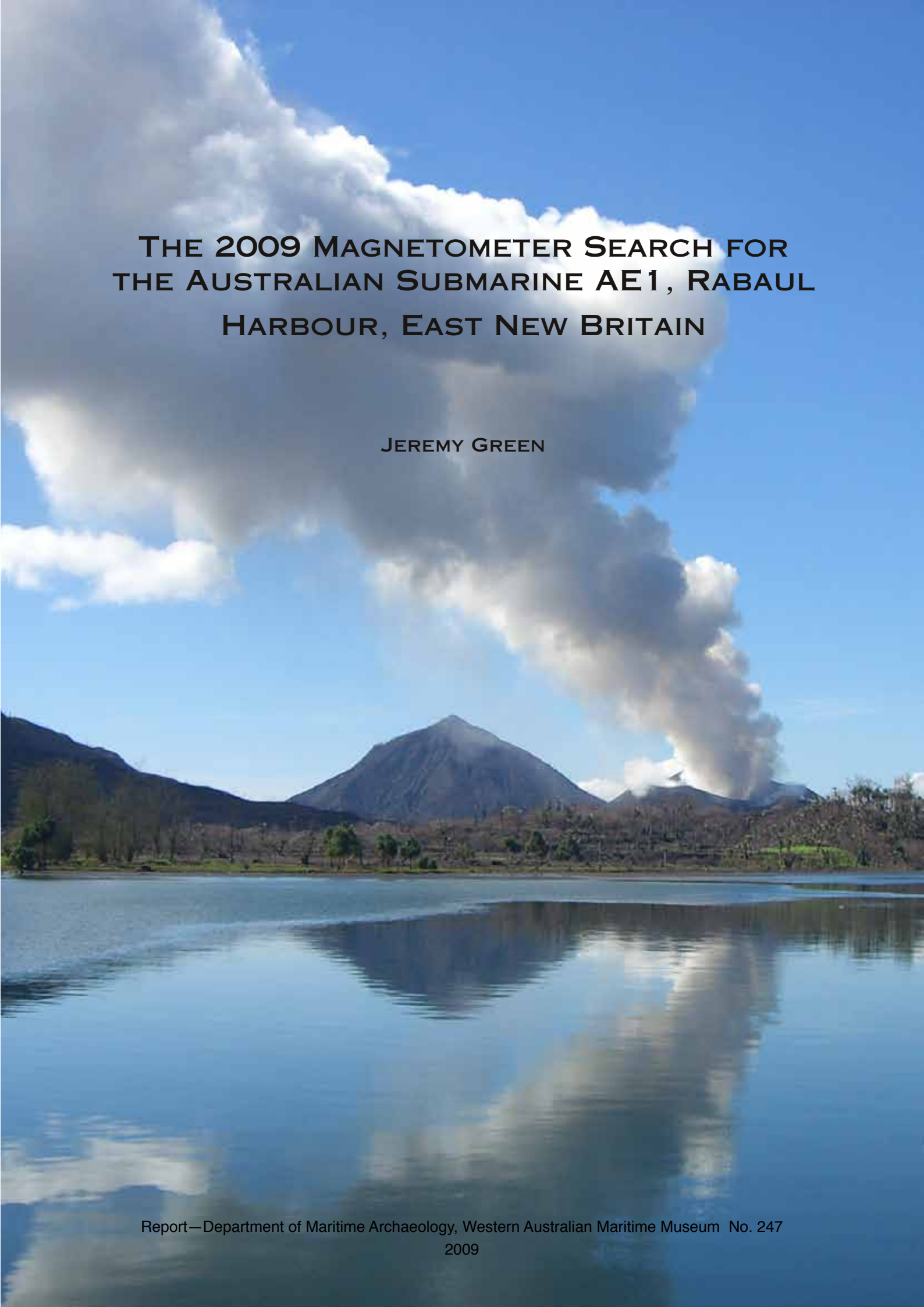

The 2009 Magnetometer Search for the Australian Submarine AE1, Rabaul Harbour, East New Britain

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Introduction

The 2009 search for the *AE1* was undertaken between 15 to 19 July and concentrated on a reported sighting of the AE1 in 1971 by George Tyers. Previously, in 2004, this author had conducted a magnetometer and side scan sonar survey in the Duke of York Islands as part of an on-going search by Commander John Foster (retired); this survey was unable to locate the *AE1* (Green, 2003). An area to the east been searched in 2007 by HMAS *Benalla*. The 2009 survey concentrated in a box Lat. -4.250953° Long. 152.165741° and Lat. -4.253298° Long. 152.170138° (Note all position information is in decimal degrees and chart datum WGS84; see Figure ??) in the entrance to Simpson Harbour. The NW corner of the search corresponded to the position of the *Keifuku Maru*, otherwise known as the 'Upside Down Wreck'. The original Tyers' report indicates he was anchored on this site and subsequently drifted off that site, hooking onto something else with his anchor. He subsequently had to dive to about 330–350 feet (101–107 m), to recover the anchor and reported that the anchor was snagged on a deck rail of a vessel. He later reflected that what he saw could have been the *AE1*. The objective of the magnetometer survey was to confirm the position of the *Keifuku Maru* and then search the box which extended from that wreck east and south.

Procedure

The system used to search for the site was to use a Elsec 7760 Proton Magnetometer, which provide a RS232 data stream of magnetic field intensity at a rate of 1 reading per second. This was fed into a MacBook Pro running Windows with a software package (SeaScan PC) that provided a visual output of magnetic field intensity and combined with a GPS position plotter. Thus the operator was able to observe both the magnetic field intensity trace and the track of the vessel in real time, enabling search tracks to be monitored and adjusted. The combined data (magnetic and position) was recorded in a data file. Post processing entailed producing track plots and magnetic field intensity contours shape files using Surfer 8. These were then incorporated into a GIS (Geographical Information System, ArcView 9.3) that allowed geospatial data to be examined.

The survey vessel, MV *Barbarian* was a 14 m steel vessel, which presented some problems because of its magnetic signature. As the magnetometer fish and cable was 30 m long, it was necessary to operate the magnetometer

at the stern of the vessel to keep the maximum distance from the ship's magnetic influence. This was not the best solution because it then became a problem in giving directions to the helm regarding course and lane spacing. Even in this configuration small heading anomalies were noted. More significantly, very large geomagnetic signals were observed in the area, while they were spread out over large areas they still presented problems in interpreting the information.

It is known that the AE1 had a displacement of 800 tons (submerged) and was 181 feet (55 m) long with a beam of 22 feet 6 inches (7 m). It is therefore possible to calculate the size of the expected anomaly using the Hall equation:

$$M = \frac{A}{B} 10^4 \frac{W}{D^3}$$

Where
M = Size of the anomaly in nano Tesla
W = Mass in tonnes
D = Distance between recording point and centre of mass of the object in metres

$\frac{A}{B}$ = Length to breadth ratio of the object

Assuming a L/B ratio of 7 and a mass of 800 tonnes and a reasonable detectable anomaly of 100 nT (given volcanic geomagnetism). This comes out at a conservative distance of likely detection of 82 m, (i.e. if the detector head passed over the top of the *AE1* in 82 m of water there would be a 100 nT signal). If the vessel passed 50 m off from the centre of the submarine there would be a signal of roughly 56 nT.

The location of the *Keifuku Maru* (the 'Upside-down Wreck')was determined with some difficulty because, not only were their geomagnetic anomalies in the general area, but it appeared that there was some remnant magnetism in the seabed, because as the depth changed, the magnetic field also changed, suggesting that the seabed was influencing the total magnetic field intensity. With careful survey over a small area it was possible to identify a magnetic anomaly that corresponded very closely to the last charted position of the *Keifuku Maru* on the Admiralty chart of 1963.

Depth issues

Three wrecks in the general search area are of interest, The Keifuku Maru (the 'Upside-down Wreck'), Kiesho Maru and Hakkai Maru. All

three wrecks are marked on the 1963 Admiralty chart AUS680 and on the 1997 chart which was post the 1994 eruption of volcano Kalamanagunan (Vulcan). The depth contours of the old chart were georeferenced and converted from fathoms to metres and the superimposed on the 1997 chart. Note the datum of the 1963 chart required GPS positions to be move 0.01' min S and 0.36' E to correspond with 1963 chart.

