# Using Single Beam Echo Sounder to Recheck Shipwreck Location

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## Abstract

The research aimed to ensure the searching capability of Single-Beam Echo Sounder (SBES) as same as Multi Beam Echo Sounders (MBES). The testing was about rechecking shipwreck on the Clyde River floor. If the solution from SBES technology is suitable for positioning shipwreck, it will save time and budget. The experiment was with five main objectives. GIS Software was the tool for processing and analyzing data. After the experiment was completed, the result showed that the map from the MBES dataset (2014) could find the location and measure the dimension of the shipwreck while the map of SBES (2019) neither found the location nor measured the dimension. SBES (2019) and MBES (2014) could be separately displayed on the river floor in different colours representing different depths. Moreover, the collected data by SBES (2019) on the fieldwork met Order 1b of the specific requirements (S-44) of IHO. Furthermore, the feature and contour lines from the SBES (2019) and MBES (2014) dataset presented quite the same feature of the river floor, but the map of SBES dataset (2019) from fieldwork showed a few differences in contour lines because the dataset did not cover the entire study area. Finally, the SBES dataset (2019) could not be used for identifying or rechecking the location and dimension of the shipwreck, but it could be used for generating the map of the river floor or seafloor. Although this research achieved most of the tasks, SBES still has some limitations and cannot achieve the main objective. The conclusion was that the capability of SBES was not suitable for searching and locating shipwreck.

***Keywords:*** Single-Beam Echo Sounder, Multi-beam Echo Sounder, Shipwreck, seafloor

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## 1. Introduction

The hydrographic survey has the principal purpose to determine the data related to bodies of water [1]. It is a technique of surveying mapping to determine the seafloor. The collected dataset is processed to create an ocean map or navigation chart which benefits navigation or checking the features of the seafloor. The Single-Beam Echo Sounder (SBES) is a technology system used to survey mapping. It can reach sub-decimetres in terms of accuracy in shallow water [2]. The SBES system may use different equipment which has different frequencies to determine the depth of the seafloor compared to the MBES (ibid). However, the MBES system uses several beams technique to determine the depths of the seafloor and provide an accurate raw dataset, resolution, and the total seafloor (ibid). Therefore, this research compared the dataset from different sources; The United Kingdom Hydrographic Office (UKHO) [3] and collected on the fieldwork. Moreover, there are two datasets from the UKHO (ibid) which is MBES and SBES. Then the MBES dataset was surveyed in 2014 and the SBES dataset was surveyed in 1997. Furthermore, the surveying area was surveyed by SBES. Two techniques were used in this research including the Single Beam Echo Sounder (SBES) and the Multibeam Echo Sounder (MBES). The first system is the Single Beam Echo Sounder (SBES) which uses a single beam to determine the depths on the seafloor. While the Multibeam Echo Sounder (MBES) use several beams to determine the depths on the seafloor. The survey was performed in the Greenock west area to investigate the dangerous wreck near the riverside. This shipwreck ID is 4124 which is approximately 500 metres from the shipwreck to the Cruise Terminal (riverside) and then this shipwreck is 22 metres of depth. The dataset from MBES and SBES which cover the shipwreck was extracted to prepare for processing. Next, all dataset was processed by GIS Software to generate the map. Then the map of MBES and SBES from UKHO (ibid) and fieldwork was compared to find the difference between these maps.

## 2. Objective

The MBES is a system which is quite expensive and consumes a lot of time for processing. Moreover, this research would help several companies or countries who have limited budgets to purchase the MBES. Therefore, this research aimed to use SBES for rechecking shipwreck location on the seafloor.

2.1 The shipwreck was investigated by GIS Software. This process required both MBES and SBES dataset from the UKHO (ibid) to analyse and plan to survey by SBES.

2.2 The MBES and SBES dataset from UKHO (ibid) were processed and generated to the map then these maps were compared to find the difference between MBES and SBES dataset.

2.3 The SBES dataset was investigated so that it could meet Order 1b of the specific requirements (S-44) from IHO.

2.4 The SBES dataset from fieldwork was compared with MBES dataset to find the difference on the maps.

2.5 The map of SBES dataset was analysed that it could use for identifying the location and feature or independent check of the shipwreck on the river floor.

