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**Title:** Preserving a layered history of the Western Wadden Sea: managing an underwater cultural heritage resource
**Date:** 2017-12-12
5. How do we physically protect underwater heritage sites in situ?

Fig. 5.1 Artificial seagrass mat lowered down to the BZN 10 site. Photo: Paul Voorthuis, Highzone Fotografie.
5. How do we physically protect underwater heritage sites in situ? ¹

5.1 Introduction

After gaining an understanding of the deterioration processes occurring on site, as well as the execution of a baseline study on the condition of a site and the formulation of reasons for protection (including what values prevail), measures to mitigate degradation can be taken. These measures are always a compromise between (1) the archaeological or other value of the site, (2) the reasons we want to preserve it, (3) the expected effects of the mitigation strategy, (4) the time span over which it has to be effective, (5) the effect on the local environment and (6) the resources required. When we talk about in-situ preservation, we usually mean sites that are protected in their original position and context, preserving and protecting their current condition and archaeological integrity as long as possible or needed. However, it is obvious that techniques used for reburial of underwater sites post excavation should also be included in an evaluation of the different methods that are and can be used for in-situ protection.

Ongoing monitoring of a wreck site is a critical component of the overall conservation management plan and one way to investigate the effectiveness of the in-situ conservation measures taken. This should be taken into consideration before deploying any in-situ protection methods. Unfortunately, it is often the case that when shipwrecks are protected in situ, little, if any, subsequent monitoring to determine the effectiveness of such techniques is undertaken. A holistic approach to the study of the environment pre- and post-burial is necessary to gain a full understanding of the changes occurring in the local reburial environment. This information allows accurate assessment of the success, or otherwise, of the mitigation strategy in relation to the long-term preservation of the wreck site.²

In-situ conservation of underwater sites has increased considerably since the 1990s.³ The first serious attempts were already made in the 1980s, also in the Western Wadden Sea.⁴ The techniques used have ranged from the relatively simple depositing of extra layers of sediment and/or sandbagging a site, to more complicated techniques that promote the natural accumulation of sediment on a site and the construction of artificial mounds in several layers.⁵ These techniques will be described below. I will first discuss the three different ways of physically protecting sites in situ in Section 5.2, followed by a discussion of reburial in Section 5.3. Then, in Section 5.4, the protection of a single object or site in comparison to the landscape approach will be discussed, followed by the complex issue of protecting well-preserved sites in Section 5.5, how to choose the best method (Section 5.6), and the costs involved (Section 5.7). Why and when excavation is still an option in underwater cultural heritage management will be explained in Section 5.8. This will be followed by a discussion on avoiding a dualism between in situ protection and excavation and the need for the latter in archaeological heritage management in Section 5.9. The chapter will finish with some concluding remarks (Section 5.10).

5.2 Three ways to preserve sites in situ

Generally speaking, there are three different ways to physically protect underwater sites in situ.

1. A barrier can be placed between the object and the major or other threats.
2. Sacrificial material can help to preserve a site over a longer period of time.
3. A site can be covered.⁶

The chemical protection of cultural heritage sites has also been trialled and microbiological methods of protecting wrecks against bacterial degradation have also been discussed. These will, however, not be taken into account here, as they do not seem to be viable options.⁷ In addition, after excavation, sites may also be reburied in order to preserve the archaeological materials. In this process, the same methods, techniques and materials are used.

5.2.1 Barrier methods

Although sediment can serve as a barrier, in this section the barrier methods discussed only concern human-made material that is used to obstruct the main confirmed threats to specific