Conclusions

The search for the *AE1* was logistically very difficult, the search area had large geomagnetic anomalies which confused the magnetometer survey work. In addition the change in the depth of the sea bed in the area of the *Keifuku Maru* also made the survey work difficult.

There is no reason why the survey should not have detected the *AE1*. The anticipated magnetic target of the 800-tonne *AE1*, the magnification component of the large length to breadth ratio, would be seen as an anomaly on the slowly varying earth's magnetic field. There are, however, two complicating factors: the presence of the large geomagnetic field caused by the slightly magnetic volcanic ash and the influence of the nearby wreck of the *Keifuku Maru*. The rapidly changing depths, as one approaches the shoreline, appears to have caused a change in the magnetic field intensity, presumably because the ash is slightly magnetic and, as a result, as the range of the detector head to this mass decreases, the intensity changes. Additionally, if the *AE1* lies within the influence of the magnetic field of the *Keifuku Maru*, it could be difficult, if not impossible to discriminate between the two and their fields would coalesce as on anomaly. Thus, it is unlikely that the geomagnetic effects of the volcanic ash will mask the magnetic anomaly caused by the *AE1*, unless there is a remarkably odd situation. The *Keifuku Maru* wreck anomaly could, in theory, mask the *AE1*, but it would have to lie reasonably close to the *Keifuku Maru*.

Given the inconsistencies in the Tyers account, as outlined by Riley, the evidence suggests that the *AE1* is not in the search area. This conclusion is qualified by the fact that the magnetic survey in the area was extremely difficult and there is always a chance that the target could have been missed.

Alternative approaches to confirm this finding would include the use of a totally different system, such as sub-bottom sonar, or high resolution aerial magnetometry.

References

Green, J.N., 2003, The search for the *AE1*: magnetometer and side scan sonar survey Duke of York Islands, East New Britain, 22–28 November 2003. Report—Department of Maritime Archaeology, Western Australian Maritime Museum, No. 174.

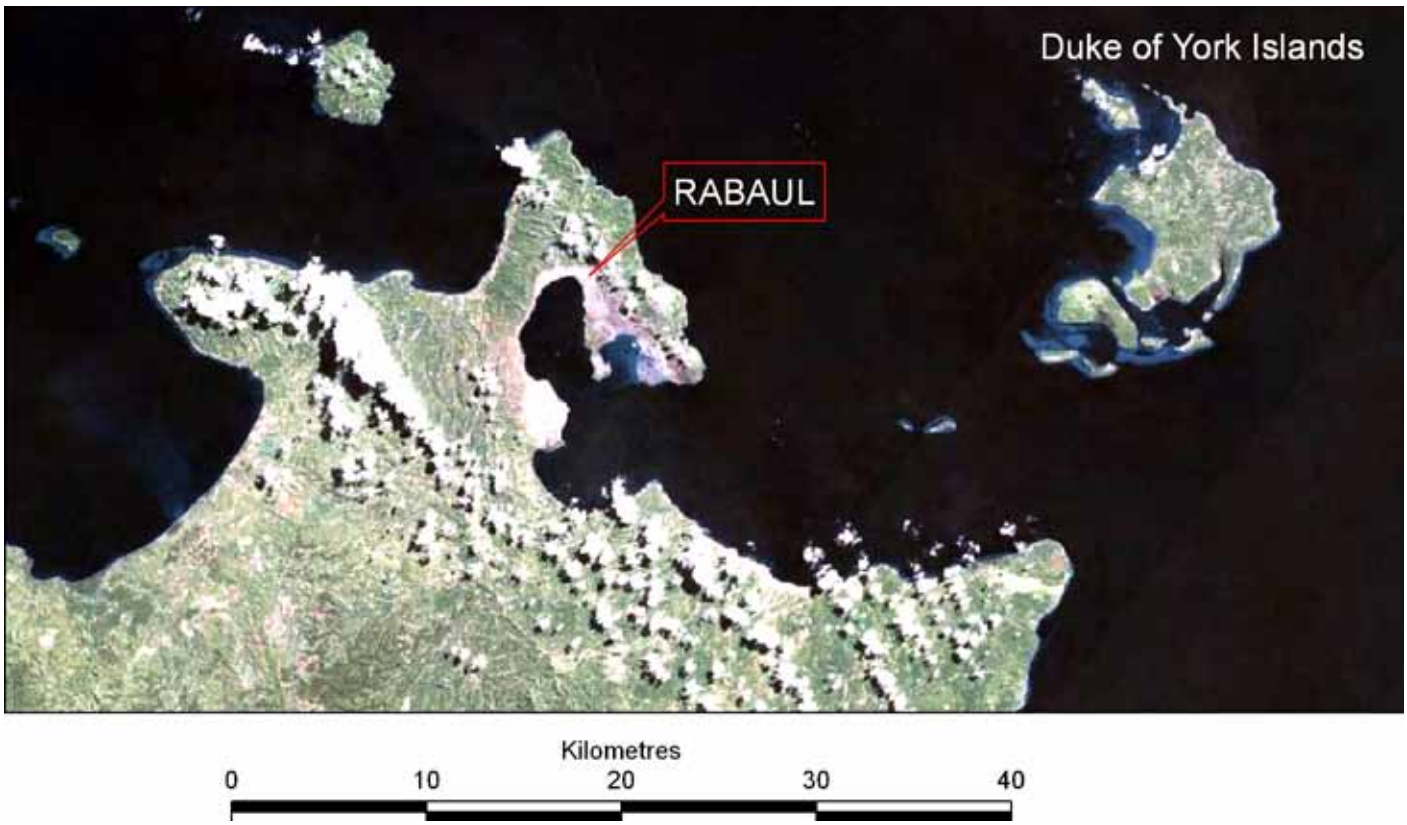

Figure 1. Satellite photograph of East New Britain showing the Duke of York Islands and Rabaul.

Figure 2. Google Earth picture showing Simpson Harbour and volcano Tavurvur erupting with the ash plume passing over the town of Rabaul.

