Figure 51: Hole in aft battery compartment in possible area of demolition charge. Note batteries and possible water heater in gap (Image: Venturoni 2015 Survey).

Figure 52: Panorama of Interior of *M24* Stern Battery Compartment. Note central longitudinal overhead rail at top and battery bays to either side. This is the approximate area of the aft demolition charge, and is comparable to the area shown in Figure 18 (Image: Panorama after Venturoni 2015 Survey).

Figure 53: Stern Battery Compartment looking through the battery bay bulkhead into the Control Room. Note Battery and Box on left. (Image: Panorama after Venturoni 2015 Survey).

i. Corrosion Survey and Cathodic Protection

A corrosion survey undertaken by Professional Diving Services in January 2015 using an ultrasonic thickness meter (Figure 54) and a corrosion meter unit (supplied courtesy of Vicki Richards - Western Australian Museum). This survey was undertaken after consultation with UXO experts and other heritage management specialists who had been dealing with similar sites [190] [191] [192] who advised that as it involved minimal invasive testing on the outside of the hull, there was a negligible danger of disturbing the UXO contained inside the submarine. This survey revealed that the hull of the vessel is currently very thin and is actively corroding. Hull thickness measurements were 8.1 - 8.4mm forward, 6.2 - 7.1mm mid ships and 5.8 - 6.4mm aft (Venturoni 2015). Unfortunately the corrosion survey of the wreck could not be completed as the corrosion meter accidentally flooded. With the permission of the Heritage Division and after consultation with the Japanese Consulate, an anode was installed on the stern section of the vessel in an attempt to reduce the corrosion rate across the site (Figure 55).

The ongoing active corrosion on the site has demonstrated the fragility of the wreck structure, which could potentially suffer a catastrophic collapse at any time, particularly if exposed to an intense East Coast Low storm event (which are regular events along this coastline).

This report proposes that full corrosion surveys of the site should be undertaken on a regular basis, with a view to eventual installation of a network of anodes around the site (if considered safe to do so). It is envisaged that a pod of anodes in a similar array to those used on the *AE2* submarine wreck site in the Dardanelles, Turkey [193] (see Figure 56) be considered as an economically viable and safe system for deploying this type of technology at this depth.

However, given the heavy swell and surge conditions in this area, the design of any anode pod would need to be reconsidered to ensure that the pod was of low enough relief to ensure it could not be knocked over in big seas. A flatbed array which would sit low on the seafloor would present the best design for these environmental conditions.

[190] **Elliot 2016;**
[191] **MacLeod pers comms 2016**.
[192] **Van Tilburg 2006**.
[193] **MacLeod 2015.**

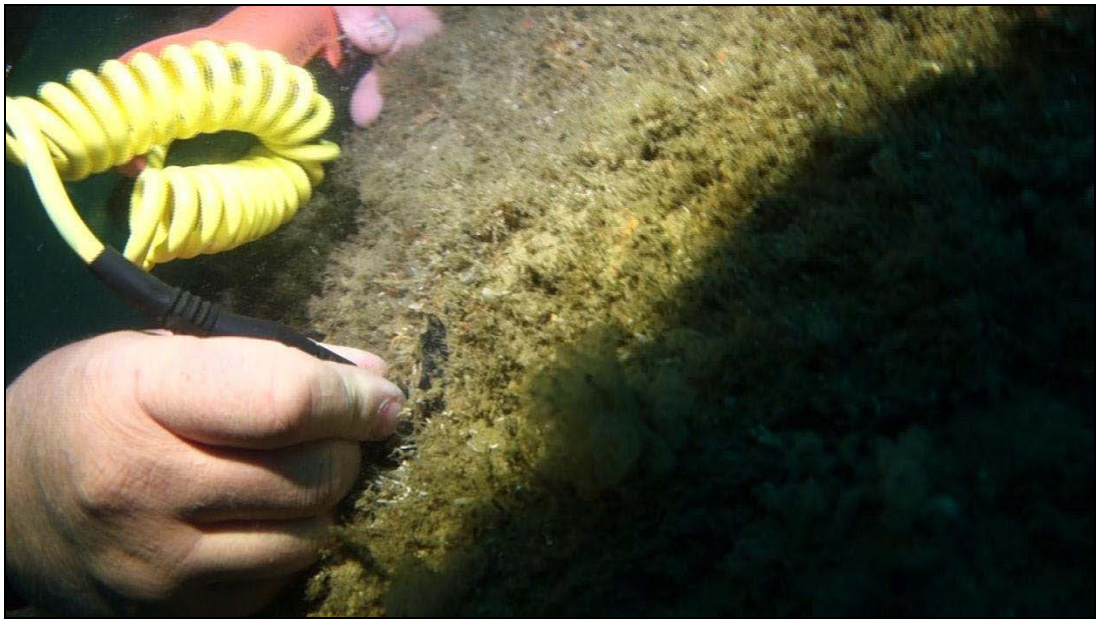


Figure 54: Diver taking ultrasonic thickness readings of the pressure hull (Image: Venturoni 2015 Survey).

