be an item of ordnance and appears to be a part of the vessel's structure, probably from the above decks superstructure.

- There has been a further 0.3 metre of scouring at the break and at the stern of the vessel. There is an accumulation of 0.2 metres at the bow of the vessel.

- There has been an increase of seabed support for both sections of the wreck. This is approximately 9% of the forward section and 18% for the aft section.

Differences at the Wreck

12. No significant changes in position or orientation of the wreck were observed. The following points were noted:

- The crack in the starboard side of the forward section had again been detected. The crack in the port side of the forward section was not detected although its presence could not be eliminated.

- Eight items of overhanging debris have been detected, one less than the previous years. There has been some slight movement in the position of the debris.

- It was possible to survey the complete superstructure of the wreck. This was not possible in previous years due to the weather conditions.

- The debris located at the break in the wreck covered an area approximately 8 metres by 4 metres with a maximum height of 2 metres above the surrounding seabed. This was the same as in the 1996 and 1997 surveys.

- The objects situated to the west of the aft section were visible on the gradient chart. Inspection of the raw survey data had again revealed that the objects were not exposed but were affecting the surrounding seabed.

SURVEY CONCLUSIONS

13. The inspection of the wreck shows that there has been no significant change in the structure below surface. There has been some movement in the debris overhanging the side of the wreck with one item less being detected.

14. The 1998 survey has indicated that the scouring of the seabed in the vicinity of the wreck is continuing as it has for the past 54 years. Between 1996 and 1997 surveys scouring occurred at the bow, the break, and at the stern of the wreck with accumulation in other areas. Further light scouring in the immediate vicinity of the wreck has occurred between 1997 and 1998 surveys, this is only in the order of 10 cm. The insignificant changes in depth between previous surveys indicate that the seabed surrounding the wreck is in a stable condition.

15. A visual inspection of the masts and derricks at the time of the survey confirmed the wasting on the eyes of the topping lift blocks had less than 10% of the original diameter of steel. The topping blocks on the two heavy lift "jumbo" derricks were well secured, however, they offer large wind resistance and due to their weight impose a strain on the masts. The mast shrouds are either missing or no longer supporting the masts.

16. As a result of the three surveys, the following findings can be stated:

- the wreck remains a significant influence on the seabed topography of the survey area

- the contractor's Seabed Visualisation System had shown good repeatability and a very valid comparison has been made with the 1996 and 1997 survey results.

PART 2

CONSIDERATIONS FOR THE FUTURE

INTRODUCTION

17. This part of the report considers the future by pulling together the available knowledge from several reports. The underlying problem lies with the munitions which remain aboard the wreck, their present condition, and what may happen to them in the future. It is fortunate in many ways that the SS RICHARD MONTGOMERY is a unique problem - a wreck containing a quantity of munitions close to a populated area. However, this uniqueness means there is no direct comparison to judge the possible effects of a mass explosion.

RISKS

18. The risks associated with the wreck of the SS RICHARD MONTGOMERY can be divided into three broad areas associated with collision, capsize and breaking up of the wreck.

Collision

19. Another vessel colliding with the wreck could sufficiently disturb the munitions aboard to produce the conditions necessary for a mass explosion. The wreck is situated in two parts in a "hollow" in a sand spit and does not obstruct normal navigation. The cargo from the after part of the wreck, situated nearest the Medway Channel, is believed to have been salvaged in 1944. There are no records of near misses since the wreck occurred in 1944.

19a. Another vessel colliding with the wreck is a remote possibility. A vessel touching the rigging is more of a possibility, however no near misses have been recorded.

20. The Medway Approach Channel runs approximately 200 metres to the south of the wreck. During 1998 the Port of Sheerness logged 5,173 vessels inwards, excluding pleasure craft.

21. There are 5 designated anchorage positions in the Great Nore Anchorage. The centre of the closest anchorage "N1" is approximately 650 metres from the wreck and has a depth below chart datum of 13 metres variable. The Great Nore Anchorage Number 1 is virtually unused.

22. The Thames Estuary is a popular area for pleasure craft, with many small vessels using the Medway. Although small, those vessels with a shallow draft could pass over the wreck at high or low water with a possibility of collision with the masts.

23. The present arrangements to avoid collisions include:

- designating the wreck as dangerous under the Protection of Wrecks Act 1973 and having an exclusion zone around the wreck

marking this area by four navigational buoys with lights, with additional smaller buoys in between

- publicising the condition of the wreck by notices on charts and in Pilot books.

- extending the time that the masts remain in place by removing the cargo blocks. The masts are visible at all states of the tide; they form a vivid visual indication of the wreck's position and give a distinctive radar return.

- Medway Ports have a Vessel Traffic Service (VTS) which uses radar to monitor vessel traffic in the Medway Approach Channel. It is under contract to MCA to provide radar coverage of the wreck site and warn vessels approaching the exclusion zone. Vessels requiring to use one of the Great Nore designated anchorages would do so as directed by the Medway Navigation Service (MNS).

Capsize or Significant Movement of the Wreck

24. The erosion of the seabed around the wreck could cause the capsize or significant movement of the vessel. This could have two effects; a mass detonation of the munitions, or the munitions could escape and be swept away by the tide.

25. The scouring in the vicinity of the wreck continues as it has for the past 54 years. In the last three years there has been some scouring at the bow, the break , and at the stern of the wreck with accumulation in other areas. The insignificant changes in depth between previous surveys indicates that the seabed surrounding the wreck is stable. It is probable the wreck is sitting on London clay which is the underlying bottom of the Thames Estuary. The surveys also find that there has been a slight increase in the

seabed support for the hull (5% between 1995 and 1998). A reduction in seabed for support would increase the risk of the wreck moving.

26. During the last 54 years there has been little change in the angle at which the vessel is lying on the sea bed, although scouring has occurred resulting in the apparent sinking of the vessel.

27. There are no physical measures presently taken to reduce the risk of capsize or movement of the wreck.

Break Up

28. The wreck has been subject to 54 years of deterioration. This has resulted in the loss of some of the vessel's superstructure. The results of the deterioration increase the risk that at some stage the wreck will loose its structural integrity and start to break up.