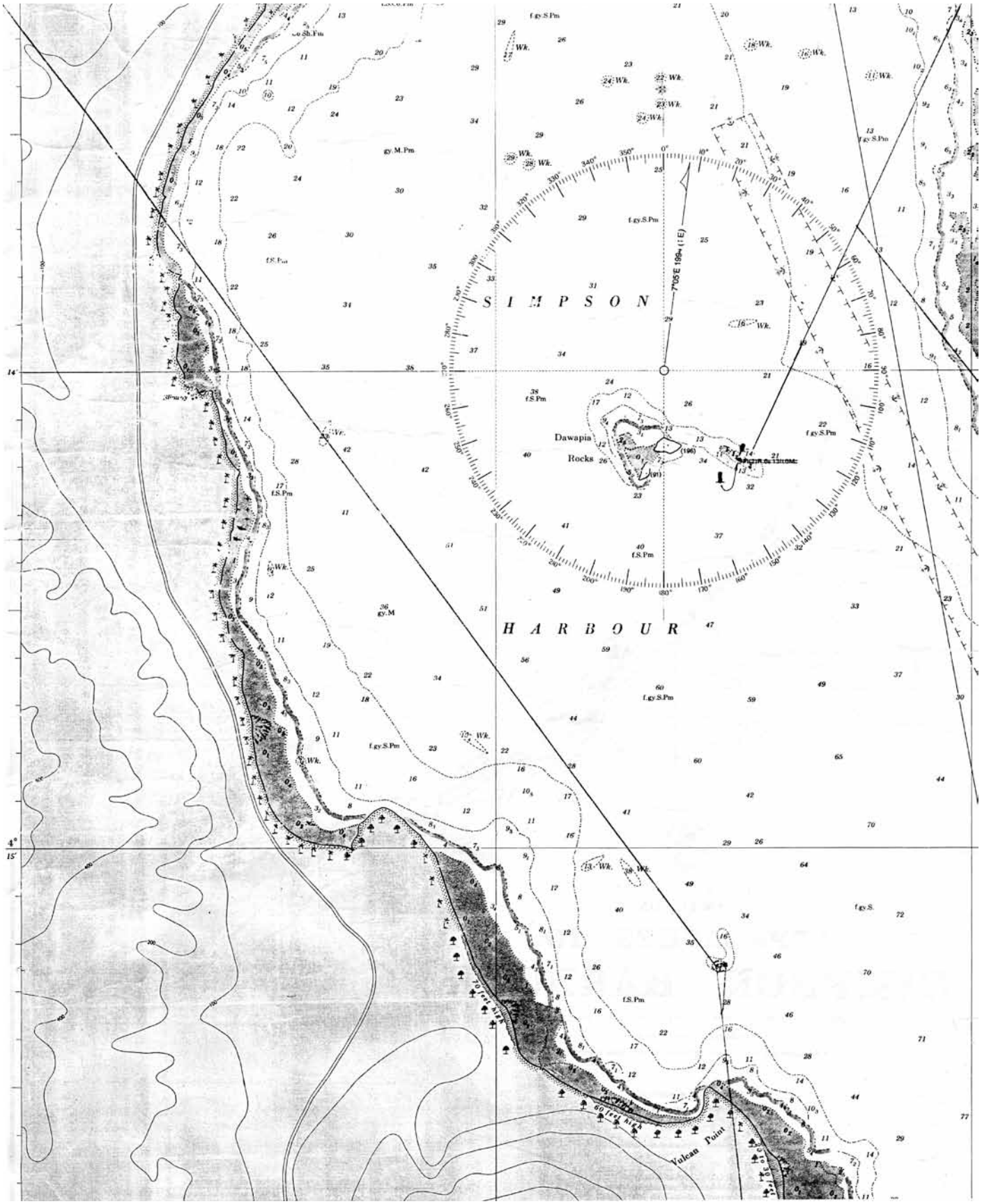

Figure 3. The 1963 Admiralty chart AUS680 (depth in fathoms) showing Simson Harbour. Note three wrecks marked in and around the center of the chart on the 4° 15' S latitude line.

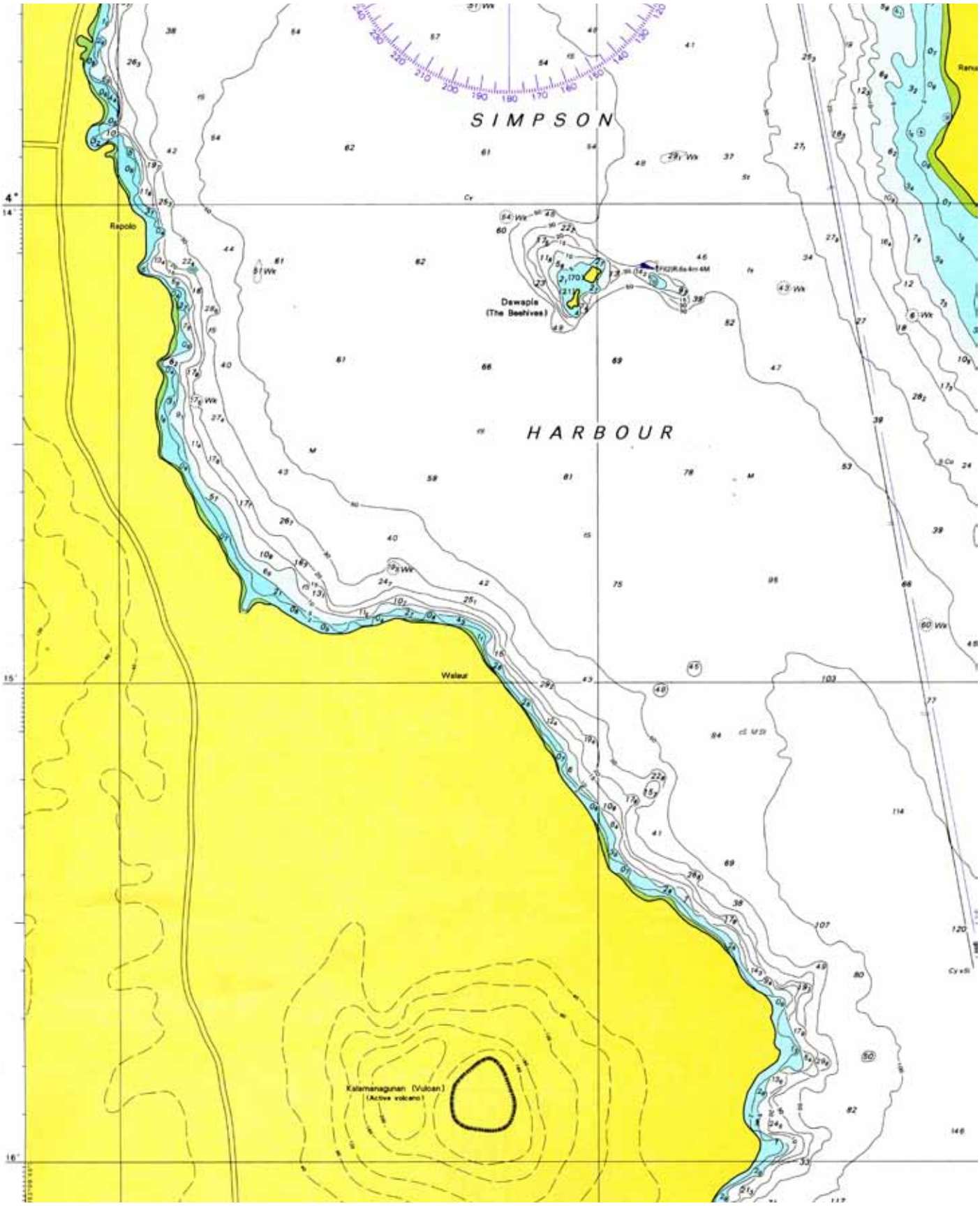

Figure 4. The 1997 Admiralty chart AUS680 (depth in metres) showing Simson Harbour. Note only one of the wrecks shown in 1963 chart is still visible.