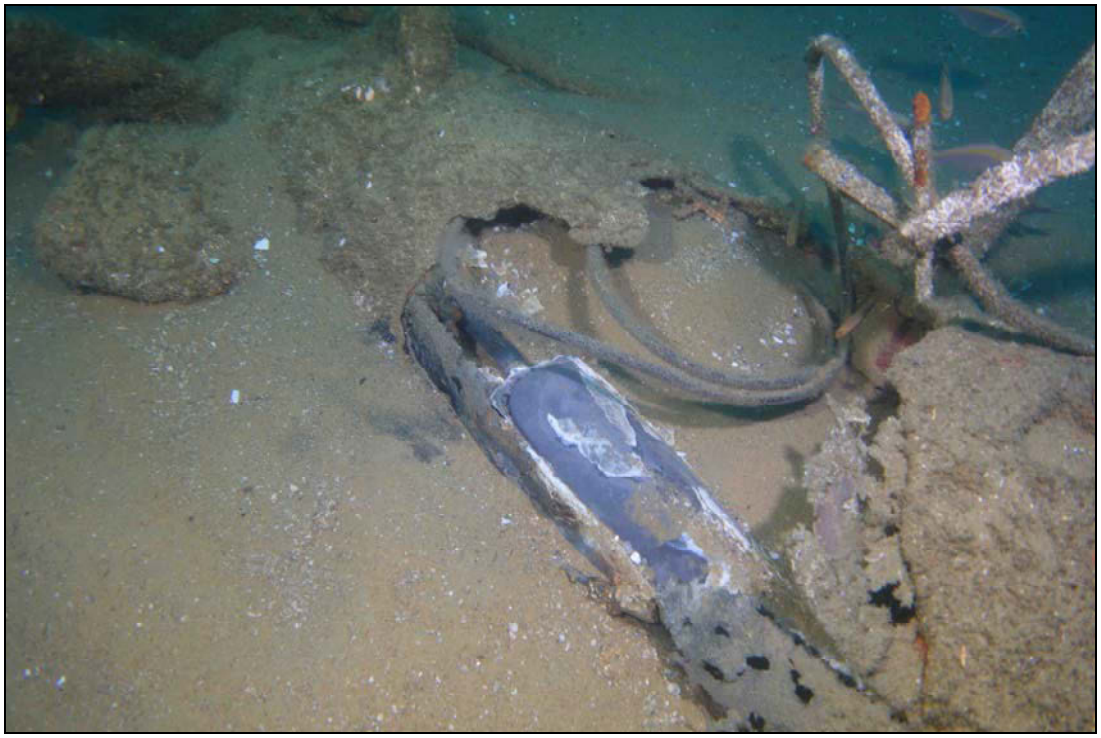


Figure 55: Anode placed inside the engine room compartment. Node silver anode in centre and attached cables and clamp on right (Image: Venturoni 2015).

Figure 56: Anode Pod deployed on *AE2* submarine wreck, Turkey (Image: After MacLeod 2015, Project Silent ANZAAC).

ii. Sediment and Water Sample Analysis

Dr Ian MacLeod recommended that a sediment sample be taken of the interior of the wreck in the after battery compartment to test for the presence of dissolved picric acid or picratic salt compounds, which could identify whether the demolition charges have leaked and the picric acid compounds have become stable. Furthermore, it could also be used to assess the toxicity levels present at the site, and the possible risk they present to divers.

In September 2016, after consultation with the RAN AUDCDT One and other explosives experts, water and seabed sediment samples were taken by Professional Diving Services, who had been contracted to service the Historic Shipwreck Protected Zone buoy and to inspect the wreck site. PDS reported that it was not possible to take sediment samples in the immediate area of the supposed location of the depth charge, due to an abundance of collapsed structure in this area and the ability to reach this position through the available corrosion opening in the hull.

The samples were collected from inside the rear compartment of the *M24* submarine to try to detect the presence of residual compounds of picric acid, but were taken between the battery bank and the hull (and not the main passageway), as a risk strategy so as not to disturb the area of the demolition charge. The sediment samples were shipped to the

Chem Centre at Curtin University, where the samples were analysed for traces of picric acid or associated compounds.

A report produced by Chem Centre, Curtin University (Appendix Three) [194] found no traces of residual picric acid in the samples taken. This does not necessarily mean that the demolition charge has not leaked. Possible scenarios are that:

- The demolition charge has leaked and the picric acid has fully dissipated from the surrounding environment;
- The demolition charge has leaked but the picric acid has not extruded from the canister;
- The demolition charge is intact.