29. The structural failings which may occur are:

- loss of masts/derricks
- a large crack in the hull
- the loss of individual hull plates
- the failure or collapse of a deck

- loss of remaining parts of the vessel's superstructure

30. There have been no studies into the forces being exerted on the vessel by the remaining cargo and the surrounding seabed. This is because there is insufficient knowledge of the disposition of the remaining cargo. The internal condition of the wreck does not allow for an internal investigation. Without this information it is not possible to forecast if/ when structural failure may occur. Visibility in the water is never considered to be of sufficient clarity for such an assessment

31. Should the vessel start to break up the risks are that some, or all, of the munitions contained within the hull would be free to be swept away by the tides. This could result in individual munitions being washed ashore on beaches. This reduces the effect of a mass explosion from the remaining munitions, however, a new risk of individual munitions exploding or burning on beaches is created particularly as some of the remaining munitions are known to have a phosphorus content.

32. What munitions are free to move depends on what part of the wreck has broken up. There are two basic types of munitions which raise the most concern. The fused fragmentation bombs, which are the most likely to spontaneously detonate, are believed to be stowed in number 2 tween deck. The 100 lb. phosphorous bombs are stowed in the deep tanks in number 1 hold.

33. Number 2 hold is situated in the centre of the forward section of the wreck and will be prone to the greatest bending action should the wreck move. There is a crack in the

starboard side of number 2 lower hold and a similar crack in the port side, although not detected, cannot be ruled out.

34. The deep tanks situated in number 1 hold are constructionally some of the strongest parts of the vessel. It is probable that this part of the vessel will be the last to break up.

35. There are no physical measures presently taken to reduce the risks caused by the wreck breaking up apart from the planned trimming of the cargo blocks from the masts.

EFFECTS

36. There are two effects which could result from disturbance of the wreck; a mass explosion of the munitions aboard, or the explosion or burning of isolated munitions. These are discussed below.

Mass Explosion

37. The Defence Evaluation and Research Agency (DERA) have reviewed the information[3] available on the wreck and found that there have been a number of studies of the likely effects of a mass detonation of the munitions remaining in the wreck (equivalent to 1500 tonnes of TNT) either as the consequence of an accident or as the result of a planned disposal operation[1].

38. The reports which estimated the effects of a mass explosion of the remaining cargo were both written some time ago. As there have been significant developments in computer programmes capable of modelling events of this type, it may now be possible to obtain a better risk assessment of the effect of a mass explosion under a variety of wind and tidal conditions than was previously available.

39. Whilst there is little data available that can be directly related to the particular situation with the Richard Montgomery, it has always been accepted that a mass explosion would put property and the local population at risk. However more information on the likelihood of mass explosion is sought in order to quantify this statement.

Distribution of Munitions

40. The River Medway and approaches contain a great number of munitions from many sources. Recent dredging operations have produced a wide range of ordnance of both age and type, from cannon balls to a variety of shells, both real and practice. No ordnance which could be definitely identified as originating from the "Richard Montgomery" has been recovered. No modelling of the effects of the free movement of escaped munitions has been undertaken.

41. If escaped munitions wash ashore they will be prone to drying out. For the TNT or RDX explosives in the majority of the bombs the drying out of the explosives after a

[3] DERA, *WSS/WX4/CR97625/1.0*, July 1997. [3] SLADE A C T, *Effects of detonation in the wreck SS Richard Montgomery*, WAE/121/06, 15 May 1970. TATE F E G, *The Richard Montgomery*, XB 243/1/3. 4 December 1975.

long period of immersion may render them more unstable. When phosphorus dries out it will spontaneously combust.

SOLUTIONS

42. Five basic scenarios to solve the problem of the wreck ranging from "do nothing" through to the sanitising of the wreck site are identified. A table summarising the extent of the risks and costs associated with each of the solutions appears at Annex E.

Do Nothing

43. This option involves the ceasing of the present monitoring and the saving of the monitoring budget of £50k per annum. For this solution to work, the wreck would need to be assessed as having no risk of explosion. If this was accepted the wreck would no longer be designated as dangerous under the 1973 Protection of Wrecks Act.

44. Although having no cost, this option has the risk that compensation may have to be paid in the event of a mass detonation. There would be a cost associated with the neutralising of any munitions washed ashore following the break up of the wreck.

45. The assessment of the munitions aboard indicate that there is still a residual risk of explosion. This option has therefore to be discounted, or further examined.

Monitor With Non Intervention

46. This is the status quo option in which there is no intervention or measures taken to reduce risks; the wreck and surrounding seabed are regularly surveyed. This option has a regular and managable cost, however, there is still the risk that compensation may have to be paid in the event of a mass detonation. There would be a cost associated with the neutralising of any munitions washed ashore following the break up of the wreck.

47. Although the seabed appears stable there is no guarantee that the annual surveys presently undertaken would give sufficient notice of movements caused by severe weather conditions. This solution has been used successfully for the past 54 years, but ultimately it cannot be the final solution.

Containment

48. Under this option there are many possibilities depending on the desired achievement. These range from the use of placing a rigid structure around the wreck to the use of spoil from dredging operations.

49. There is a risk associated with any works on or near the wreck and this would need to be quantified before any approval could be given for work to proceed. The risk of causing a mass detonation by the works needs to be reduced to the same or smaller level than that existing at present.

50. Medway Ports are presently in the process of undertaking a feasibility study into dredging the approach channel to 12.5 metres depth (The environmental risk assessment will however explore options to dredge as deep as 14 metres). This will result in the Port Authority having to dispose of quantities of spoil from the dredging. It is their intention to use the spoil in a beneficial manner.

51. The use of a quantity of London clay to form a bund around the wreck site is a consideration under this option. London clay is classified as a rock due to it's age and the fact that it has undergone compression through burial. It is described as a stiff silty clay not prone to erosion and would be a good material to form a long term natural barrier. The filling of the area between the bund and the wreck's hull with sand could also be considered. This would have the effect of supporting the structure of the wreck, while the partial burial and re-instatement of the Sheerness Middle Sand Bank would add protection against collision.

52. A 1971 report[4] stated:

> "A protecting barrier around the wreck is feasible from a hydraulic standpoint although great care will have to be taken both in the design and in the construction of such a structure."