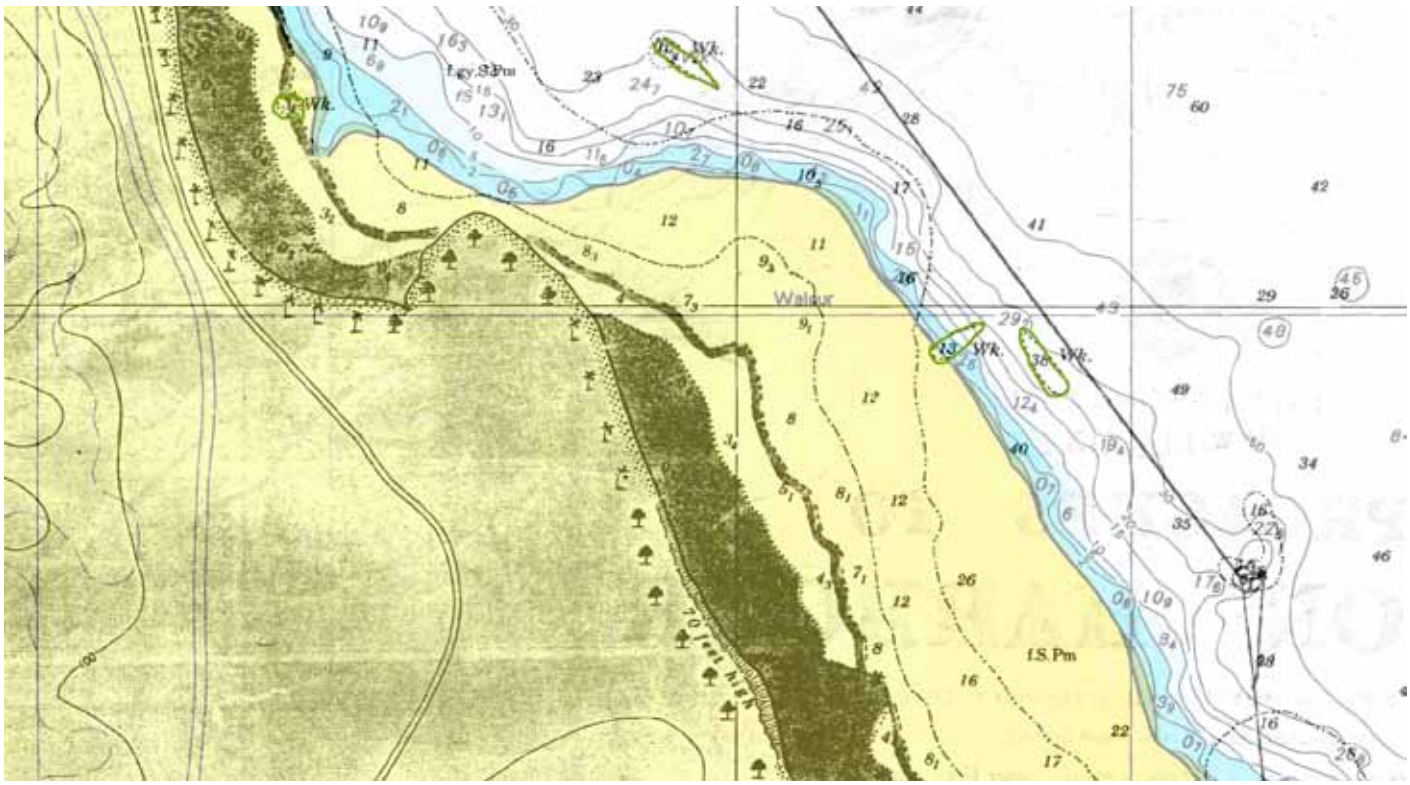

Figure 5. The 1963 chart superimposed on the 1996 chart. Note the wreck in 13 fathoms (38 metres) in 1963 is now partially buried under the low water mark, i.e. now buried under 38 metres.

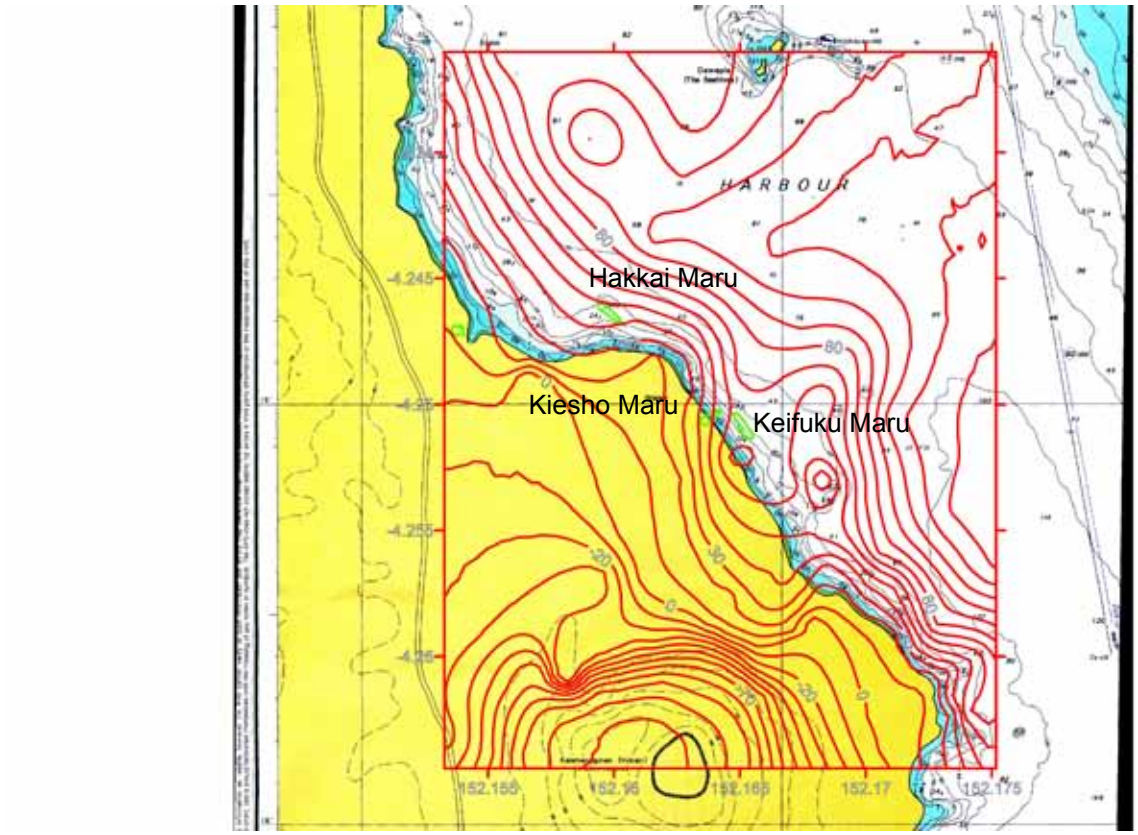

Figure 6. Georeferenced 1963 Admiralty Chart AUS9680 contours converted from fathoms to metres (red contours) superimposed on 1996 Admiralty chart. The wrecks of the *Keifuku Maru* (the 'Upside-down Wreck'), *Kiesho Maru* and *Hakkai Maru* are shown in green. The original shoreline is the zero contour, negative contours are metres above sea level.

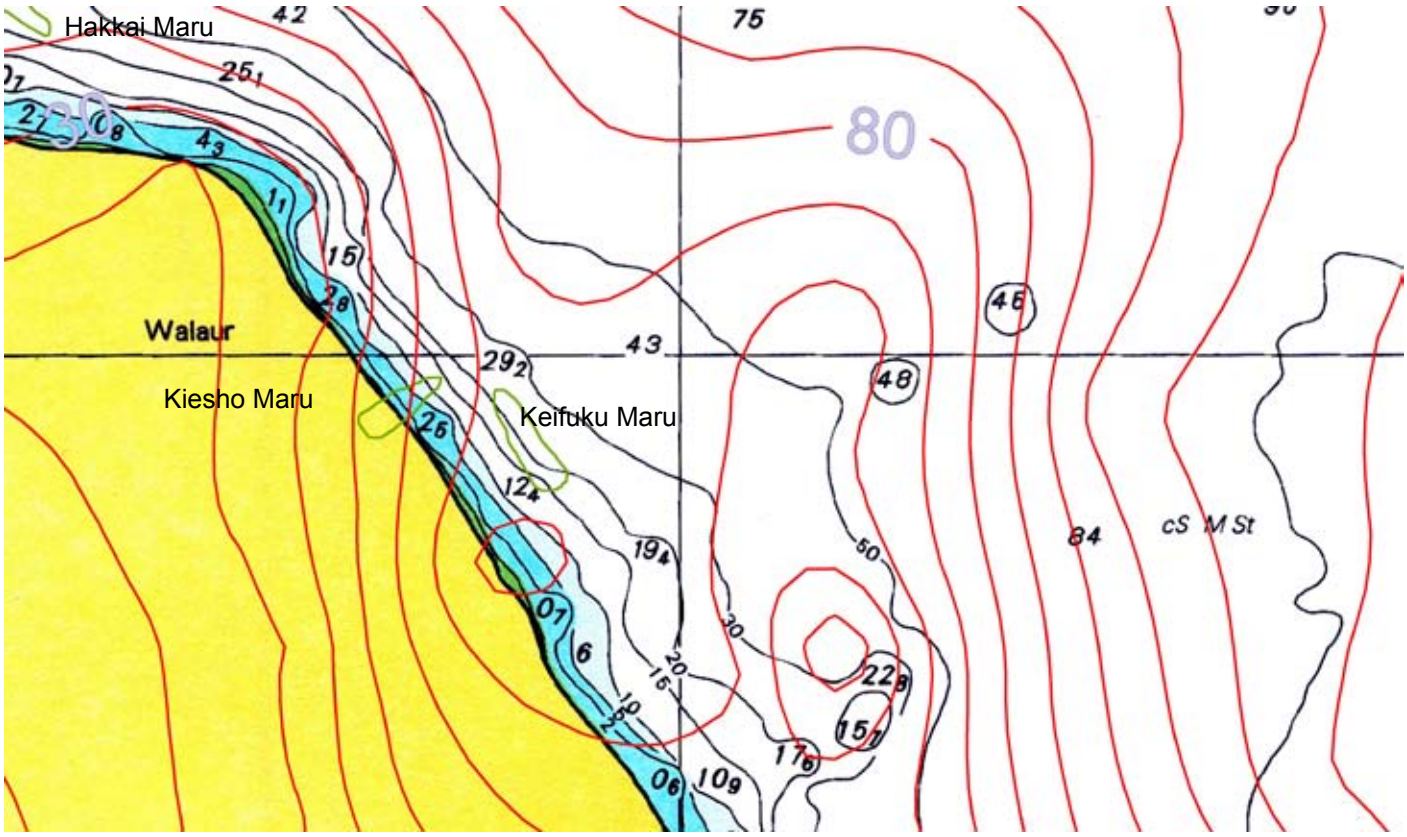

Figure 7. Detail of Figure 6 (opposite). Comparing 1963 depth contours (red) with 1996 depths (black) it can be seen that the seabed around the *Keifuku Maru* was 65 m (1963) and 20 m (1996), the seabed around *Kiesho Maru* was in 40 m (1963) and now 0 m (1996) and the *Hakkai Maru* was 45 m (1963) and 25 m (1996). This can also be compared with the spot depths on the wrecks in 1963 (*Keifuku Maru* 69 m; *Kiesho Maru* 24 m; *Hakkai Maru* 20m).