Detata [195] suggested that given the period of time elapsed since the submarine sank that, as picric acid was partially soluble in water, it was highly unlikely that any picric acid would remain. This scenario is dependent on the length of time that has passed since the container flooded (if at all). This is consistent with observations of picric acid leakage from munitions in other wrecks (e.g. Royal Oak in UK) where Albright noted:

> *It is feasible that if the shells have corroded allowing ingress of water, which is very possible, the water will de-sensitise the energetic materials and in the case of picric acid fillings dissolve them as these are of relatively high solubility in water* [196]*.*

It may be possible to test for the presence of picric acid again in the immediate area of the demolition charge, but this work should only be undertaken by suitably experienced and qualified UXO experts, or archaeologists working under their direction, due to the potential for directly disturbing the demolition charge. It is recommended that discussions be undertaken with the RAN AUSCAT with a view to assessing their ability to incorporate these actions into the annual tasking activities.

[194] **Detata 2017 a**.
[195] **Detata 2017b: email David Detata to Brad Duncan 7 February 2017.**
[196] **Liddell pers comms 2012**, after **Albright 2012** p. 78.

7. RISK MANAGEMENT OF UXO SITES

a. Comparative Analysis of Non Disturbance Risk Management and Access to Wrecks Sites with UXO

In order to determine how the *M24* wreck UXO issue should be handled, other wreck sites with similar UXO risks were assessed both in Australia and worldwide.

i. Australia

The Northern Territory arguably has the greatest concentration of UXO on board ship and plane wrecks of any Australian state, as a result of the Japanese attacks on Darwin Harbour in 1942. Despite the presence of UXO on board many of these vessels (especially the *Florence D* shipwreck and USS *Peary*, both of which contain significant amounts of artillery shells, small arms ammunition and other ordnance), the Heritage Branch of the Northern Territory government has elected not to close these sites to diver access. The sites can be visited by the diving public on the basis that the divers should be aware of the UXO risks on board. In fact most of Darwin Harbour is littered with UXO and divers and fishers have been regularly and safely visiting these sites since the 1950s [197] [198]. This approach sets an Australian precedent for the management of wreck sites where UXO hazards are present.

Although there are a number of WWII Australian freighter wreck sites of Defensively Equipped Merchant Ships in NSW which are likely to contain ammunition for their gun defences and other states (e.g. William Dawes and Limerick), the UXO risks aboard these wrecks are not currently actively managed aside from marking their locations and the fact that they were carrying munitions cargoes, on Australian Hydrographic charts.

ii. International

Kimura [199], in their Report to UNESCO entitled *Research on Good Practice in the Protection and Management of WWII Related Underwater Cultural Heritage in the Pacific Small Island States and Territories,* have presented perhaps the most comprehensive consideration of how to manage shipwrecks with UXO present in the Pacific region. Their consideration of the management of UXO wreck sites in the Chuuk, Palau, Saipan, and Hawaiian Islands, where there are probably the greatest concentrations of diveable UXO wrecks in the Pacific region, have recognised the importance of identifying and reporting UXO on underwater heritage sites, but does not suggest closure of these sites. Instead they have advocated:

- a Diver code of Ethics for when diving these sites (Micronesia and Chuuk [200]);
- a "Recognise and Retreat approach which encourages divers to report the existence of UXO and a policy of non-penetration of UXO wreck sites (Hawaii [201]); or
- the active removal of, or sealing of UXO from underwater sites accessed by recreational divers [202].

Whilst the latter example recognised that there was a risk of UXO disturbance based on diver activity, it did not lead to closure of the site, but instead diver access guidelines were generated, which led to the introduction of a Tour Guide Certification Program and Manual

[197] **Steinberg pers comms 2016**
[198] **Steinberg 2015**:4.
[199] **Kimura et al 2015**.
[200] **Jeffery 2015**.
[201] **Van Tilberg 2015**: 21, 26.
[202] **Kimura 2015**.

for professional guides leading tourist access to the wrecks (Palau [203]). This approach recommended the publication of a summary booklet/ guide that explained the heritage values and UXO hazards of sunken WWII wrecks which should be used in conjunction with local diving industries to promote local tourism of these sites.

There are multiple international examples of ongoing successful public access programs to historic WWII wrecks where UXO is still present onsite. These sites are tourism drawcards for these areas, and as such essential economic factors for the local economies (e.g. Chuuk or Truk Lagoon, Guam [204]; Saipan [205]; Solomon Islands [206]; Palau [207]; Hawaii [208]) where shutting the site does not present the best economic option. These studies demonstrate that safe access to sites with UXO present can be achieved if safe management strategies are implemented.