## 3. Methodology

This research processed the dataset by using GIS Software. The dataset was brought from the UKHO (ibid) and collected on fieldwork. The area of the dataset was nearby Greenock West and this dataset had to cover the shipwreck 4124 which is a dangerous wreck. The research compared two datasets, so the suitable generated surface was the Inverse Distance Weighting (IDW). This might generate a surface which can compare different surveying techniques. However, this method was still limited in prediction to generate the contour line on the surface because it was insufficient contour point in that area. The calculation was still limited by using various algorithms [4]. However, there was a new method which based on the triangulation interpolation using Delaunay tessellations (Deltri Analysis) which was superior to existing methods (ibid). This method could fulfill the gap in the original calculation and provide the most accurate and objective measurement. It displayed the contour on the surface. This technique was calculated by estimating the rough data of the surface and analysing the direction to the surrounding triangles of each contour point. Therefore, this new method is currently able to provide the most accuracy in the predicted point on the surface. Furthermore, this research generated not only the IDW surface but also Hillshade and Slopes. These surfaces helped the surveyor to analyse the shipwreck to determine the location and dimension of the shipwreck before surveying the fieldwork

## 4. Results and Discussion

### 4.1 Analysis of the surveying area and shipwreck before surveying

#### 4.1.1 Analysis of the shipwreck area

The survey area was nearby Helensburgh. There were many shipwrecks in this area.

Each shipwreck was suitable for surveying because it was not too deep. If it is deep, it would make an effect on the dimension of the footprint from the SBES. Therefore, the suitable shipwreck should be less than seventy-five metres due to the limited specification of the BTX/SPX software. Finally, the shipwreck was the dangerous wreck (ID: 4124) which was 22 metres deep and was selected. The result showed that the diameter of the footprint was 3.07 metres so this shipwreck was suitable to survey by SBES. Another considerate factor was that the location of the shipwreck (Shipwreck ID: 4124) had to be in the MBES dataset because there was no MBES equipment to survey on the fieldwork. Moreover, the shipwreck should be in the SBES dataset because the surveyor could download the SBES dataset from the UKHO [3]. Therefore, this shipwreck was in the SBES dataset and then it was processed to create the map. This map was analysed to explore the feature of the shipwreck.

4.1.2 Analysis of the shipwreck from the MBES dataset

The results of the MBES process were in three different surfaces; Hillshade, Depth, and Slopes. According to Figure 1, the shipwreck noticed two large hills on this map. One hill was large and the feature or dimension was like a ship. Moreover, this hill was found that the location was the same as the shipwreck (Shipwreck ID: 4124). This location was 390,034.45 m. of the easting and 6,203,218.59 m. of the northing and the datum was WGS 1984 UTM Zone 30N. The dimension of this hill which was measured by GIS Software was 25 m. in length, 7.5 m. in width, 22 m. of depth and 1 m. in height. The depth after processing by GIS Software matched the official dimensions in the UKHO (ibid). Therefore, it might assume that this hill was a shipwreck (Shipwreck ID: 4124)

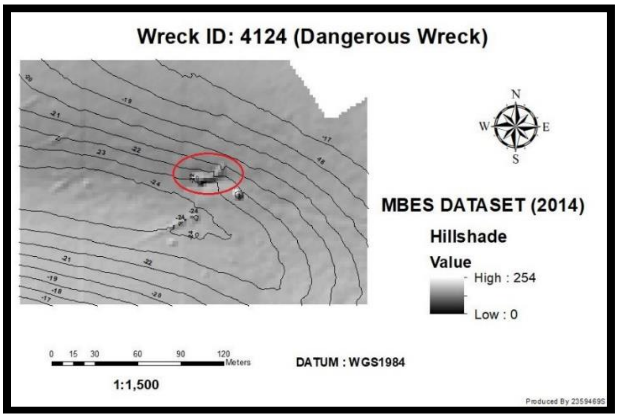


**Figure 1** The profile of shipwreck (Shipwreck ID: 4124) from MBES dataset (2014) in Hillshade surface.

According to Figure 2, it was a map in which the depths were represented by colours. It could notice that the area which was the same location as the shipwreck presented suddenly changed in different colours and contour lines. Therefore, it could support that it was a wreck (ID: 4124).