Vessel	Seabed depth 1963	Wreck depth 1963	Seabed depth 1996	Increase in depth
Keifuku Maru	75	69	20	55
Kiesho Maru	38	24	0	38
Hakkai Maru	42	19.5	30/19.3	12

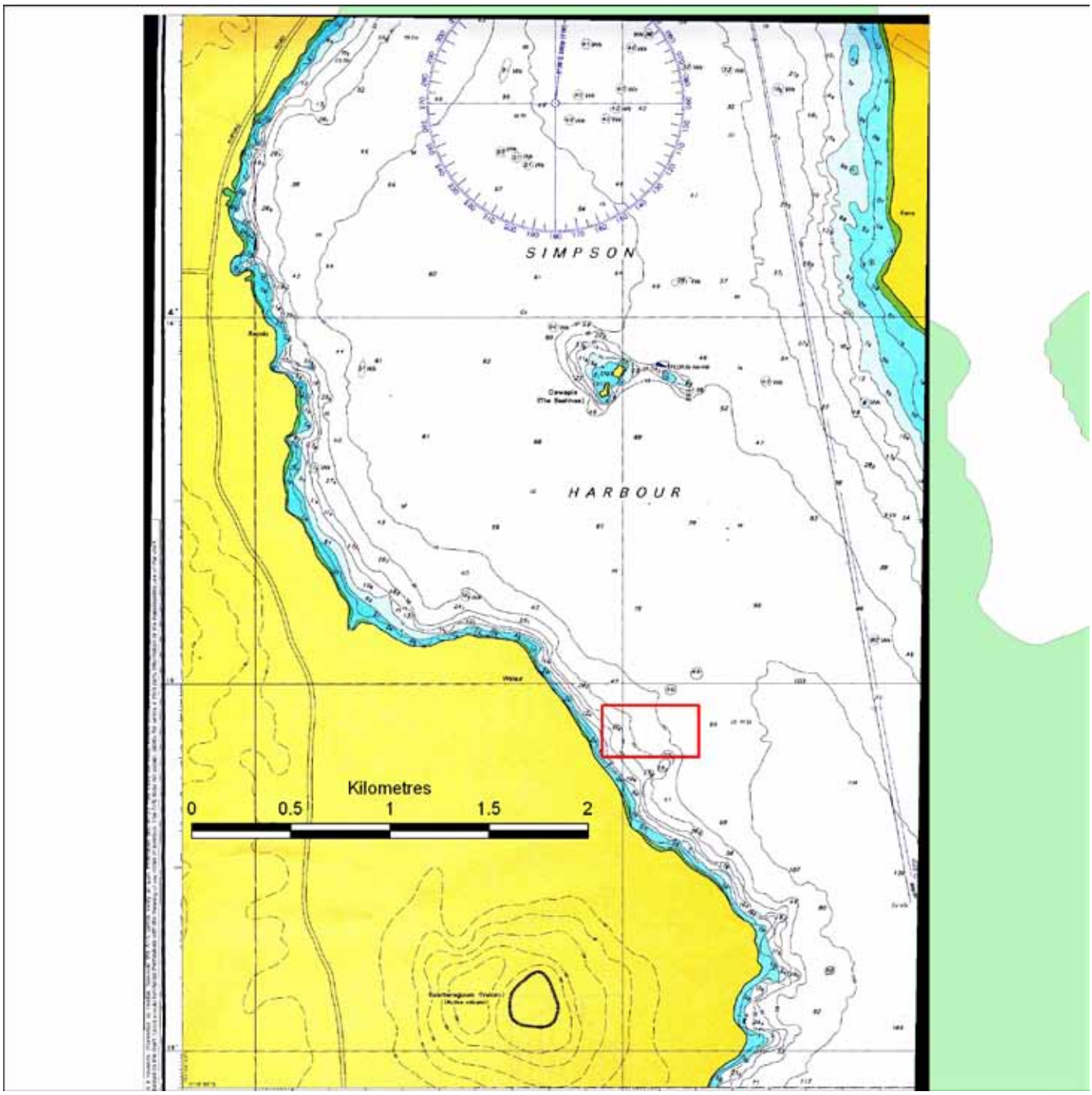

Figure 8. Plan showing proposed search area.

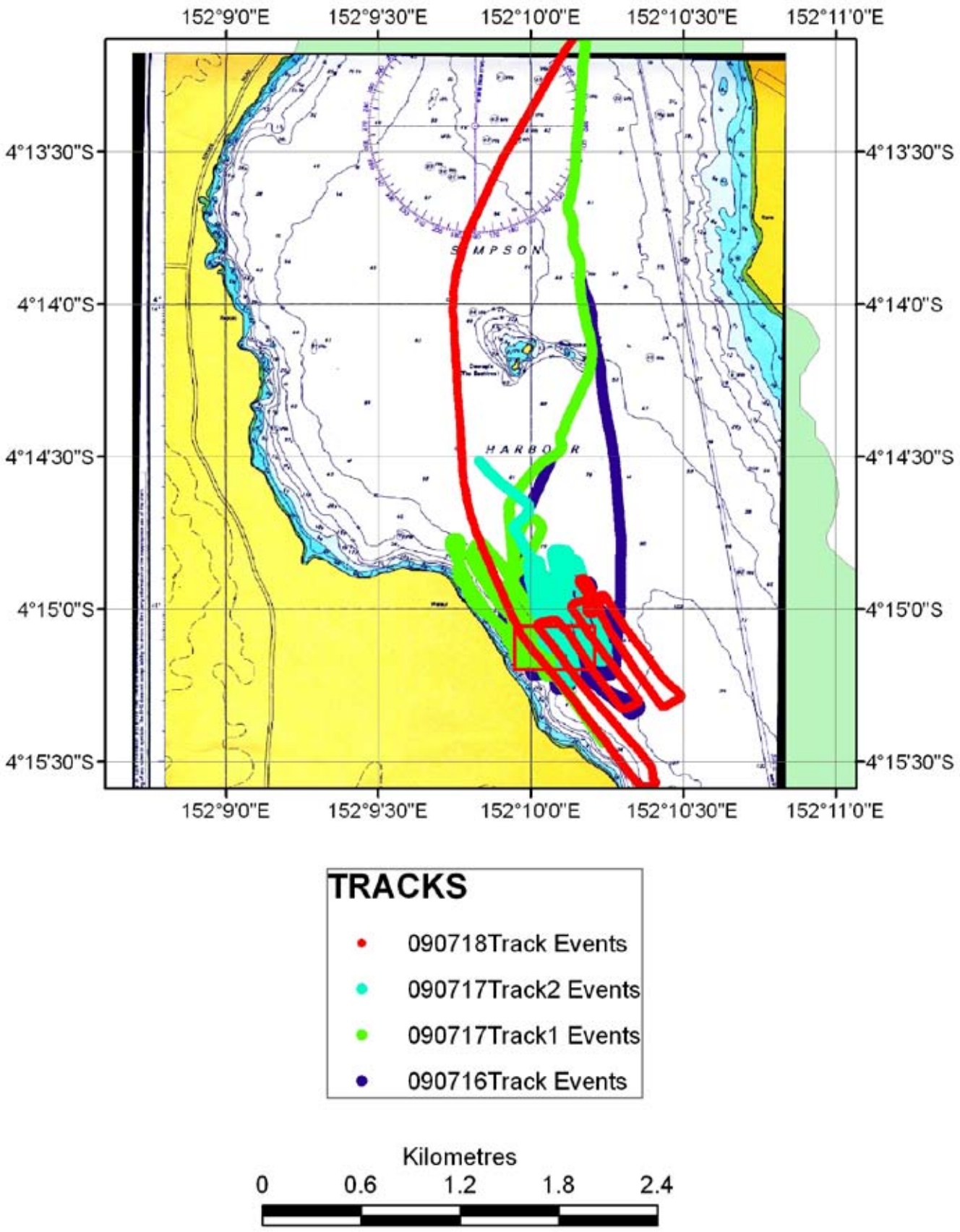

Figure 9. Track of survey vessel 16–18 July showing areas searched.