53. The cost of undertaking this type of work has not been quantified and before any work was undertaken a feasibility study looking into the specific nature of the solution, the underlying seabed condition and the effects of tides in the area of the wreck would need to be undertaken.

54. The risks associated with the capsize of the vessel and the dispersing of munitions following a break up are reduced. There is the possibility, if using dredging spoil, that the work may need remedial action after a period of time. The monitoring of the seabed around the wreck would therefore need to be continued.

Entombment

55. Essentially this is a deluxe version of containment, with a structure designed to completely enclose the wreck. To achieve complete entombment some form of rigid structure would be required.

56. There would probably be a greater risk with constructing and maintaining such a structure than with the containment option. Additionally as with any permanent structure there is the problem of what to do with it when it reaches the end of its

[4] *Wreck of the SS Richard Montgomery off Sheerness. An investigation into the proposed schemes for protecting the wreck*. Hydraulics Research Station , Wallingford, Report number EX508.

design life. There is the possibility that further erosion of the seabed around the structure could occur. The monitoring of the seabed would therefore need to be continued.

57. The greater complexity of the structure and its "end of design life" problems mean that this solution may well prove not to be cost effective.

Removal

58. The sanitising of the site is the most attractive environmental solution. This can be achieved in two ways; the removal of the remaining munitions or the complete removal of the wreck. Both these solutions would involve a high one-off investment with no ongoing costs after completion of the project.

59. The technology does not presently exist where the removal option can be safely carried out. It is with regret that this option has to be discounted.

CONCLUSIONS FOR THE WAY FORWARD

60. There are three broad areas of risk associated with the wreck; another vessel colliding with the wreck, the wreck capsizing or moving significantly, and the breaking up of the wreck

- The risk of collision varies with the number of vessels passing close to the wreck. This will fluctuate with the success (or otherwise) of the operations associated with the Medway Ports and with the number of pleasure craft. The various measures which have been in place for the past 54 years have contained this risk. The sandbanks which are either side of the wreck, and parallel with either side of the approach channel, protect the wreck to a great degree from the risk of collision, certainly at low water.

- Erosion of the seabed around the wreck could cause capsize or significant movement. During the past 54 years there has been little change in the angle at which the wreck is lying, although scouring has resulted in the apparent sinking of the wreck. No physical measures have, or are being, taken to reduce this risk.

- The wreck has been subject to 54 years of deterioration. At some stage structural failure will occur. This may consist of large cracks in the hull, the loss of individual plates, the failure or collapse of a deck. This risk will increase with time. Apart from the planned work to trim the cargo blocks from the masts no measures have been taken to prevent the break-up of the wreck.

61. DERA have concluded it is probable that some of the munitions remaining on board are still capable of detonation but the likelihood of a major explosion is remote. Experts have consistently advised that the best way to keep the risk to an absolute minimum is

to leave the wreck alone. However, the balance of risk between a mass detonation and between individual munitions becoming free is slowly shifting with the latter becoming the more likely.

62. Five basic scenarios to solve the problem of the wreck ranging from "do nothing" through to the sanitising of the wreck site have been identified. The most promising are the monitoring of the condition of the wreck (the status quo) and constructing a containment barrier around the wreck. However before any intervention options are seriously considered a feasibility study assessing the risks needs to be undertaken.

PART 3

RECOMMENDATIONS

MASTS AND DERRICKS

63. The 1993 survey stated that the condition of the masts and derricks was such that serious consideration should be given to removing them in an attempt to stabilise the surrounding deck areas. Recent inspections of the masts found, however, that they remained sufficiently robust to leave largely undisturbed. As a consequence it was clear that the existing warning notices placed on the wreck should also remain in

place. The 1997 survey indicated that minor "trimming" of the fixings to the masts (cargo blocks) might be necessary during 1998. This would have the effect of reducing the effects of wind and tide on the masts and help to preserve their integrity. The remedial work is to be carried out in the near future.

RECOMMENDATION 1.

That the masts, derricks and warning notices remain in situ, subject to ongoing inspection and that the cargo blocks are removed when convenient.

CONTINUAL OBSERVATION OF THE WRECK

64. The wreck remains under close observation under a contract let by the Secretary of State for the Environment, Transport and the Regions to Medway Ports to provide for the continual 24-hour guarding of the wreck. The Company are well placed and equipped to undertake this role and the contract has been operating to the satisfaction of the Secretary of State.

RECOMMENDATION 2

That the continual close observation of the wreck is maintained.

SURVEY OF THE WRECK

65. The sonar surveys of recent years have produced repeatable data. They have identified some movement in the debris overhanging the vessel's sides. This proves that any survey requiring manual intervention would be extremely dangerous. Although the seabed surrounding the wreck appears to be in a stable condition, some scouring and build-up does occur.

RECOMMENDATION 3

To monitor the seabed around the wreck an annual survey should continue with a new contract in 1999.

ASSESSMENT OF RISK

66. There is no up-to-date assessment either of the risks associated with the present policy of not disturbing the wreck, or what effects a long term intervention may have. Without a quantified risk assessment it is not possible to recommend a way forward that is based on sound principles. Any survey would need to consider cost, environmental impact and fluid dynamics.

RECOMMENDATION 4

That a risk assessment study is undertaken to cover the following points:

- The effects of a mass detonation of the remaining munitions under a variety of wind and tide conditions
- The conditions required for a mass detonation to occur
- The likelihood of those conditions occurring
- The possibility of the wreck breaking up
- The likely distribution of any escaped munitions
- Feasibility of a containment or entombment solution
- Feasibility of removing the ordinance
- Feasibility of totally sanitising the wreck site

POLICY OF OPENNESS

67. There has been a veil of secrecy surrounding the wreck and the risks involved. The public is not always aware of the true facts and this has led to scare articles appearing in the media from time to time. The MCA (and The Coastguard Agency before) have made available the results of the annual survey, with copies being placed in the libraries of both Houses of Parliament and copies sent to Local Authorities.

RECOMMENDATION 5

That information about the wreck be placed in the public domain, and that the results of the risk assessment are published to form part of a consultation exercise regarding the way forward in the long term.