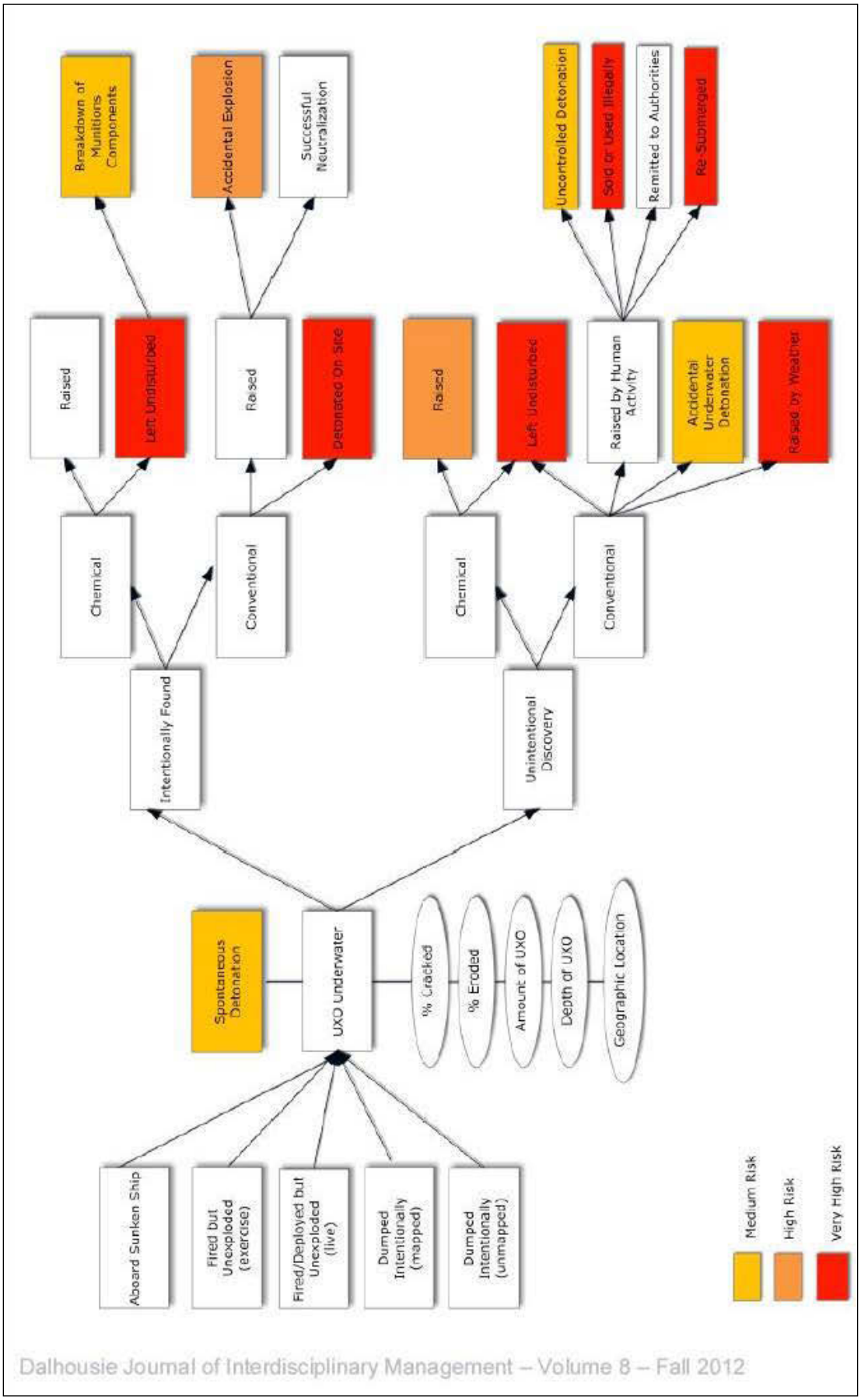
These approaches vary to recommendations for terrestrial battlefield sites or underwater UXO site mitigation (e.g. Francis and Alama [209]) where the focus is on safe land use or developmental planning use, where there is a greater risk of accessing sites through direct disturbance during planned works and subsequent relics collection. However, even in these scenarios, initiatives to provide greater public awareness of the risks and presence of UXO were key drivers and strategies for management of these types of risks, along with the safe removal of UXO where possible. These types of uses of UXO sites vary markedly from cultural tourism of underwater sites, where the prime focus is to visit and preserve the site.

b. Risk management of UXO on Underwater Sites

Aker et al [210] present a risk management pathway for mitigating risk on sites where UXO are located on underwater archaeological sites. Although they demonstrate that the consequence of a diver detonating a UXO is moderate (6 on a scale of 1 – 10), the probability is quite low (2), which leads to a risk factor of medium. Given that risk is usually managed within a Job Safety Analyses (JSA – the standard tool for managing risk in the workplace) and that even high levels of risk can regularly be mitigated through suitable risk management matrices, this level of risk to divers should be able to be mitigated through various factors including limited exposure of the diver to the risk and education of those risks. Given the depth and relative inaccessibility of the site, and the limitations of access to the site via a Permit system, the risk of a diver or boat unintentionally disturbing the UXO is limited already. Further reduction of risk onsite could be initiated by education of Permit holders before they access the site, and possibly by limited work to prevent access to the interior of the wreck.

It is also noted that the site is already displayed on Australian Hydrographic Charts as containing munitions, which further serves as a risk reduction measure by informing mariners of this hazard. This identification of the wreck was undertaken particularly to mitigate the accidental impact of large ships mooring over the site, and to mitigate percussion risks of potential explosions.