¹ Parts of the research below have already been published in Manders, Gregory & Richards 2008 and Manders (ed) 2011.
² For monitoring, see Chapter 6.
⁴ The first physical in-situ protection in the Netherlands was executed in 1988 on the BZN J wreck in the Wadden Sea, Maareleveld 1988.
⁵ The County Museum of Bohuslän, Sweden, protected the wreck of the seventeenth-century Danish warship Stora Sophia in 2002. A mound was created over the site consisting of gravel covered with EPDM rubber carpet and small stone blocks.
⁶ There is little data to indicate how long sites can be preserved in situ and what the effects are regarding their integrity, the condition of the materials that are being protected or even the protective materials themselves. Much of this depends on different parameters and thus are site specific. However, within the SasmAP project (www.sasmap.eu accessed 30-01-2017), an investigation of the quality of the protective materials used is being conducted. New, as well as old material from different in-situ protected sites is being examined. See also Gregory, Shashoua & Eriksen (eds) 2013, 47.
⁷ Chemicals were used in the 1970s to protect underwater sites. One example is the use of Tributyltin Oxide on the Rapid wreck in Australia (Ortmann 2009). The BACPOLES project discussed whether the introduction of bacteriophages (viruses) could stop bacteriological decay. However, in addition to the fact that the introduction of phages is not be something that would be met with much enthusiasm by cultural heritage managers, it would also be a temporary, short-term solution, as bacteriophages live on bacteria and if this food source decreases, the phages will also die. Also, it has been proven to be difficult to identify and isolate wood-degrading bacteria. It is, however, important to know which bacteria are present, as specific bacteria require specific phages, see March 2005 & BPOLES team 2005, 206.
material or the site in general. Geotextiles can serve as a barrier method and will be further discussed below. Other materials include plastic film, such as PVC barrier materials. Flexible barrier materials which are placed around pilings may also have potential applications for archaeological timbers that protrude too far from the seabed to be covered with sediment. These have not been used for the protection of underwater cultural heritage sites until recently. However, they could be of use by creating a physical, and possibly an oxygen-free, barrier around the objects to be protected. PVC barrier materials have been trialled in Denmark. The main aim of such methods is protection against shipworm larvae. This barrier does not allow the larvae to attach to the wood surface. Furthermore, any living shipworm in the timber will not be able to respire due to the lack of oxygen. There are several proprietary manufacturers of these materials. One of the major manufacturers is Pile-Gard and the flexibility of the material they produce would appear to allow it to be moulded to timbers.

A possible barrier method that is still to be trialled is the use of long ropes placed around wood. According to Paalvast (2014), who undertook some initial testing, these ropes become overgrown with sea life that uses up all the oxygen under the rope. This would make colonization of the wood unattractive to _Teredo navalis_. Indeed, this may be a cost-effective solution for the protection of pilings in water; whether this will be practical for the protection of underwater cultural heritage sites remains to be seen. Interesting observations of biofouling were also made on the surface of geotextile bags used in the MoSS project and sandbags investigated during the SASMAP project. Evidence of barnacles, algae, bivalves and other marine organisms was recorded. Sometimes the surfaces were completely overgrown. It has been suggested that the growth of barnacles, which can be extremely abundant in the Western Wadden Sea, provides a ‘screen’ against wood borer attack, in the eventuality that infestation has not already occurred. However, due to the low intensity of sampling within the MoSS project, which made this suggestion (once after 3 and once after 12 months), this could not be confirmed. In addition, observations made on the biofouling of the data logger that was in place during the MoSS project suggests that this coverage may be seasonal and thus may only have a temporary preventive effect (Fig. 5.2 A + B).

There are also other methods in use that serve as a barrier to protect underwater cultural heritage. In Croatia, cages have been constructed around Roman shipwrecks to prevent them from being looted by divers (Fig. 5.3). Here, looting is considered to be the main threat to the sites, which consist – at least visually – of only tumuli of amphoras and ballast stones. Obviously, these cages do not prevent biological deterioration. The first cage was installed in 1990. Newly designed cages have been placed on site since. Monitoring of the separate sites is done by local dive schools, which have also been permitted to give guided tours around the wreck, even within the cage. In 2000, two Phoenician shipwrecks off the coast of Cartagena were given the same kind of protection against looting. When closed, the site is completely invisible to possible visitors, while the cages in Croatia are made

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*See, for example, the use of geotextiles on the Zakynthos shipwreck in Greece (Pournou et al. 1999).*

*Manders (ed.), 2011, 35, Fig. 30.*


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pinewood. See also Chapter 3 and Paalvast 2014, 74.