ANNEX CONTENTS

ANNEX A TECHNICAL DETAILS OF THE 1998 SURVEY

Geodetic Control ..... Page 20

Navigational ..... Page 20/21

Sounding Datum and Tide Gauge ..... Page 21

Seabed Visualisation System ..... Page 21

Peripheral Instruments ..... Page 21

Calibration ..... Page 21

Data gathering ..... Page 21

On Line Data Processing ..... Page 22

Seabed Post Processing ..... Page 22

Wreck - Post Processing ..... Page 22

ANNEX B THE HISTORY OF THE WRECK

Background ..... Page 23

Responsibility for the Wreck ..... Page 23

The Committee on Hazardous Wrecks ..... Page 24

The Explosives On Board ..... Page 24

Condition of the Explosives ..... Page 24

Risk of an Explosion ..... Page 25

The KEILCE Explosion ..... Page 25

Measures taken to Contain the Danger ..... Page 25

ANNEX C MONOCHROMATIC GRADIENT PLOTS

1997 ..... Page 26

1998 ..... Page 27

ANNEX D COLOUR CONTOUR PLOT 1998 ..... Page 28

Appendix 1

Munitions Remaining aboard SS Richard Montgomery ..... Page 29

Appendix 2

Keilce Explosion ..... Page 30/31

Annex E

Analysis of Risks Associated with Solutions ..... Page 32

ANNEX A

THE TECHNICAL DETAILS OF THE 1998 SURVEY

1. The tide gauge and Kinematic GPS base station were established at Sheerness on 10 August 1998. Survey operations started on 11 August with a confidence check whilst alongside. The vessel then sailed for the site of the wreck, some 2 miles north-east of Sheerness.

2. The survey was conducted using pre set north/south run lines. Two sets of line data were generated; one set to cover the whole area at a 15- metre interval, and another set to cover the wreck examination area at a 10- metre interval. Each line was identified with a number and a total of 56 lines were generated to cover the whole survey area. Twelve shorter lines, at 10-metre intervals, were generated to cover the immediate vicinity of the wreck.

3. Over the period of high water on 12th August, a series of high resolution passes were made around the wreck using the starboard transmitter only. Run lines closest to the wreck were conducted at either slack water or down tide. Two sets of transverse lines at standard resolution were run across the wreck at the Master's discretion.

4. Small gaps in coverage may be present in the vicinity of buoys and in shallow water. These gaps do not have a detrimental effect upon the achievement of the aims of the survey.

5. Tidal streams were not measured, but by observation it could be seen that they were setting strongly approximately east/west. The set of the tidal stream could be easily seen on the buoys which mark the danger area around the wreck. In consultation with the Master, the vessel worked on the downtide, or "safe" side of the wreck.

GEODETIC CONTROL

6. The survey was referred to the WGS 84 Datum, WGS 84 Spheroid, and plan data was presented at various scales on the Transverse Mercator projection using the Universal Transverse Mercator Grid Zone 31(Central Meridian 3° East).

NAVIGATION

7. Primary positioning was provided by a Ashtech Z-sensor RTK DGPS system consisting of 1 base station and 1 rover unit. The base station was positioned at Sheerness Signal Tower trig 51° 26' 47".152 N 000° 44' 39".584 E.

SOUNDING DATUM AND TIDE GAUGE

8. Chart datum at Sheerness, 2.90 metres below Ordnance datum Newlyn, was chosen as the sounding datum. Data was reduced to sounding datum using tidal data from Sheerness, no co-tidal data was used.

9. Tide readings were obtained using a Sonar Research and Development Ltd portable tide gauge, whose datum was referred to the tide gauge at Sheerness. The tidal data was compared with data from the permanent tide gauge at Sheerness, and a good agreement was obtained.

SEABED VISUALISATION SYSTEM

10. The Seabed Visualisation System provides a continuous electronic scan of the seabed. The system was configured with 3 sets of transducers, designated centre, port, and starboard. The port and starboard transmitters were high resolution, and the centre transducer was standard resolution. The whole area was surveyed using standard resolution. A detailed survey of the wreck was carried out on the 12th August using the starboard transmitter set only.

11. The transducer array was mounted at the bottom of a vertical beam, which was supported over the vessel's moonpool by a fabricated triangular rig. This allowed the array to be retracted to deck level during transit. For sonar operations, the array was lowered down beneath the keel level using a simple winch mechanism, and locked into position using securing clamps and bolts.

PERIPHERAL INSTRUMENTS.

12. The following peripheral instrumentation was used:

- Heading — Anshutz Standard 20 (SEC-OP) gyro compass
- Motion — TSS335b
- Position (Primary) — Ashtech Z-sensor DGPS.
- Tide — SRD portable tide gauge.

CALIBRATION.

13. The system was pre-calibrated before transit to Sheerness. A sound velocity of 1508 metres per second was used.

DATA GATHERING.

14. The Seabed Visualisation System stores raw data and on line processed data on 1.6 Gbytes discs. Data was gathered at a position resolution of 20 cm for standard resolution data, and at a positional resolution of 10 cm for high resolution data. Both data sets were gathered with a vertical resolution of 1 cm.

ON LINE DATA PROCESSING.

15. The data was processed on line to give an assessment of data coverage and quality. Further data processing to remove noise spikes and to compose high resolution representations of the wreck was carried out at the survey contractor's factory.

SEABED-POST PROCESSING.

16. All seabed and wreck data was processed at standard resolution. The data processing procedure was a staged process consisting of:

- Filtering of on line data to detect and remove spurious returns.
- Visual inspection of adjacent swathes.
- Creation of Digital Terrain Model (DTM)
- Visual inspection of printed data.
- Final Chart Printing.

WRECK POST PROCESSING.

17. Data obtained during the standard and high resolution passes of the wreck was processed as follows:

- Replay of Raw Data.
- Application of Tides.
- Visual Inspection of on line data and the removal of any spurious returns.
- Visual inspection of adjacent swathes.
- Creation of DTM.
- Visual Inspection of printed data.

18. In order to assess the extent of the seabed supporting the wreck, the wreck echoes were filtered out of the records using manually set gates. These plots showing the wreck's contact with the seabed are included amongst the graphics.