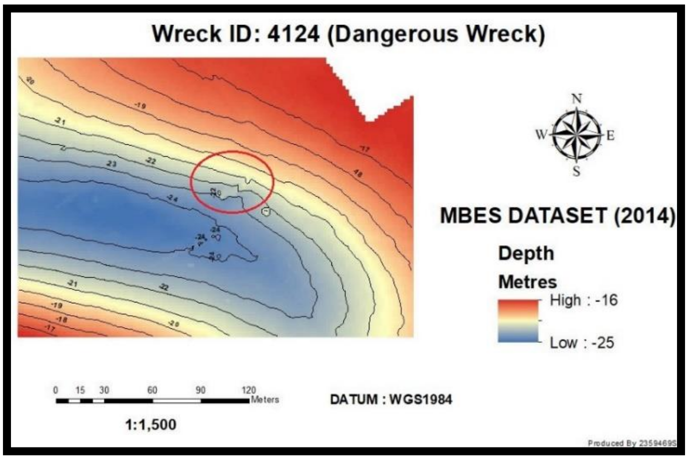


**Figure 2** The profile of shipwreck (Shipwreck ID: 4124) from MBES dataset (2014) in Depth surface

Moreover, it could support the location of the ship by using the slope Toolbox in GIS Software. According to Figure 3, the area of the shipwreck was noticed that the angles of slopes were higher than in the other area. It is presented in red colour and the slope was from 16 to 24 degrees Therefore, this could assume that the high slopes were the shipwreck (Shipwreck ID: 4124).

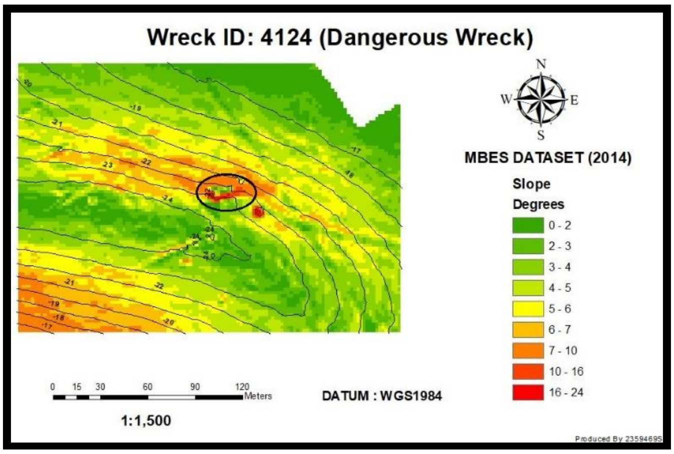


**Figure 3** The profile of shipwreck (Wreck ID: 4124) from MBES dataset (2014) in Slope surface

4.1.3 Analysis of the shipwreck from the SBES dataset

Although the map of the MBES dataset could locate the location of the shipwreck, the SBES dataset in the area of the shipwreck should be processed. The SBES dataset from the UKHO [3] was extracted and processed to generate the map of the SBES dataset. There are two SBES datasets which were in 1993 and 1997. According to Figure 4, the contour was generated by depth. There was no feature or any of the suddenly changed. Moreover, the SBES dataset (1993) did not cover the entire map so it could not investigate the shipwreck on this map since it was unclearly representing the river floor. However, Figure 5 shows the map which was generated in different colours depending on the depth. It could represent clearly on the river floor. Although the map from Figure 5 was completely covered by many datasets more than Figure 4, it could not investigate the shipwreck on these maps because no feature suddenly changed on this map.