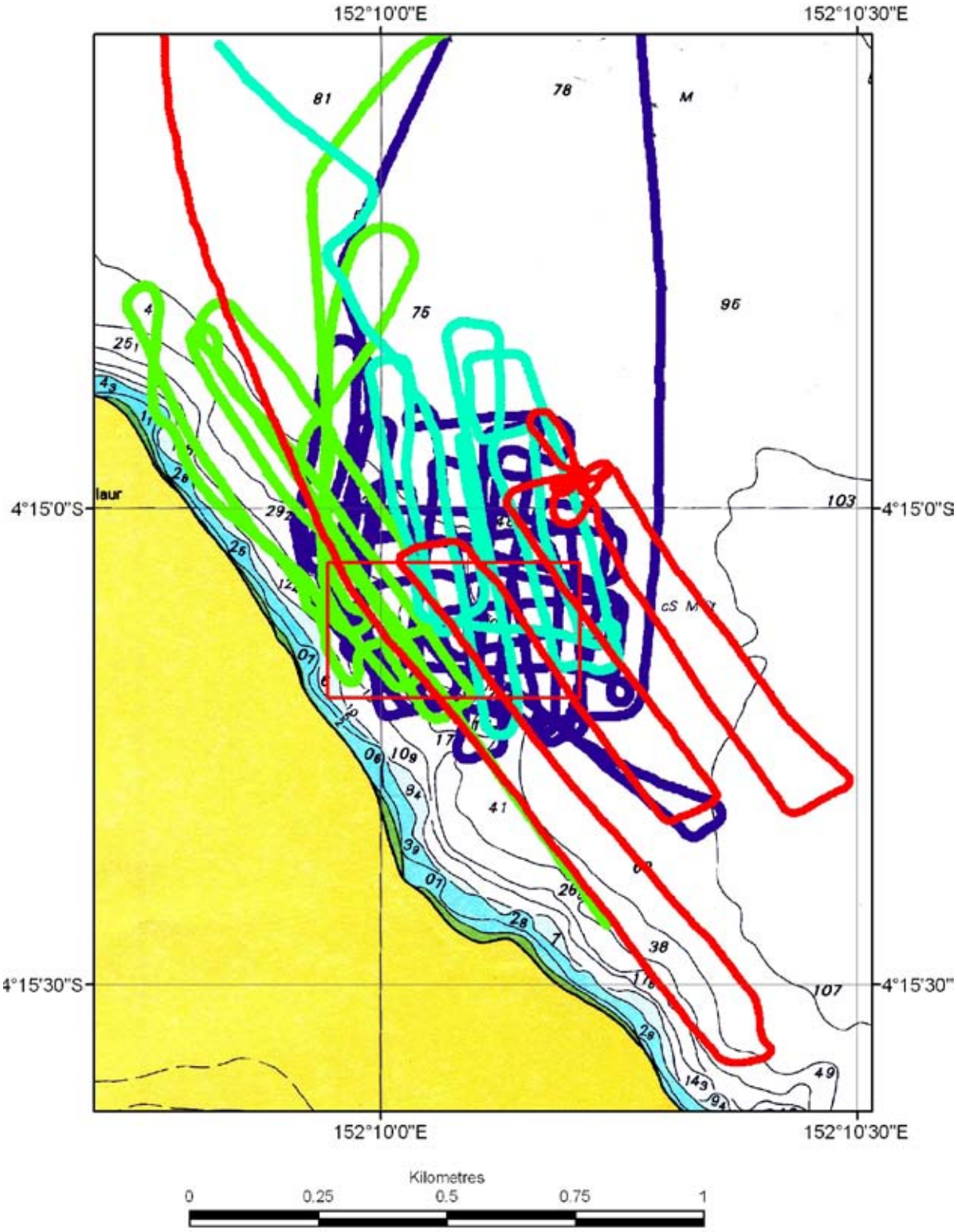

Figure 10. Detail of survey vessel's track and the search box.

Figure 11. Survey vessel MV *Barbarian* (Photo: John Riley).

Figure 13. John Foster (left) and Jeremy Green operating magnetometer on stern of MV *Barbarian*. Note relatively simple setup, with laptop computer.

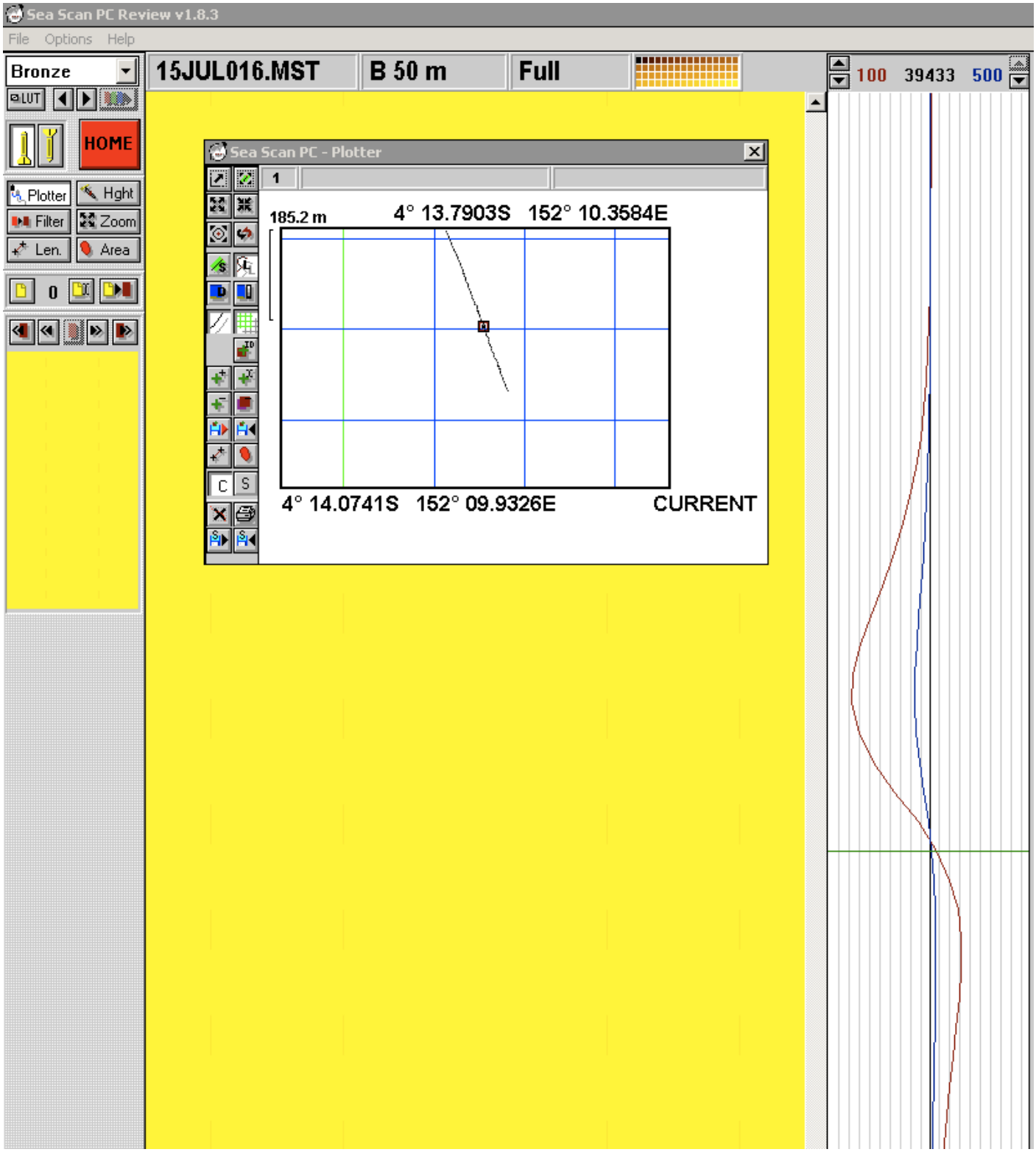

Figure 14. Screen grab of the SeaScan PC software showing basic interface.. On the right is the analog magnetic field intensity, red trace is 100 nT full scale deflection, blue trace 500 nT full scale deflection. The trace shows a typical geomagnetic anomaly.