Appelqvist 2011, 59.

See also Palma 2004 (2), 25.

A double layer of full oak planking has been archaeologically observed on different Dutch wrecks, such as the Mauritius wreck (see e.g. L’Hour et al. 1990) and historically described, for example, on the ZONDACHT from the Schouten and Lemaire expedition between 1614 and 1616. See Spruit & Manders 2007.

with bars so that the sites may be viewed from a distance but not touched.

5.2.2 Sacrificial in-situ protection

Some materials degrade more readily and rapidly than others. With this in mind, sites can be protected by introducing sacrificial new material that will be attacked instead of the original archaeological material.

Two examples are the use of sacrificial metals and wood. In the 17th and 18th century, Dutch wooden ship hulls were often protected against shipworm (Teredo navalis) by adding a sacrificial layer of thin pinewood over the oak hull (Fig. 5.4). This ‘doubling’ seems to have been an effective way of preserving the most valuable ship hull on trips to the tropics. The pinewood layer was used in combination with tar and hair mats between the hull and the doubling, as well as thousands of iron nails that were used to fix the thin planks onto the ship’s hull. These nails, with large heads, would rust in saline waters and form a protective corrosive layer offering additional protection to the hull.

This idea of using sacrificial wood to protect other wood might also be used when protecting an archaeological site. However, practicalities may be an issue. Observations on shipwrecks have clearly shown that the shipworm likes to drill through oak as well as pinewood. It does, however, seem to have some preferences. The reason why a shipworm drills through wood is to create a living space in which it can also protect itself against fluctuations in, for example, salinity, by closing off the tube that it has created. It does not eat the wood. Therefore, the preference of the animal should lie in easy access and minimal effort to drill through the wood structure. Since Teredo navalis seems to have no problems in drilling through hard oak wood, it remains to be seen whether less resistant wood would be a solution that would distract the shipworm from the archaeological wood over a long period of time.

Not being able to withstand the attack of Teredo for a very long time may have been the reason why, in the seventeenth century, (at least) some Dutch ships that were to be in the tropics for a very long time were protected with another layer of oak planks in addition to the sacrificial pinewood. The solution was not only sought in the type of wood, but also in the number of layers that could be ‘eaten’ away. One downside to adding easily accessible sacrificial wood might be that it has a negative effect on archaeological sites in situ, insofar as it may make it easier for the site to be colonized.

Iron ship hulls are often protected with sacrificial anodes of inferior metal such as zinc, magnesium or aluminium. In passive cathodic protection, these blocks of metal are attached to the metal object that is to be protected. The naturally occurring electrochemical potentials of different metals are used to provide protection. Corrosion will take place on the anodes rather

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6. For doubling, see also Duivenvoorde 2008, 174. It was also fascinating to find a pole, probably used in a quay or harbour structure, in Zeeland, the southwestern province of the Netherlands, in 2004. This pole was protected against Teredo in exactly the same way as the hull of wooden ships. See Acker et al. 2007, 97.
7. In the wrecks of the Wadden Sea, oak as well as pinewood is attacked. Research with sacrificial woodblocks, however, showed that the shipworm has a preference for pinewood. See also Chapter 3 and Paalvast 2014, 74.
9. See also Palma 2004 (2), 25.
10. A double layer of full oak planking has been archaeologically observed on different Dutch wrecks, such as the Mauritius wreck (see e.g. L’Hour et al. 1990) and historically described, for example, on the Zendacht from the Schouten and Lemaire expedition between 1614 and 1616. See Spruit & Manders 2007.
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than the higher quality metal object. This method is in use for the protection of pipelines, oil rigs and, for example, ship hulls, and has also been and is still applied on cultural heritage sites. For example, several iron cannons lying on the seabed have been preserved in situ in this way. Other ship elements have also been preserved, such as the windlass, chain and deck knees on the James Matthews and the engine of the Xanths, both in Australia (Fig. 5.5). A free flow seawater environment is ideal for the use of sacrificial anodes. Its use in the sediment is more problematic because a current flow is needed, as well as regular monitoring.