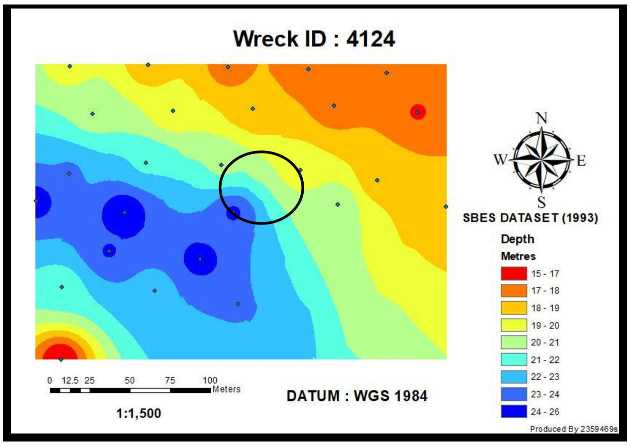


**Figure 4** The IDW surface from SBES dataset (1993)

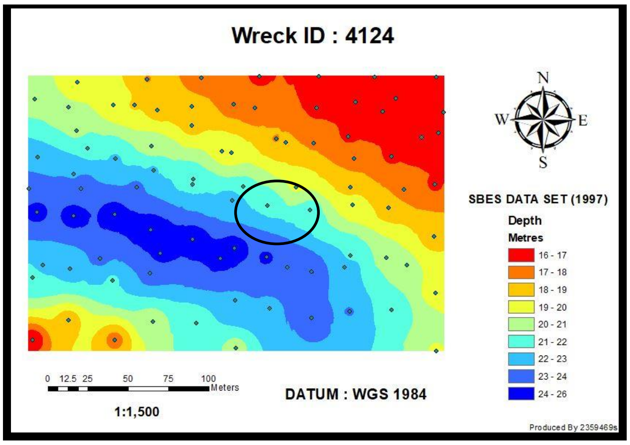


**Figure 5** The IDW surface from SBES dataset (1997)

4.1.4 Analysis for designing line layout

Before surveying, the surveyor prepared the line layout which helped the surveyor to sail a boat in the right direction. The map which was generated was 1: 1500 in scale. Moreover, the shipwreck dimension was 25 m. in length and 7.5 m. in width. It lays in from the North to South direction. Therefore, the gap between the line layouts should be 5 m. and the directions were the North-South and East-West. Each line was 100 m. and was designed in GIS and AutoCAD Software.

4.2 The comparison of the results between MBES and SBES from UKHO

The map of MBES and SBES which were extracted from the UKHO (ibid) were generated by IDW interpolation. Then the surfaces of these maps were created to be analysed in terms of the depth. Moreover, the main point was to analyse the difference in the maps between the MBES and SBES from UKHO (ibid).

The MBES was extracted from the UKHO (ibid) which was surveyed in 2014. The raw data could be generated to the surface. The MBES dataset could cover the entire area and the grid was 2 metres. Therefore, this map of MBES dataset could generate the map and analysis the shipwreck. According to Figure 6, the map is from -16 to -24 metres in depth, the deepest was the dark blue colour and the shallowest was in red colour. Moreover, the datum was UTM Zone 30N in WGS 1984 with a scale of 1: 1500. The shipwreck 4124 was noticed by three different contour lines which suddenly changed in the same feature. Therefore, this MBES dataset could provide dense datasets to generate the high - resolution map. This map did not provide only the location of the shipwreck but also shows the rough dimension of the shipwreck. Therefore, the surveyor might estimate the dimension and location of the shipwreck from this map.