[203] **Kimura 2015**.
[204] **Kimura et al 2015**.
[205] **McKinnon and Carrell 2014**.
[206] **Gibbs, Duncan and Lawrence In Prep**.
[207] **McDonald 2016**.
[208] **van Tilberg 2015**.
[209] **Francis and Alama 2011**.
[210] **Aker et al 2012**:13.


Aboard Sunken Ship
Fired but Unexploded (exercise)
Fired/Deployed but Unexploded (live)
Dumped Intentionally (mapped)
Dumped Intentionally (unmapped)
Spontaneous Detonation
UXO Underwater
% Cracked
% Eroded
Amount of UXO
Depth of UXO
Geographic Location
Intentionally Found
Unintentional Discovery
Chemical
Conventional
Chemical
Conventional
Raised
Left Undisturbed
Raised
Detonated On Site
Raised
Left Undisturbed
Raised by Human Activity
Accidental Underwater Detonation
Raised by Weather
Breakdown of Munitions Components
Accidental Explosion
Successful Neutralization
Uncontrolled Detonation
Sold or Used Illegally
Remitted to Authorities
Re-Submerged
Medium Risk
High Risk
Very High Risk

8. RECOMMENDATIONS

a. Risk Management and Mitigation Measures of the *M24* Wreck Site

The presence of potentially unexploded ordnance (UXO) on board the *M24* midget submarine wreck requires careful management of the site.

It has been demonstrated above that it is possible to mitigate the risk presented by UXO on the *M24* wreck site from a number of perspectives. These factors include:

- Locating the UXO within the vessel;
- Identifying the type, volatility and toxicity of UXO;
- Preventing disturbance of/ exposure to the site;
- Prevent site deterioration.

After the expert UXO advice mentioned above, the following risk mitigation measures are recommended to protect anyone accessing the *M24* site:

- **Locating the UXO within the vessel**;

This report has identified the probable locations of all UXO within the *M24* wreck. It is probable that the demolition charges lies approximately amidships within the forward and aft battery compartments. The flare gun and Nambu pistol cartridges are likely to lie within the conning tower/ control room compartment.

- **Identifying volatility and toxicity of UXO**;
    - **UXO specialists**

The demolition charges aboard the *M24* have been identified by UXO specialists to represent the greatest risk of accidental explosion aboard the vessel. The flare gun cartridges are likely to be inert, and the Nambu pistol rounds are of low velocity and present little risk to divers. UXO specialists should be approached to inspect the site in conjunction with archaeologists to determine if any of the UXO charges are currently exposed, particularly in the aft battery compartment area, prior to any further exploration of the site.

Any proposed works at the site that could possibly disturb UXO should be undertaken only after consultation with appropriate UXO experts/ specialists.

- **Sediment samples**

Dr Ian MacLeod [211] recommended that a sediment/water samples be taken of the interior of the wreck in the after battery compartment to test for the presence of dissolved picric acid has already been actioned (as outlined above). During this assessment, a risk strategy was undertaken to ensure that sediment samples were only taken from spaces where which were well away from the known location of the demolition charge (e.g. in the spaces between the battery banks and hull) or using devices that minimised possible disturbance (e.g. using a slurp vacuum tube to suck in topsoil sediment from inside the hull). Although no trace of picric acid was found in the sediment samples, it may be possible that the sample was taken in the wrong location within the submarine, or that the picric acid has dissipated.

It is therefore recommended that additional sediment/water samples be taken in areas closer to the supposed location of the demolition charges. This additional work may identify whether the demolition charges have likely leaked and the Picric acid compounds have become stable. Furthermore, it could also be used to assess the toxicity levels

[211] **MacLeod pers comms 2016.**

present at the site, and the possible risk they present to divers. This work should only be undertaken by in conjunction with suitably experienced and qualified UXO experts (especially if direct disturbance of the likely UXO area is required/proposed) or by using a risk minimisation strategy that identifies areas which are unlikely to disturb the UXO charges. It is recommended that discussions be undertaken with the RAN AUSCAT with a view to assessing their ability to incorporate these actions into the annual tasking activities.

- **UXO expert inspections and advice**

Discussions should be instituted with the RAN and NSW Water Police to investigate the possibility of arranging regular visits and works at the site by the AUSCDT and Minehunter fleet and Water Police. These works could include participation in corrosion surveys of the wreck and the installation of an anode system (see below), along with regular monitoring of any unauthorised activity at the site. The RAN AUSCDT should also be approached to discuss the possibility of removal of the demolition charges IF the charges were ever exposed and could be accessed with minimal disturbance to the wreck. The removal of the demolition charge should only be considered if it can be accessed through current openings in the hull and does not disturb the contents of the submarine (i.e. the demolition charge is found on the surface). Note: It is imperative that the interior of the submarine is not disturbed due to the Japanese sensitivities of the site who consider it a war grave).