ANNEX B

THE HISTORY OF THE WRECK

Background

1. The SS RICHARD MONTGOMERY was a Liberty ship, 441' 6" long and 7146 gross tons, of a mass-produced design not necessarily intended for more than a single voyage. She was built in 1943 by St John's River Ship Building Company, Jacksonville, Florida. The ship sailed from the USA to the UK as part of the convoy HX-301 in summer 1944 with a cargo of some 7000 tons of munitions. On arrival in the Thames Estuary the vessel was directed to anchor in the Great Nore Anchorage, off Sheerness. On almost the next tide, however, the ship's anchor dragged and it drifted on to a bank running east from the Isle of Grain (at 51°78'57"N 00°47'12"E) about 250 metres north of the Medway Approach Channel. The ship grounded amidships on the crest of the bank and - this being a weak spot in this design - shortly afterwards broke its back. The wreck now lies in some 15 metres of water, with the masts protruding at all states of the tide.

2. The wreck lies about one and a half miles from Sheerness and the Isle of Grain and five miles from Southend. It lies on a bank across the tide.

3. The wreck is not an obstruction to navigation - indeed, it serves to mark for other shipping on the bank on which it grounded.

4. Intensive efforts were made after the grounding to unload the cargo and about half was removed. The two stern holds were probably emptied. The other holds were less accessible. When the wreck flooded, the salvage operation had to be abandoned. An investigation by the Southend Chamber of Trade[5] concluded that all of the fused bombs (situated in number 2 tween deck) had been cleared during the salvage operation. This information is considered inconclusive. The remaining cargo represents some 1400 tonnes of explosive material; the balance being the heavy bomb casings etc. The table at appendix 1 shows the best estimate of the disposition of the remaining explosives.

Responsibility for the wreck

5. The UK Government has assumed de facto responsibility for monitoring the wreck - firstly through the Board of Trade and, since 1983, through the Department of Transport (now DETR). It has relied upon expert advice provided by a Committee on Hazardous Wrecks comprising various experts from the Ministry of Defence, the Home Office

[5] E G WHITEBREAD, *SS Richard Montgomery*, 23 March 1973

and the Health & Safety Executive, together with the Port of London Authority and the Medway Ports. The Committee sought advice from US experts on the contents of the wreck, the design of the munitions carried, and the nature of the hazards they posed. The Committee is now formally disbanded, but the Department still has access to the experts if needed.

The Committee on Hazardous Wrecks

6. The Committee's consistently firm advice was that no attempt should be made to disturb the site. In the Committee's opinion, any such action would increase the likelihood of the very explosion that must be avoided if at all possible.

The Explosives on Board[6]

7. The Committee's advice was based on the most exhaustive information available about the types of explosives involved, and the likely effect upon them of age and/or contact with sea water. The bombs thought to be on board are of three types. The bulk are standard, un-fused TNT bombs. In addition, some 800 fused cluster bombs are believed to remain. These bombs were loaded with TNT. They could be transported fused because the design included a propeller mechanism at the front which only screwed the fuse into position as the bombs fell from an aircraft. These two types of bombs could therefore be handled - with care - when the accident occurred. There are also some smoke bombs on board (paragraph 10 below).

Condition of the explosives

8. TNT does not react with water and is extremely stable, particularly if stored at a steady, low temperature. As it has been contained in metal bomb cases there has probably been little change in its chemical or explosive properties as a result of the long period of immersion.

9. When the condition of the munitions was first assessed there was considerable concern over the possibility of the formation of very sensitive copper compounds from reaction between the lead azide in the detonators with the brass components of the fuses of the cluster bombs. This would have been a possibility whilst the fuses contained significant amounts of air, however, as the fuses will probably all have been flooded for many years, and the sensitive compounds referred to are all soluble in water, this is no longer considered to be a significant hazard.

10. Following the 1996 survey a review was made by the Defence Evaluation and Research Agency, based on the information available, as to the probable condition of

[6] See Appendix 1

the munitions still remaining in the wreck. The review concluded that the munitions would retain their explosive power but would be no more sensitive than in their normal state. Any fuses present in the wreck would have deteriorated to the extent that they were no longer functional. The white phosphorus filling of the smoke bombs is stable under water but is capable of spontaneous ignition if exposed to the air.

Risk of an explosion

11. The break in the ship has already exposed the contents of No 3 hold/tween deck, without an explosion occurring. There are two reasons why a cluster bomb fuse in an unstable condition could explode without even setting off the cluster bomb to which it is attached; the fuse is not screwed into the main charge or the main charge might now be wet or non-explosive. The same reasons make it still less likely that such a fuse could detonate the main cargo.

12. It is believed that, left to itself, the wreck will break up gradually. There is a good prospect that all the ordnance will get wet in this process and will become neutralised. Even if the water has not already rendered them inert, a small explosion at any distance from the wreck will not set off the bulk of the cargo. The risk would significantly increase, however, if the wreck were to be disturbed by moving it or attempting to unload it.

13. The risk of a major explosion is believed to be remote and is probably becoming even less likely with the passage of time. It may eventually pass altogether, but this is not likely to be for some considerable time. It would probably be very dangerous to try to find out the true situation within the wreck, particularly if this involved significant interference.

KEILCE explosion[7]

14. The explosion of the munitions aboard the wreck of the KEILCE in 1967, reinforced the decision of the Committee on Hazardous Wrecks to recommend a policy of non-interference. The mass detonation of the cargo occurred after explosive cutting charges were fired during an attempt to clear the wreck. Appendix 2 gives fuller details of the incident.