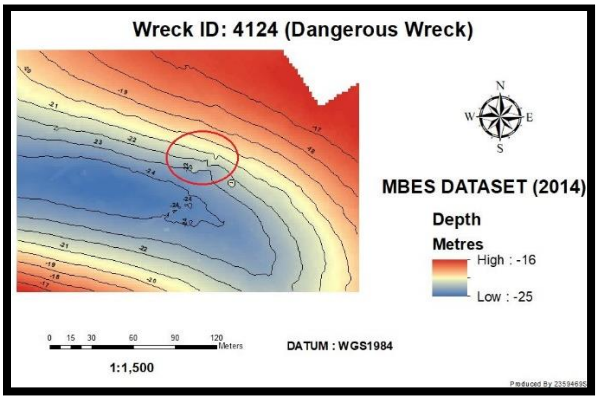


**Figure 6** The profile of shipwreck (Wreck ID: 4124) from MBES dataset (2014)

The SBES dataset from the UKHO (ibid) could generate the map by IDW interpolation. This was surveyed in 1997. The gap between each point was approximately from 5 to 25 metres. Moreover, the raw data was likely to follow the surveying line and the depth of this map was from 16 to 26 metres. The deepest was in dark blue and the shallowest was in red. Therefore, the SBES dataset could generate the map which was quite the same as fieldwork. However, this dataset could not generate the map which could analyse to estimate the dimension and location of the shipwreck (Shipwreck ID: 4124).

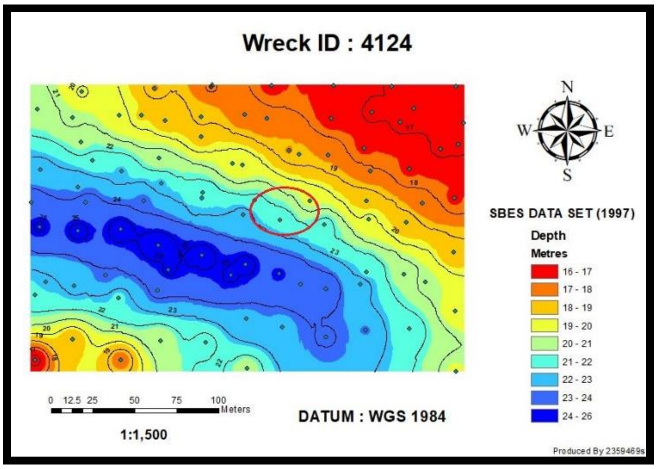


**Figure 7** The IDW surface from SBES dataset (1997)

According to Figures 6 and 7, there was quite the same pattern, but there were some points which were different. The dataset of the MBES and SBES were scattered to cover the surveying area. However, the gaps between the MBES and SBES were different because the grid of the MBES dataset was two metres. The SBES dataset was approximately from 25 to 50 metres. Therefore, the MBES dataset was denser than the SBES dataset to cover the surveying area. The map from MBES dataset was quite better than the map from the SBES dataset. Next, the map from MBES dataset could analyse the shipwreck to determine the location and dimension of this shipwreck, but the SBES dataset could generate the map. It could not analyse and determine the location and dimension of the shipwreck. In conclusion, the Multibeam Echo Sounder (MBES) dataset could generate the map which could analyse and determine the location and dimension of the shipwreck. However, the Single Beam Echo Sounder (SBES) dataset from UKHO (ibid) could generate the map but this map could not analyse and determine the location and dimension of the shipwreck.

4.3 Analysis of the SBES dataset from fieldwork

The shipwreck (Shipwreck ID: 4124) was surveyed by SBES and generated to the map. It was analysed to investigate that this survey met the Order 1b of the specific requirements (S-44) from IHO. Furthermore, this map was compared to SBES dataset from the UKHO (ibid). According to Figure 8, the line layout was designed over the shipwreck. It was imported to set the waypoints of the boat to ensure that the SBES collected the data over the shipwreck. However, the line layout was unable to import to RTK screen. As a result, it sailed without presenting the line layout. Nevertheless, the surveyor solved this problem by setting the location of the shipwreck. Then the boat could be sailed over the shipwreck in North to South and East to West direction. Moreover, the surveyor also concerned about the safety of the other ships which sailed in that area. According to Figure 8, the boat track was in the green dot line. However, this tract does not present as the line layout due to the limitation to import information. Therefore, it might affect to the location of raw data of this surveying.