- **Previous disturbance of the site**

There is a very low probability that the explosive charges are still volatile, as demonstrated by the lack of an explosion during the likely catastrophic rolling of the wreck when it was entangled in a fishing net. However, it may be possible that the charges were not in an unstable state at the time of that event, and therefore the state of their volatility is currently uncertain.

- **Toxicity**

If the UXO charges have leaked, then there is a likelihood that toxic picric acid or subsequent compounds have leaked into the submarine's interior. Although the sediment sample (mentioned above) did not detect traces of picric acid, there is a chance that it may be detectable immediately below the probable location of the demolition charge. In order to prevent exposure to toxic compounds within the wreck, community diver access should be limited to non-penetration of the submarine's hull. Any access to the interior of the hull should only be approved to personnel with recognised skills and experience with UXO and/or under guidance following appropriate advice from these personnel. Any diver accessing the interior of the vessel under Permit (following consultation with the Japanese Government) should wear appropriate protective clothing (e.g. double gloves) when handling sediments from this area or use appropriate mechanical devices to prevent bodily contact with the sediments inside the hull. It is recommended that further testing of sediment samples taken in the immediate vicinity of the demolition charge are taken by suitably qualified UXO specialists working in conjunction with maritime archaeologists.

- **Preventing disturbance of/exposure to the site**:

  - **Advertising site Location**

The *M24* Historic Shipwreck Protected Zone Marker Buoy should continue to be maintained in this area as a warning to shipping and recreational boats that there may be active UXO present in this area. It is recommended that the surface marker buoy should be painted with a UXO symbol to warn mariners entering the area. The site is currently marked with UXO warning signs on Australian Hydrographic Charts. This will ensure that mariners do not accidentally moor or anchor in this area. However, given the dynamic nature and large seas experienced at this location (particularly during East Coast Low storm events), consideration should be given to investigating other methods for promoting the location of the site.

- **Education**

Info sheet/ site access guidelines for permit holders: The Heritage Division has developed an information brochure/ sheet on the *M24* wreck and UXO on site, outlining the hazards and risks of accessing this site (Appendix Four). This information will be issued with valid Permit approvals, and the Heritage Division will outline guidelines and conditions for accessing this and other shipwreck sites containing UXO. This should be issued to all successful Permit applicants prior to the Permit being issued.

All Permit holders should be advised that the site has potential unexploded ordnance inside the wreck and that no entry or tampering with the inside of the vessel is allowed under the conditions of the Permit. Similarly, issues of potential toxicity within the hull related to UXO leakage should also be addressed in the Permit and similar exclusion from accessing the interior of the hull should apply. An information brochure should be developed on this aspect for distribution with all Permit applications that are approved.

- **No mooring or anchoring**

The above guideline will also cover the risks associated with anchoring in the protected zone or mooring/ attaching lines to the wreck. Heritage Division should continue to work closely with the Australian Hydrographic Service to ensure the wreck site is marked as a Historic Shipwreck Protected Zone and also as a site containing unexploded munitions. The use of shot lines or dragging grapnel anchors to locate the site is forbidden due to the potential damage they can cause to the site.

- **Permit System**

Access to the site should continue to be restricted using a Permit system to enter the Historic Shipwrecks Protected Zone. This will reduce the number of people exposed to the risk of UXO at the site both through diving and anchoring/ mooring. Permit conditions should state that no hard weight shot lines can be attached to or dropped onto the wreck, and that any shot lines used off the wreck should consist of a soft shot (sand or ball bearing lead weights) and that these should only be used as descent/ascent lines.

- **Social significance of site**

The Japanese Government shall be included in consultation for any works to the site at the site (except routine maintenance of the Historic Shipwrecks Protected Zone marker buoy or the proposed anode system). The *M24* midget submarine wreck site has been recognised to be of international heritage significance, particularly to the Japanese community both in Australia and abroad. Despite the possible presence of live UXO on-board, no attempts to detonate, explode or render safe the demolition charges on-board (as has been suggested would be normal practice by the AUDCDT [212]) should ever be approved or Permitted by the Commonwealth Government or their NSW Delegate (administering the *Historic Shipwrecks Act 1976*), as the site is highly valued by the Japanese and Australian Governments, who considers the site to be a grave site due to the presence of the two submariners who are still inside the vessel. The site has been actively managed for over a decade in collaboration with the Japanese Government and community, who still seek the permission of the relatives of those on-board whenever visits outside of the Maritime Heritage Program are proposed.

- **No Penetration Diving unless by qualified UXO specialists**

Although it is probable that the canisters containing the demolition charges of explosive picric acid compounds inside the wreck have leaked, it is still possible (although not likely) that a risk of explosion/detonation could occur if the interior of the hull is disturbed.

[212] **Elliott pers comms 2016**.

Therefore any diving on site by the public should be restricted to visual activities undertaken outside the hull only.