Measures taken to contain the danger

15. The site is the only one designated as a dangerous wreck under the Protection of Wrecks Act 1973. It is an offence to interfere with it in any way. This augments measures

[7] See Appendix 2

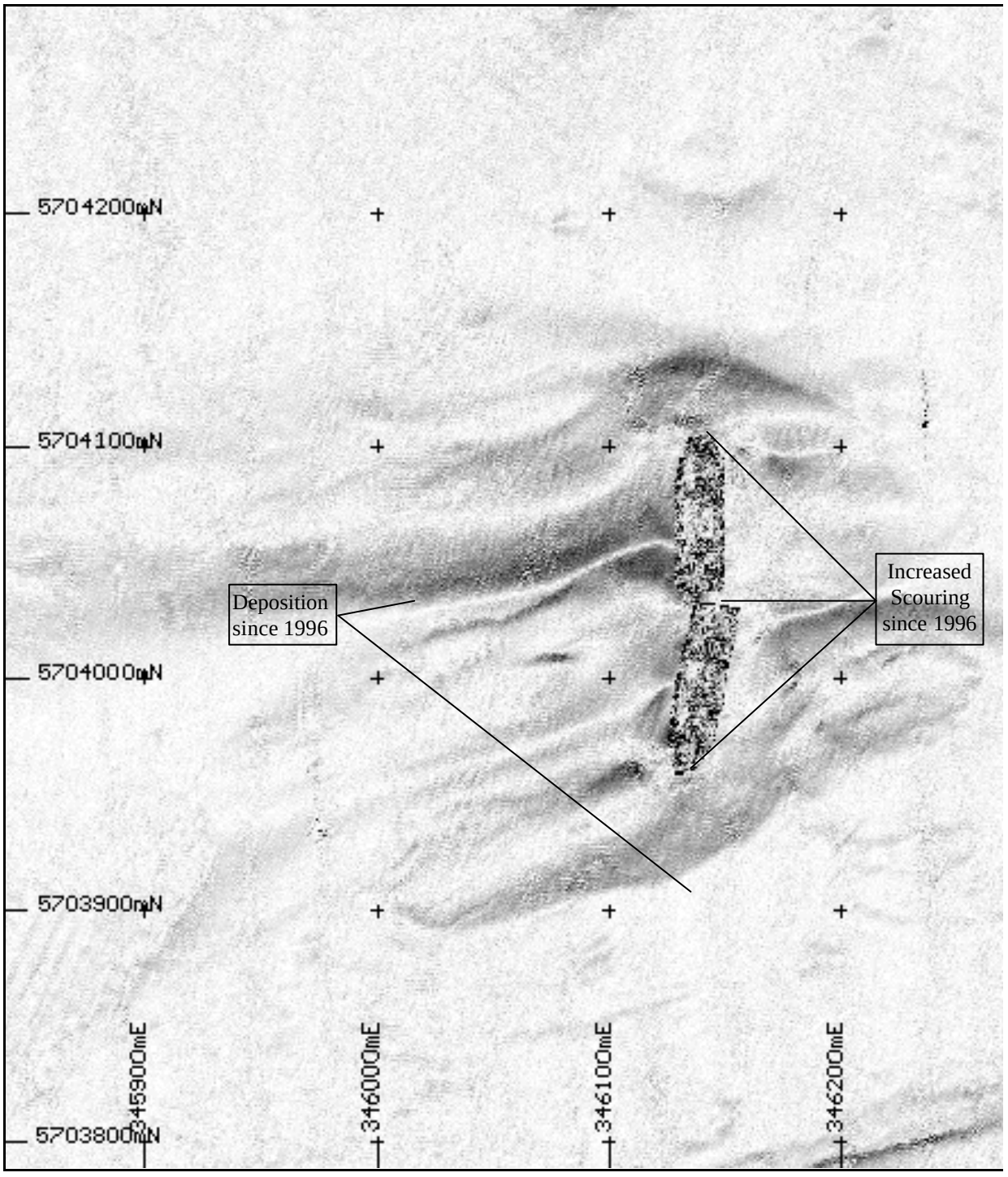
taken in the 1960s which included additional buoys and a Notice to Mariners designating the site as a "foul area" where trespassers would be liable to prosecution. Medway Ports at the Port of Sheerness keep a close watch on the site by sight and by radar, and maintain the buoys and warning notices under contract to the Maritime and Coastguard Agency.[1] See Appendix 2