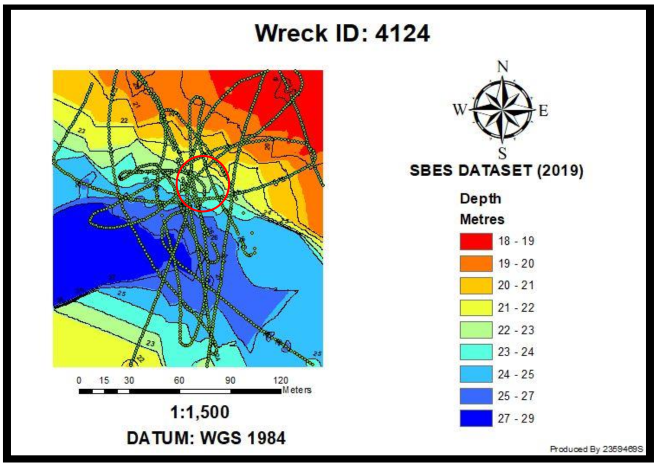


**Figure 8** The surveying track was over the shipwreck (Shipwreck ID: 4124)

After surveying, the surveyor conducted the quality test of the quality of SBES to check the difference in depth between SBES and Secchi disc. This quality test repeated the quality test for three times. Moreover, the surveyors checked Order 1b of the specific requirements (S-44) from IHO and found that the maximum allowable total vertical uncertainty was 0.5 metres of a and 0.013 of b [5]. According to the measurement in depth between SBES and Secchi disc, TVU was calculated by using the formula to confirm that the SBES met Order 1b. It was the result of the measurement between SBES and Secchi disc. The Order 1b of the specific requirements (S-44) was calculated to check the maximum allowable TVU (ibid). The result showed that the SBES met Order 1b of the specific requirements (S-44) in term of TVU because the differences between SBES and Secchi disc were within the maximum allowable TVU. Additionally, the accuracy of the SonarMite BTX/SPX Specifications is +/-0.025 metres (RMS). Therefore, the SBES also met Order 1b of the specific requirements (S-44) in term of TVU.

The measurement in depth between SBES and Secchi disc [5]

| Types / Times | SBES (Metres) | Secchi disc (Metres) | The Order 1b of TVU (S-44) (Metres) |
|---|---|---|---|
| First | 1.10 | 1.10 | +/-0.50 |
| Second | 1.05 | 1.00 | +/-0.50 |
| Third | 1.06 | 1.00 | +/-0.50 |

Furthermore, the maximum allowable Total Horizontal Uncertainty (THU) of the Order 1b of the specific requirements (S-44) was five metres plus 5% of depths. This SBES used the RTK Smartnet, which could limit the error within 0.02 metres in good satellite coverage, good geometry, and low multipath environments [6]. After the data was extracted using Leica Infinity software, the report showed the coordinate quality in three dimensions (CQ 3D) which were the indicator to represent the accuracy of the current RTK location in the x, y, and z-axis [7]. The CQ 3D was less than 0.025 metres while the CQ 2 D was less than 0.015 metres. Therefore, the SBES met Order 1b of the specific requirements (S-44) in terms of TVU and THU since the error of THU was within 6.10 (5+ (0.05*22)) metres. Then, the error of THU was not affected by 3.07 m. of SBES footprint because this error was calculated by many uncertainty sources such as all instruments, measurements, and environment [5].

According to Figure 9, the SBES dataset was collected from fieldwork and the map was generated by using GIS Software. Moreover, another map was generated by using SBES dataset from the UKHO (Figure 10) (ibid). Even though these maps had several differences, the overall feature was placed in the same direction. The contour lines and the feature of the river floor between these maps were likely to be similar, but the contour lines of Figure 9 were not smooth. These contour lines were not systematic because the contour line suddenly changed. It led to many errors in the depths of this map depending on the distance from the location of surveying data.

The surface in the template was affected from the nearest of the dataset. Therefore, the real depths would be different from depths of the IDW surface. According to Figure 7, there were some differences in contour lines because the locations of surveying datasets between these two maps were different. Moreover, the change in contour lines in Figure 9 came from a lack of information in some areas. However, these changing contour lines could be improved by making a line layout and the surveyors should keep the boat on the line. Thus, it could obtain the data to cover the survey area. Although the SBES dataset (2019) could not provide the high resolution of the MBES map, it could fill the gap and generate a map which was similar to the SBES dataset (1997) in Figure 10. Therefore, it might conclude that these two maps are different because the SBES dataset (2019) did not cover the entire area which led to the changes in the contour line.