Although not currently possible due to high levels of sand accretion within the wreck, no penetration diving of the wreck (except by approved qualified UXO specialists; or approved specialists after seeking their UXO specialist advice, and acting under permission/conditions of a valid Permit) should be permitted onsite. This will reduce the risk of disturbance of the UXO still contained within the site and will assist in preventing site formation processes changing the site over time. The social significance of the site must also be considered before any penetration diving is approved, and only after consultation with the Japanese Government. These conditions similarly apply to any penetration of the wreck using cameras or remote operated vehicles.

Consideration should be given to blocking access to the interior of the submarine in the aft battery compartment, possibly by placing sandbags or netting over this area, or filling the interior with sand (the latter would require sealing up external plate openings).

- **Excavation and disturbance**

No works that propose to disturb, excavate or raise the vessel should be permitted onsite unless prior investigations have shown that the UXO onsite are inactive, and this work should only ever be permitted following discussions with the Japanese government and community. This will reduce the risk of any unintended disturbance of the UXO and possible detonation as a result.

- **Maintain / upgrade existing surveillance**

The onshore surveillance camera system should be upgraded to incorporate increased telephoto capacity and night vision, along with automated recording of any potential breaches of the Historic Shipwrecks Protected Zone either onsite or via the web or mobile app. An alert mechanism should also be developed to notify the site managers whenever an unauthorised zone breach has taken place.

- **Long term monitoring of the site**

Long term monitoring of the physical integrity of the wreck is required in order to prevent and/or predict rapid catastrophic deterioration of the wreck site, which might result in the exposure, deterioration and/or detonation of the demolition charges. Furthermore, active monitoring also provides a check balance against unpermitted physical disturbance of the site by divers, anchoring or other environmental factors. These steps allow for preparatory works to conserve or prevent deterioration of the site.

- **Prevent further site deterioration**
  - **Ongoing corrosion surveys/ Installation of anode system**

The wreck site of the *M24* is actively corroding and in time is likely to experience catastrophic failure (i.e. total collapse), which will lead to the contents of the wreck (including the ordnance and the remains of the submariners) being exposed and/or strewn around the site (although there is currently no data to predict the likely timeframe of this occurring). If it is determined by suitably qualified and experienced UXO specialists that conservation works can be undertaken safely on site (see discussion below), then a project to undertake complete and ongoing corrosion surveys should be commenced ASAP at the site. These works are in anticipation of the potential installation of a pod of anodes being installed at the site (of a suitably modified design to those used on the *AE2* wreck site in Turkey). Anode installation will provide greater protection of the site through partial reversal of previous corrosion processes and will likely extend the life of the wreck by reinforcing its structural integrity. External funding sources should be investigated to potentially fund the anode installation project (e.g. DFAT Australia- Japan Foundation Grant Program).

Dr Ian MacLeod [213] has advised that the taking of corrosion measurement, especially when done in conjunction with the use of a battery powered drill, was unlikely to initiate an explosive event. MacLeod bases this advice on many similar surveys in Chuuk (Truk Lagoon) Micronesia, where corrosions surveys were often undertaken within a few metres of unexploded torpedoes and 10 inch shells in WWII shipwrecks (with due consideration of their proximity) and of the shells themselves [214]. He has further stipulated that the installation of anodes would most likely have a beneficial effect on UXO as they may retain proximity protection if close to an installed anode point, and the anodes themselves are likely to have negligible effect on the UXO themselves. CPO Shaun Elliott (RAN AUSCDT [215]) has also indicated that, in his opinion, it was unlikely that corrosion surveys or anode installation would be likely to initiate an explosive event if care was taken on site not to directly disturb the explosive charges.

These factors were also considered in regards to corrosion testing and anode placement at the *AE2* submarine site in Turkey (Turner 2007a; 2007b). To add surety, no corrosion testing was undertaken in the vicinity of the rear torpedo tube, which was the possible location of the remaining inboard torpedo.

- **Outcomes of Recommendations**

It is anticipated that the implementation of these measures should sufficiently reduce the risk of exposure to the UXO hazard aboard the *M24* to an acceptable level to enable visitation of the site under given specific Permit conditions.

Table Five (below) provides a summary of the potential risks and recommended mitigation factors for UXO aboard *M24* wreck.

[213] **MacLeod pers comms 2016**.
[214] **MacLeod 2016.**
[215] **Elliott pers comms 2016**.

Risk	Risk Assessment	Risk Mitigation Method
Exposure to UXO hazard	Locate the UXO within the vessel	UXO location identified through historical research
	Identify type, volatility and toxicity of UXO:	UXO specifications identified through historical research.
		Sediment samples to detect UXO system leakage and volatility.
		UXO expert inspections/guidance
		Assess previous disturbance of site
		• Determine if wreck has rolled - does this indicate UXO is inert?
	Preventing disturbance of/ exposure to the site	Education
		• Publicise site location
		• Info sheet/ Guidelines for permit holders
		• Guidelines for activities on UXO sites
		• Consider social significance of site
		Control Access
		• No mooring or anchoring
		• Permit System
		• No Penetration Diving
		○ Potentially consider sealing open sections of the wreck
		○ Interior access only for UXO specialists/ trained or authorised personnel or under supervision of the same
		• Maintain / upgrade existing surveillance
		○ upgrade camera to include night vision and web alert app.
	Prevent site deterioration	Ongoing corrosion surveys
		Install anode system

Table 5: Potential Risks and mitigation factors for UXO aboard *M24* wreck.