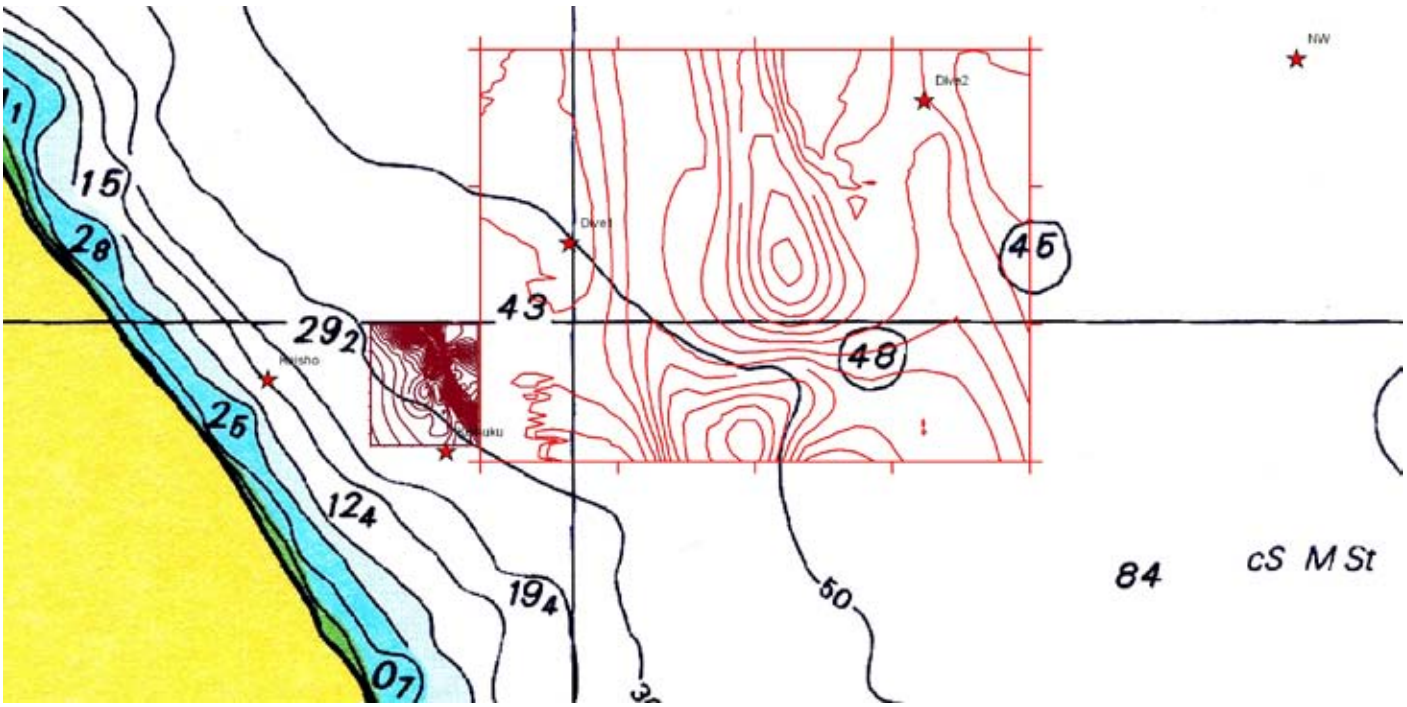

Figure 15. Two magnetic contour maps showing large geomagnetic anomaly (red, right) and small anomaly (left) corresponding to the *Keihuku Maru*.

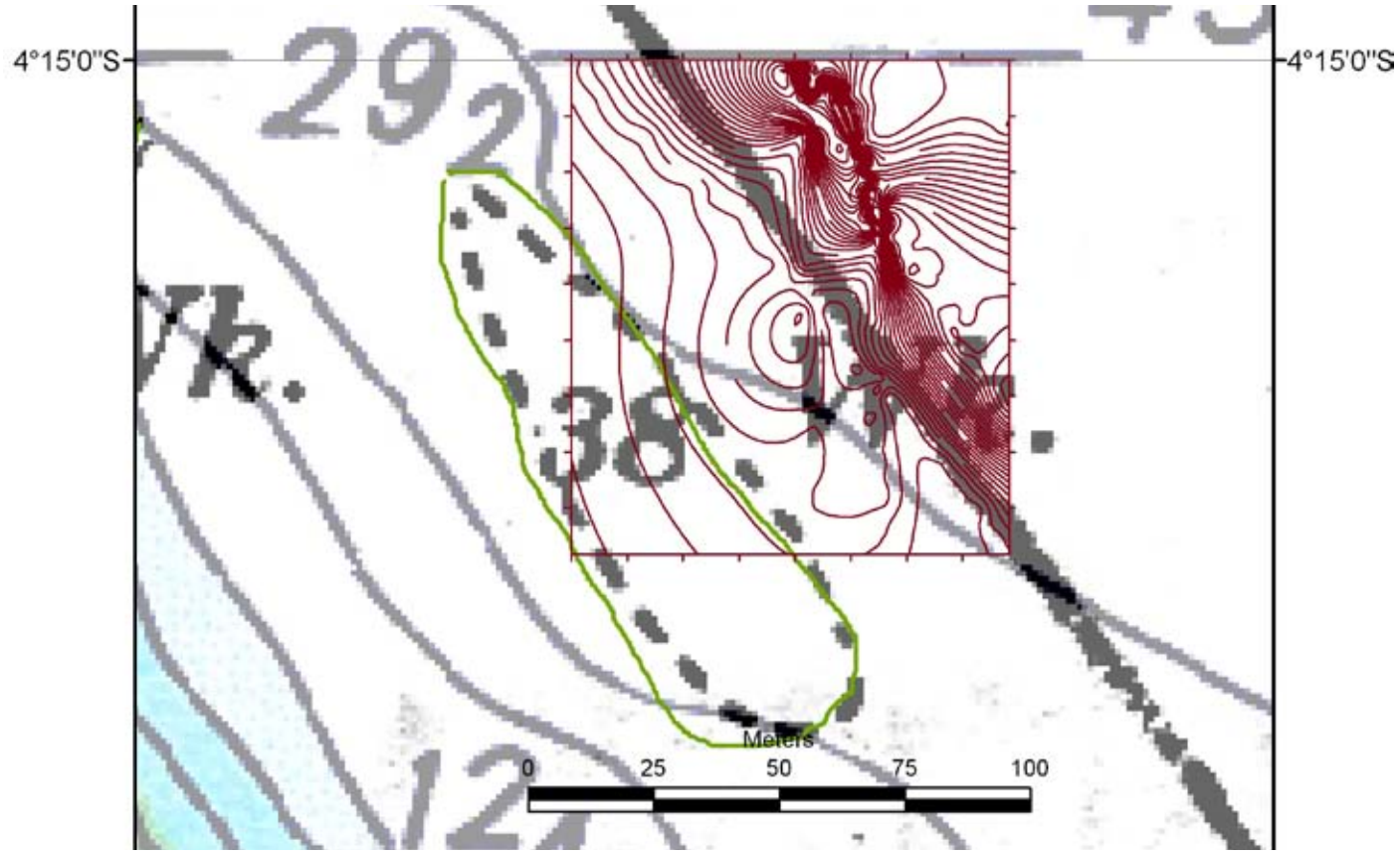

Figure 16. An enlargement of Figure 15 (above) showing magnetic anomaly not quite aligning with the 1963 charted position.