In addition to sacrificial (or galvanic) anode cathodic protection, impressed current cathodic protection also exists. This requires an external power source with inert anodes. At present, in the Netherlands and the Western Wadden Sea no cathodic protection methods have been applied on cultural heritage sites under water. The protection would allow metal parts of shipwrecks to have a longer lifetime in the water. This may be important for scientific reasons, to ensure sufficient time to organize proper ex-situ conservation or to allow for visitors (sports divers) to view the objects in situ. Some of the wrecks in the Burgzand area have exposed iron objects that could be protected in this way.

5.2.3 Covering a site

Covering sites with sediment or other materials works by limiting the access of oxygen. The presence of oxygen can be the cause of severe corrosion or biological attack from bacteria, fungi or shipworm. In environments where sediment erosion is not prevalent, a covering of just a few centimetres is sufficient to prevent the diffusion of oxygen and thus the growth of shipworm, one of the most vicious degraders in salt water.

Covering with loose sediment

The simplest way of protecting or stabilizing a site in situ is to dump either clay or sand on it. Whether this is effective or not depends on the dynamics and whether other measures are taken to keep the added sediment on the site. However, even in still water, the dumping of sediment has to be done carefully and with much thought. When dumping fine sand from the water surface, it may disperse and not all end up on site. The deeper a site is, the bigger the problem to ensure the sediment ends up where it should. Moreover, in relation to particle size, the finer the grain, the better it is for creating an anaerobic environment, but the more difficult it becomes to deposit it on the right spot. Open areas may then not have sufficient protection. In addition, even in water that is usually stable, shallow sites are especially vulnerable to wind erosion and ice disturbing the seabed. Marine traffic such as sailing boats (with their leeboards) can also form a threat by cutting through the top sediment layer, while motor boats may push away sediment from the seabed, especially in places where they must manoeuvre.

Another aspect to keep in mind is that when lose sediment is dumped on a site, it may mingle with the original stratigraphic layers and obscure observations of where the historical layers begin and end. This can be mitigated by adding an artificial layer – for example geotextile – between the original sediment on site and the material deposited on it.

Fig. 5.5 Cathodic protection of an anchor at the James Matthews site in Australia. Photo: Maritime Museum of Western Australia.

25 Heldberg, MacLeod & Richards 2004, McCarty 1998. For more information, see also Steyne & MacLeod 2011.
29 The iron anchors at the BZN 3 site and an exposed cannon on the BZN 10 site, for example. Before taking such actions, research to establish the current condition of these objects should first be conducted.
30 See Chapter 3.
32 The fifteenth-century Hoornse Hop 1 wreck and nearby the foundered eighteenth-century Hoornse Hop 2 (Bartels 2011) are both lying near the entrance to the harbour of Hoorn and at a depth of only 3.5 metres. Multibeam sonar revealed that both wrecks are under threat of being hit by the swords and long keels of pleasure yachts. Also, the Roman site (Quay, Cuijk 6000 area) at Cuijk is constantly under threat of being hit by large river boats or of the silt being blown away by ship propeller action, Manders 2006 (3), and Manders & Brouwers 2016.
33 This has, for example, been done on the Cuijk 6000 site, see Section 4.6.
between the original sediment on site and the deposited sediment, one can also choose a completely different sand (not present in the local environment). In this case, it is important to know the origin of the sand, as unwanted materials such as iron and too much organic material may have negative effects on the site due to unwanted biological and chemical processes and bioturbation.  

Sandbags  
Sandbagging has often been used in the past, as the unit costs are low and they effectively act as a barrier against looting, erosion and shipworm by creating an anoxic environment in which the shipworm larvae cannot settle (Fig. 5.6).