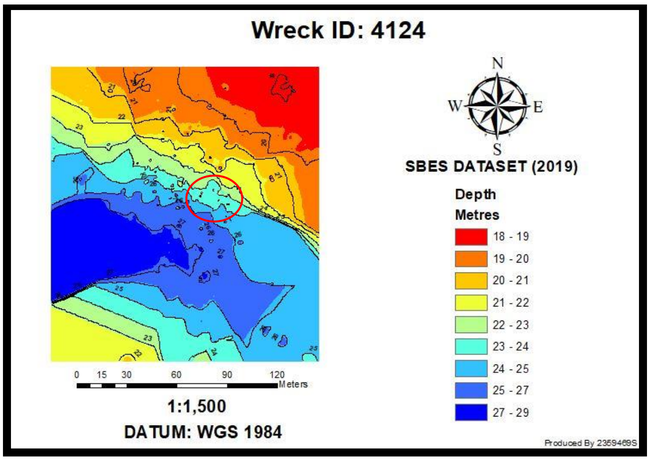


**Figure 9** The map of SBES dataset (2019) from fieldwork

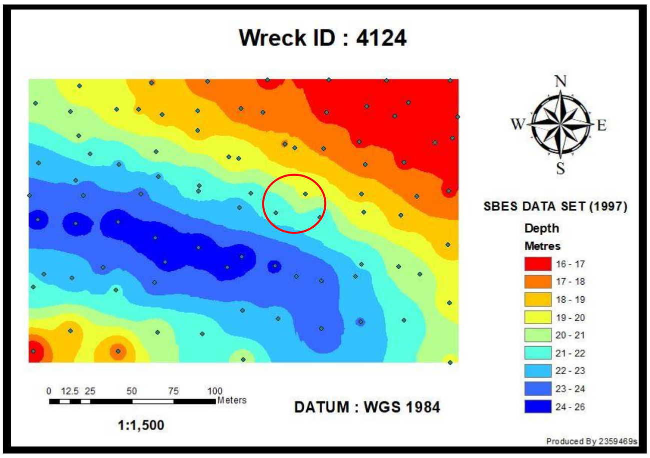


**Figure 10** The map of SBES dataset (1997) from UKHO (ibid)

Although the SBES dataset (2019) did not cover the entire area (Figure 9) and it might cause an error on the contour lines, the raw data over the shipwreck area was completely collected. Therefore, the shipwreck area (as presented in the red circle) of Figure 11 was similar to the area in Figure 10 However, the map of the SBES dataset (1997) from UKHO [3] and fieldwork could not identify the shipwreck (Shipwreck ID: 4124) on the surveying area. According to Figure 11, the red circle was over the shipwreck location. The location of the red circle was not from identifying the shipwreck from the map of the SBES dataset, but the location of the shipwreck was from the map of the MBES dataset. It might conclude that the maps from the SBES dataset from both UKHO (ibid) and fieldwork could not be identified in term of the location the dimension of the shipwreck.