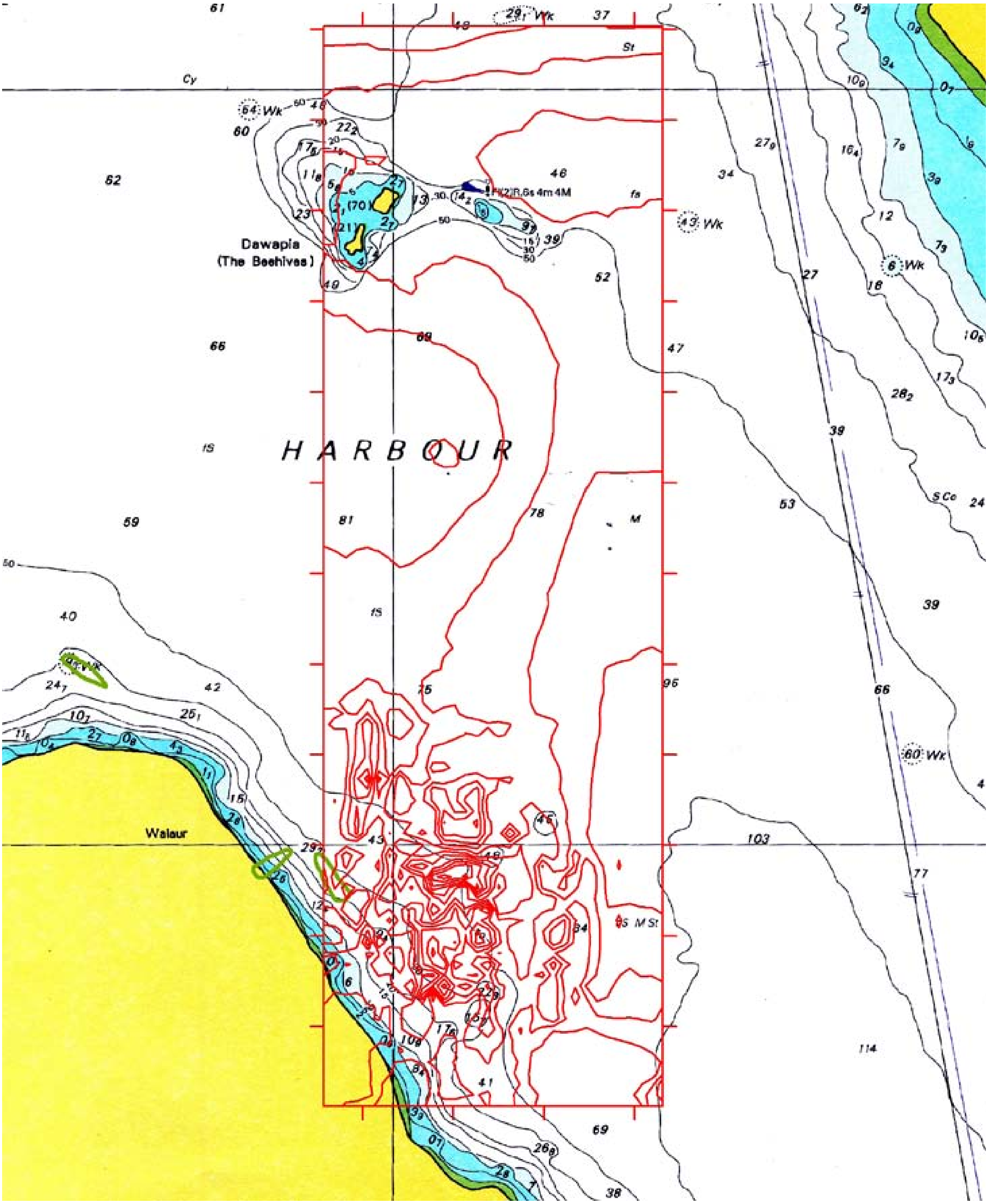

Figure 17. Overall magnetometer survey showing enormous variation caused by geomagnetic anomalies.

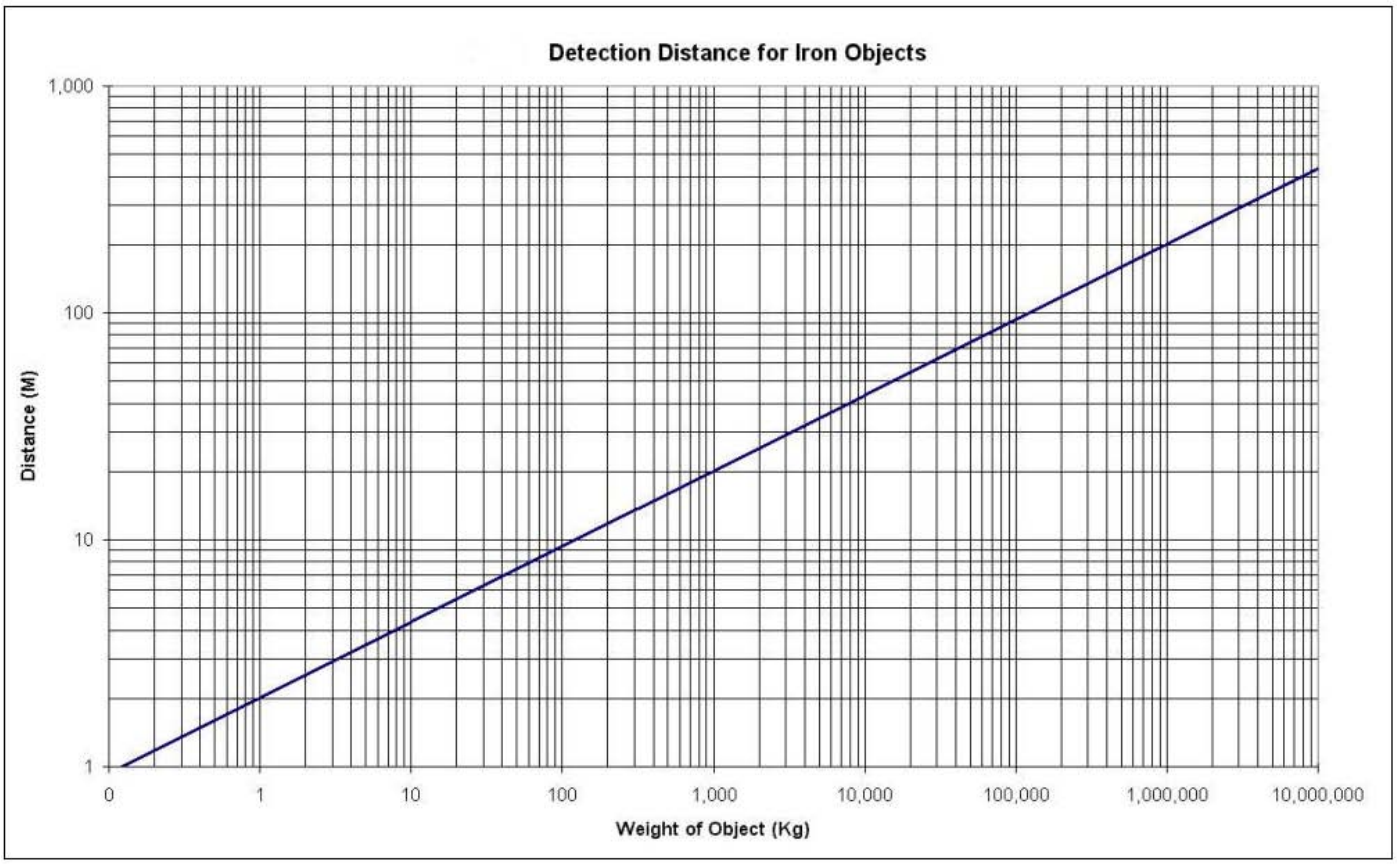

Figure 18. A plot of a normal detection range against size of magnetic target in kg. Note an 800 tonne object would be detected at 200 m on this scheme.