9. CONCLUSION

The evidence gathered to date provides certainty that the Sydney midget submarines had two demolition charges consisting of 67 lb (30.39 kg) each of Shimose Powder (compressed picric acid) explosives packed inside a steel canister for each charge. The archival records of blast damage in *Ha-14* and the historic photograph of the remaining charge in *Ha-21*, confirms that they are most likely located in the forward and aft battery rooms. The *Ha-21* photographic evidence also indicates that the forward charge was probably placed just aft of the midpoint of the forward battery room, under the netcutter connection point on the hull. It is possible the aft battery room had a similar configuration (i.e. a similar equidistant point from the Control Room Bulkhead - just forward of the midpoint of the aft battery room), although this has not been positively confirmed at this date. These demolition charges canisters were lashed to the passageway floors and had either safety fuse wicks for manual firing and/or electric connections to a dedicated power supply within each boat, and that an electrical timer may also have been used as an option.

Shimose Powder/picric acid compounds are highly volatile, particularly if the canister has remained dry or damp. Picric acid compounds can explode when subjected to disturbance or movement, and are also highly toxic. However, it is likely (although not guaranteed) that the canisters have failed either at the lid (where the fuses/ electrical cables join enter, and where a cardboard flange is located) or may have corroded due to contact with lead from the batteries in conjunction with seawater (if the batteries have failed or broken). Picric acid compounds exposed to full saturation and/or regular flooding by surrounding seawater are likely to be of lower volatility of possibly inert.

The archaeological inspections have confirmed the inability to view these two charges within the *M24* hull. The forward charge will be retained with the forward battery room, whose hull around the compartment is intact and sealed, thus preventing direct inspection, although it appears the hatchway to the conning tower is open, but is inaccessible by divers. The charge in the aft battery room is possibly in the area that is open to the sea at its forward end. However, the accumulation of sand deposits within the compartment means that the charge may be buried entirely (if it is still intact in this area). The current inspections did not find any visual trace of this device.

Without the ability to inspect and document the *M24* demolition charges, it is difficult to conclusively predict their current condition and the impact of corrosion to the canisters and explosives. Although it is likely that the demolition charges have probably failed due to flooding, (and thus decreasing the potential of explosive volatility) and that there is a low potential that the demolition charges are still volatile, this cannot be guaranteed.

Furthermore, even if the charges are inert due to flooding, the detonators used for igniting the charge may have deteriorated to a point where they are volatile, although their size is relatively insignificant. If the match/safety, electrical or percussion fuses have been exposed to seawater or perished, they are likely to have become inert over time. However, if the electrical detonator contained picric acid, and has remained waterproof, then the danger exists of increased volatility of the detonator, although this is unlikely.

Therefore any disturbance of the *M24* shipwreck, including corrosion testing of outer hull plates (e.g. especially by standard pneumatic drilling/ hammering or sample test sites to original bare metal fabric), should be restricted within the vicinity of the probable location sites. This would minimise any vibration/other effects that could potentially elevate the risk potential of these charges.

Furthermore, it is probable that ammunition from the Flare Gun (Very pistol) and service pistol are located in the control room compartment (based on the location of where the *Ha-21* Officer committed suicide). The ammunition from these pistols is likely to have degraded over time, and do not present a high risk to personnel at the site.

There is no UXO risk presented by explosives or inertia pistols associated with torpedoes at the site, as both torpedos were fired during the Battle of Sydney, and no spare parts for the explosive mechanisms of the torpedoes were likely to have been carried within the submarine's crew compartments.

In summary, the possible explosive devices carried aboard the submarines included:

- 2 x Scuttling explosive charges (Shimose Powder/ Picric Acid), which may include two 50 ft (15m) lengths of gunpowder cotton fuse (located in the forward and aft battery compartments);
- Personal service semi-automatic pistol and cartridges (likely to be located in the conning tower or control room);
- Flare Gun (Very pistol) and cartridges (likely to be located in the conning tower or control room);

A risk minimisation matrices was also presented which places the risk of accessing the site as moderate if preventative steps are taken to avoid disturbing the site. These management steps reduce the potential risk posed to divers and mariners to an acceptable level if the submarine is not disturbed.

This report has also provided recommendations for the management of and future works at the site, which include ongoing Permitting of entry to the site, closer collaborative management of the site with the Japanese Government and RAN, and installation of an anode system to slow down/ reverse current corrosion levels onsite.

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APPENDIX ONE: 3D Photogrammetry Scan of Interior of Forward Battery Compartment of *Ha-14* at Australian War Memorial 2016.