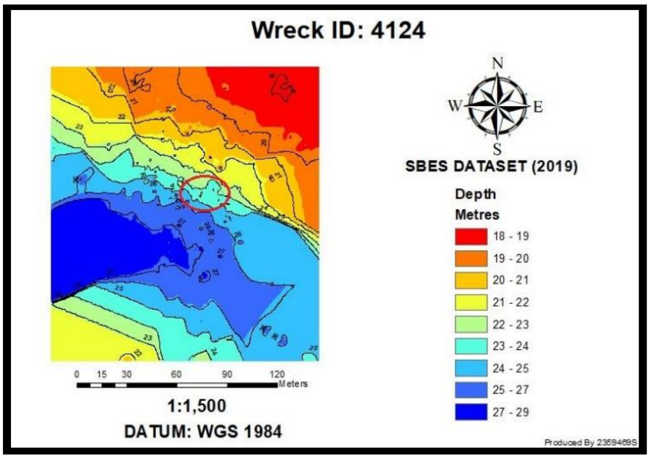


**Figure 11** The profile of shipwreck (Shipwreck ID: 4124) was in the red circle on the map

4.4 The comparison between MBES dataset (2014) from UKHO (ibid) and SBES dataset (2019) from fieldwork

The map of the MBES dataset (2014) from the UKHO [3] and the map of the SBES dataset (2019) from the UKHO (ibid) and fieldwork were compared and analysed the similarities and differences. Although the maps of the SBES dataset from the UKHO (ibid) and fieldwork showed differences in some points, the features of the river floor in these maps showed the same direction. Moreover, there was a similarity in several map features between the SBES and the MBES data set including the river floor, the direction of contour, and the depth. Even though the contour lines over the shipwreck area were not straight, these highly bent back and forth in the shipwreck area. Therefore, it might be assumed that many differences in the level of the shipwreck area might be a shipwreck (Shipwreck ID: 4124).

According to Figure 2, the location and dimension of the shipwreck were detected and measured by using GIS Software. However, the shipwreck in the red circle in Figures 7 and 10 could not identify the location and measure the dimension. Nevertheless, the SBES dataset (2019) might improve the quality of surveying by reducing the gap between line layouts to provide high resolution and detect more features of the shipwreck. Therefore, it might conclude that the shipwreck (ID: 4124) could be identified in terms of the location and dimension by using the MBES dataset (2014).

4.5 Analysis of SBES for the independent check of the shipwreck on the seafloor

The map from the SBES dataset still had gaps that limit the possibility to identify the shipwreck. However, the map from the SBES dataset could not identify the shipwreck in this research. The SBES dataset might be able to identify the larger shipwreck. As the SBES used one beam to survey and it led to a large gap between surveying lines. There were two methods to use SBES for surveying the shipwreck to gain a better result. The first one was to use the same space between lines, but it required surveying in the larger shipwreck than this research. Another one was to reduce the gap between the surveying lines to detect more features of this shipwreck. Therefore, it might be concluded that it should reduce the distance of the gap between surveying lines to detect more features of this shipwreck (Shipwreck ID: 4124). Although the result of this research showed that the SBES was unable to point to the location and measure the dimension of the shipwreck, the map of SBES could generate the map of the river floor and seafloor. This map of SBES could be similar to the MBES, but the SBES dataset could not provide the high resolution which was equal to the MBES dataset. When there were some changes on the seafloor, the surveyor would use the MBES to resurvey the seafloor in order to update the map on changing areas. Therefore, the SBES could not be used for identifying the location and dimensions of the shipwreck. Moreover, the surveyor was unable to use it for rechecking the shipwreck because there were many gaps between surveying lines. Furthermore, it could not provide the high resolution which might detect the shipwreck on the seafloor. Therefore, the SBES might not be suitable for identifying and rechecking the shipwreck on the river floor or seafloor.

## 5. Conclusion

This research aimed to use the SBES instead of MBES for rechecking the location of a shipwreck on the river floor. This research had five main points to investigate by using SBES dataset. However, it met the third objective because the map of SBES from fieldwork met the Order 1b of the specific requirements (S-44) from IHO. Therefore, the error of this map was within the Maximum Allowable TVU and THU. Additionally, it met the fourth objective to compare the maps of the MBES dataset and SBES from fieldwork. The result showed that the overall features and contour lines were quite similar. However, there were different points because the contour lines of the SBES map from fieldwork were suddenly changed. This change in contour lines resulted from missing information in the surveying area. Therefore, it led to the suddenly changed contour lines in that area. However, it was able to be used for rechecking the shipwreck on the river floor or seafloor. Although the map of the SBES dataset could not identify and recheck the location and dimension of the shipwreck, it might used for generating the map of the seafloor. The information from this research may be useful for several companies or countries which have responsibility for many important areas. Then these areas need to be surveyed by MBES to cover 100%. However, the SBES was still unable to solve the problem because SBES had many limitations which differed from MBES. Therefore, it could not identify or recheck the shipwreck on the river floor or the seafloor.

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