There are some aspects to keep in mind when installing sandbags on site. Deployment is often expensive and time consuming in terms of person hours required and the difficulty of moving sandbags around under water. Sandbags are also often overfilled. This not only makes them more difficult to deploy, but by filling them too much they create an obstruction on the seabed which, if currents are present on the site, can cause scour around the edges of the sandbagged areas. This undermines them and can expose new areas of the wreck. As a rule of thumb, the sandbag should only be a third to a half filled. Fine-grained sand with a low organic content is best. When keeping to these rules it is possible to ‘mould’ the sandbags around structures and keep as low a profile as possible.  
Moreover, it is extremely important that synthetic sandbags are used, as any made of natural material will be microbially degraded, after almost 26 years in the water they are still in remarkably good condition.  
Unfortunately, the bags also create a huge barrier to monitoring the quality of the wood inside the mound. In brief, sandbagging is most effective for small areas where currents threaten to remove archaeological material. 

Geotextiles  
Geotextiles are finely woven or non-woven synthetic fabrics and have been used for all sorts of purposes, including coastal engineering aiming to prevent coastal erosion. They are commonly used in marine archaeology to cover areas or trenches at the end of an excavation season. Laying a geotextile cover over an area and then backfilling enables the cultural layers that have been excavated to be relatively easily relocated in the following season. They have also been used as physical barriers to protect against shipworm on archaeological sites. Research carried out on the site known as the Zakynthos Wreck has shown that a specific grade of geotextile, Terram 4000, was effective at preventing the larvae of shipworm settling on the wood. Similarly, in the EU MoSS project, work with geotextiles showed the same results, as has research on the wrecks of the HMS Colossus and the Swash Channel Wreck. The flexibility of the fabrics makes them ideal to mould around timbers which are standing upright on the seabed. However, the higher the number of Terram geotextiles, the more dense and the less easy (less flexible) they are to use. Moreover, the material can be extremely buoyant and, as a standard roll is 4 metres wide, weights need to be added to lower the material onto the seabed. If large areas are to be covered, the geotextile can be prepared by inserting eyelets, allowing several parts to be easily joined using cable ties. Unrolling geotextile is remarkably good condition.
often easier if there are two divers. They should ensure that any current is behind them, which will also facilitate unrolling of the geotextile. At the same time, the divers can use sandbags to weigh down the geotextile as it is being rolled out and prevent it floating. This job can also be divided between the two divers: one rolling out the geotextile and the other placing the sandbags, as was done on test sites in Tuddse Hage (for the WreckProtect project) and in Rayong, Thailand (for the UNESCO Advanced Course on In-situ Preservation) (Fig. 5.8 A + B).

As seen within the MoSS project, Terram geotextile in the form of bags may also filter sand out of the water when, for example, wrapped around an object. The amount of sand caught is related to the thickness and density of the geotextile. The project study found that the lower the grade, the more sediment trapped, even though the bags were floating approximately one metre from the seabed. After twelve months on site, samples were completely covered by sediment within the geotextile bags. Moreover, evidence of barnacles, algae, bivalves and other marine organisms was recorded on the surface of the geotextile bags. This shows that the geotextile may be used as a component to create an artificial reef underwater that can be naturally overgrown.

Geotextile has been found to work well against attack by Teredo navalis or shipworm. The level of attack decreased with the thickness of the geotextile grades used. The grades of 2000 and 4000 were free of attack. While the lower grades of textile (500 and 1000) however, could not prevent attack by Teredo navalis, the attack was less severe. It can be concluded that the lower grades slow down attack, perhaps in combination with the sediment that they catch, and the higher grades of Terram prevent attack.

Covering with the help of sediment transport

Although sites are often protected against biological deterioration due to elements such as wood borers, underwater archaeological sites are also threatened by sediment transport. However, this sediment transport can also be used to the advantage of protection on site. While sand may cause erosion and abrasion, if sand suspended in water can be trapped in one way or another and kept on site it may be used to cover it and create an oxygen-free environment.