ANNEX C
MONOCROMATIC GRADIENT PLOT

Report of Survey 1997

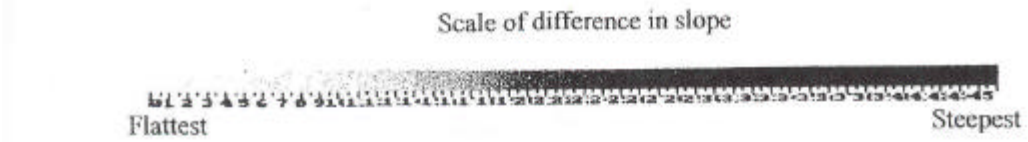
Scale of difference in slope

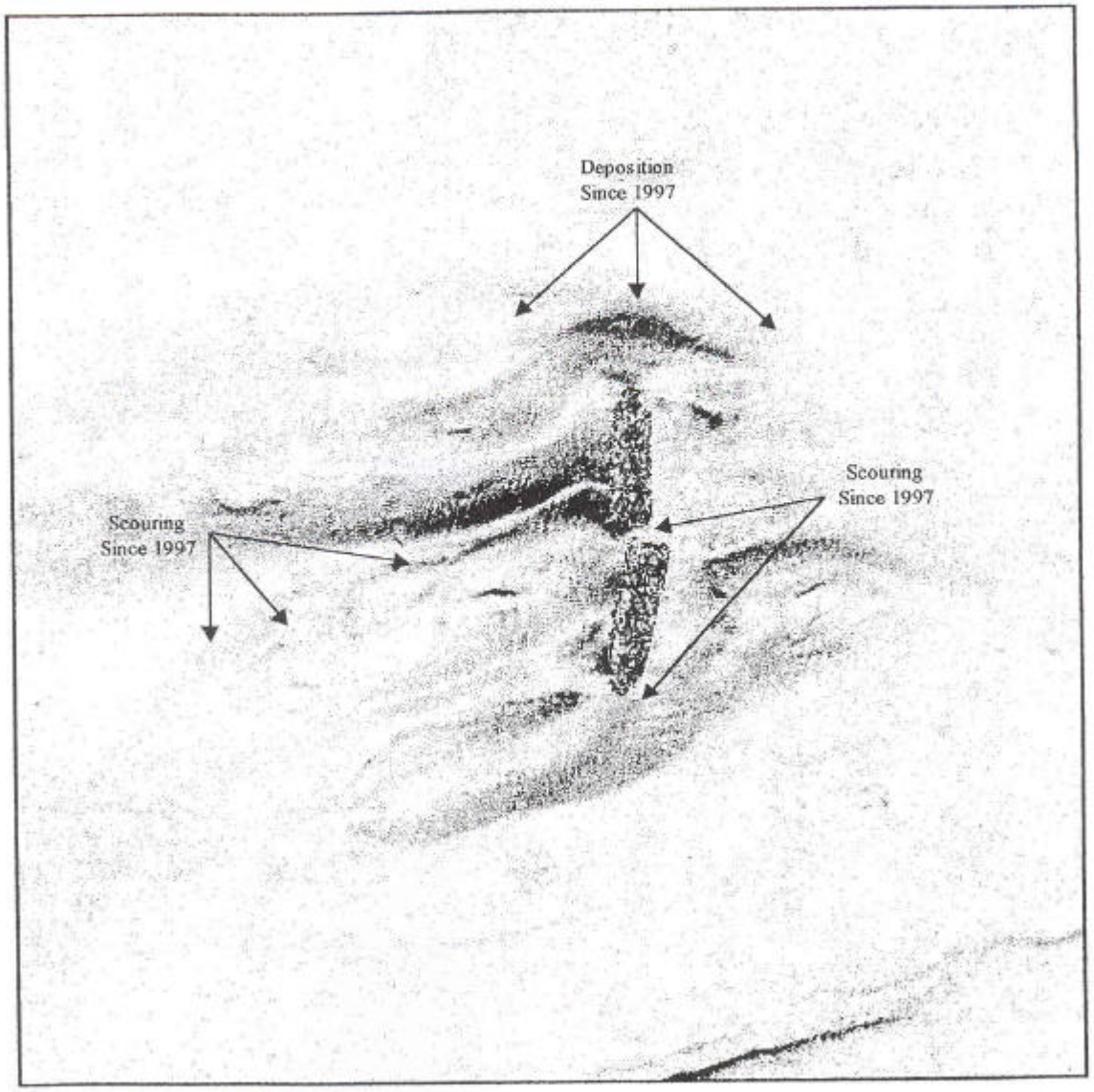
Flattest Steepest

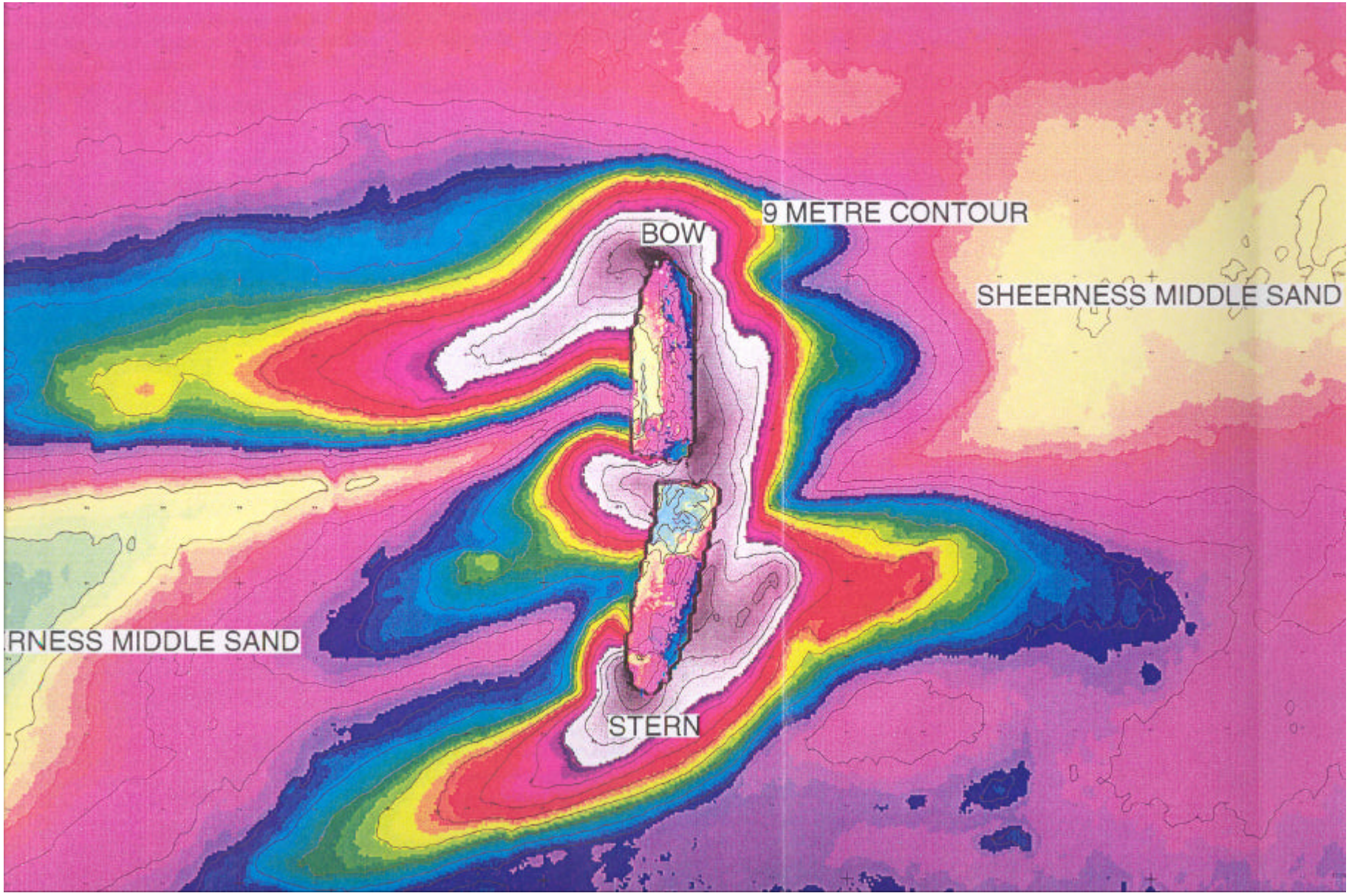


MONOCHROMATIC GRADIENT PLOT

Report of Survey 1998






9 METRE CONTOUR
BOW
SHEERNESS MIDDLE SAND
RNESS MIDDLE SAND
STERN

Appendix 1

MUNITIONS REMAINING ABOARD SS RICHARD MONTGOMERY

DERA in their summary report have listed the best estimates of the munitions which remain aboard the SS Richard Montgomery. The weights given in the table below are those of the explosive content of the cargo and not the shipped weight.

LOCATION	TYPE OF MUNITIONS	EXPLOSIVE WEIGHTS (TONNES)
HOLD NO1		
Deep tanks Aft	79 cases signals	3 (pyrotechnics)
	1429 cases wp 100lb smoke bombs	65 (white phosphorus)
Deep tanks Forward	30 Boxes boosters	31 (pyrotechnics)
	786 boxes signals	
Lower hold/tween deck	1407 500lb bombs TNT AN M64A1	167
	850 1000lb bombs TNT AN M65	208
	1500 250lb bombs TNT AN M57	84
HOLD NO 2		
Lower hold	1068 1000lb SAP bombs TNT AW-M59	140
	574 500lb SAP bombs AN M58	41
	286 2000lb GP TNT AN-M66	144
	588 1000lb AN M65	140
Tween deck	521-580 B260lb fragmentation bombs AN M81	9
	2297 cases of fragmentation bomb clusters	9
	AN M1A1 (6 x 20lb fused)	
	and/or AN M4A1 (3 x 23lb unfused)	
	and/or AN-M81 B260lb	
HOLD NO 3		
Lower hold/tween deck	1170 SAP 1000lb bombs	163
	406 GP 1000lb bombs	99
	1351 SAP 500lb bombs	97
	TOTAL	1400 tonnes

THE KIELCE EXPLOSION
Appendix 2
BACKGROUND

1. In 1946 the Kielce, a ship of Polish origin, built in 1944, was on charter to the US forces, sailing from Southampton to Bremerhaven, when it was in collision and sank in the English Channel off Folkestone. The ship was of 1896 gross tonnage, 250 ft long, 41 ft berth and drawing just over 20 ft. It had a "full cargo of bombs and ammunition" although no cargo manifest has ever been traced.

2. In the early 1950s an unknown wreck was chartered at 51°02'20" N, 01° 13'33" E, and it was not until ten years later, when Trinity House awarded several contracts for the removal of wrecks in the Channel, that this was identified as the Kielce and confirmed to contain ammunition.

3. In 1966 the Folkestone Salvage Company was given a contract to clear the wreck, to give 50 ft clearance at MLWST, and part of the contract called for the dispersal of the explosive stores. During their preliminary work to clear collapsed hull plating, the Salvage Company fired two cutting charges on the hull without serious effect. On firing the third, however, at 1159 hours on BST on 22 July 1967, a large explosion occurred which "brought panic to Folkestone's town and chaos to the beaches ".

THE EFFECTS OF THE EXPLOSION

4. At the time the Press, and the local Police, were made aware of significant damage to various properties. Chimneys were damaged, slates dislodged and ceilings were cracked, but no case of personal injury was reported.

5. Meanwhile, the seismic effects of the explosion had been recorded by at least 25 observatories, throughout Europe and America, out to a distance of nearly 5000 miles from Folkestone, and from these records, using techniques which were developed for cataloguing the severity of earthquakes and other seismic disturbances, a magnitude of 4½ ± ½ was allocated to the explosion.

6. By subsequent survey, the sea-bed crater formed by the explosion was found to be roughly elliptical with major and minor axes 153 and 67 ft respectively, the maximum, depth 20 ft, and with the "lips" rising to between 5 and 11 ft proud of the general level of the sea bed[1].

7. The wreck had been lying in approximately 90 ft of water, on a sea bed of silt, when the explosion occurred. An acoustic signal was received at one station in the UK, whose amplitude was approximately one-thirtieth of that which would have been expected from a surface explosion of the magnitude from the seismic records. In other words, by far the larger proportion of the energy released was transmitted seismically (this was confirmed by the

general absence of shattered windows, except those which were broken by the movement of the frames).

8. Two members of the staff of the Folkestone Salvage Company were in a small boat some 400 yds from the wreck when the explosion occurred, and they reported "a small ripple and some spray" - certainly not a large plume of water. However, there were a few reports of a

"tidal wave" hitting the Folkestone beaches, resulting in a small number of successful claims for property damage on these beaches, although it has been computed that the amplitude of the resulting sea wave caused by the explosion would not have been greater than about 2 ft.

THE YIELD

9. A magnitude of 4½ indicates a yield of 2000 tons of TNT, when fully contained in water or in a dense rock. The Kielce explosion was not fully contained although, as indicated above, a small proportion of the total energy release was propagated acoustically. Hence, although the total energy released may have been higher that to be expected from 2000 tons of TNT, the proportion of the energy propagated through the water and the sea-bed will have been equivalent to that released by that weight of explosive "fully contained".

ANALYSIS OF RISKS ASSOCIATED WITH SOLUTIONS Annex E

Solution	Year on Year Costs	One off Engineering Costs	Feasibility Study	Mass Detonation	Dispersion of Munitions	Capsize/ Significant Movement	Accident During Works
Do nothing	None	None	None	Unlikely	Increases with time	Increases with time	None
Monitor (Status Quo)	• Survey • Guarding	• Trim masts	Yes	Unlikely	• Increases with time • Survey to warn of deterioration in wreck	• Increases with time • Survey to warn of deterioration in wreck	Very unlikely
Containment	• Survey • Guarding	• Trim masts Engineering cost	Yes	Unlikely, but works on wreck may increase risk	• Reduced • Survey to warn of deterioration in wreck	• Reduced • Survey to • warn off deterioration in wreck	Unlikely
Entombment	• Survey	• Engineering cost greater than above	Yes	Unlikely, but works on wreck may temporarily increase risk	None	None	Unlikely
Removal	None	• Engineering cost greater than above	Yes	None, but works on wreck may temporarily increase risk	None	Not applicable	Unlikely, but works more complicated