Artificial seagrass

One method which is used in the offshore industry for stabilizing pipelines and cables involves the use of artificial seagrass. There are several proprietary products on the market, all of which function on the same principle (Fig. 5.9). When deployed, one should ensure that there is sediment transport on the site. This can be easily noted by looking at bed forms, that is, sand ripples on the seabed. During tests, it was observed that aligning the long edge of the mat with artificial seagrass perpendicular to the direction of any current allowed the maximum amount of sediment to be trapped.

The easiest way to install the mats is by ensuring the current is behind the diver, which facilitates the rolling out of the mat. After installation it is beneficial to regularly ‘rustle’ the fronds to make sure they are not filled with seaweed or other detritus. Moreover, when sediment settles between the fronds, this movement of sand also has a cleaning function.

The mats can be quite expensive, especially in relation to the budgets available for archaeological projects. Within some projects, they were produced manually; however, this is labour intensive.

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46 Palma 2004 (2), 23.
47 For more about plans to create artificial reefs on shipwrecks see: https://erfgoedstem.nl/bescherming-scheepswrakken-en-kansen-biobouwers-waddenzee/ (accessed 08-04-2017).
48 Palma 2004 (2), 23.
50 Gregory & Manders 2016, 65–73.
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Coenen et al. 2013.

See, for example, Fonseca et al. 1998, 43 and also the introduction of turtle grass in Biscayne National Park: Skowronek et al. 1987, 317.

The mats need to be fastened to the seabed. This can be done by anchors (as are used by Seabed Scour Systems, (SSCS) the producer of the tested seagrass mats). These penetrate 80 to 100 cm into the seabed and could damage underlying cultural heritage.52 They can also be weighted down with heavy material such sandbags. SSCS has now developed a system where each mat is weighted down with gravel-filled tubes on each side (Fig. 5.10). These mats were tested during the EU-funded SASMAP project.53 The prepared mats can be installed on the seabed in a couple of minutes with the help of a specially developed hoisting frame that picks up and releases the mats. This, however, requires a large ship and crane for installation.54

In strong currents, the seagrass fronds can actually lie flat and are ineffectual at collecting sediment. Tests with different sizes of fronds have revealed that in areas with strong currents, shorter fronds are more effective, due to the fact that they remain upright more easily than longer fronds.55 However, according to the tests, the Wadden Sea turned out to be extremely hostile and not favorite to use the mats and especially the fixing system. The latter seriously has to be reconsidered.

Although the artificial seagrass mats filter the suspended sediment out of the water, the collected sediment can easily be scoured out as well. However, due to the fact that the fronds will stand upright again as a result, the process of capturing the sand may start all over again. This process might work well especially when there is no barnacle growth on the fronds.

Artificial seagrass mats can be best used to protect sites with low height differences (e.g. not much of the ship’s construction protruding from the seabed) and low to modest current speed. At present, it is also being tested as a soft barrier on the edges of debris netting protection, designed to avoid scour on the netting.56

Notable examples where artificial sea grasses have been used or trialled are on the wrecks of the William Salthouse (Australia),57 the James Matthews (Australia),58 the Hårbane Wreck (Denmark)59 and a test site in Thailand60 (Fig. 5.11). For the SASMAP project, tests were undertaken at the BZN 10 wreck (the Netherlands), Tuds Hage (Denmark) and Baiae, Naples (Italy).61

Obviously, another form of in-situ protection could be the reintroduction of natural seagrass in areas where this has disappeared. This, however, involves mitigation measures that address why the natural seagrass disappeared in the first place; for example, it may be necessary to improve the water quality. The introduction of seagrass has been attempted at various sites, often with disappointing results.62 There are also plans for other areas that include cultural heritage.63

Fig. 5.10 Detail of the artificial seagrass mats with hoisting frame and gravel-filled tubes as weights on the edges. Photo: Paul Voorthuis, Highzone Fotografie.

Fig. 5.11 Artificial seagrass as used under water during the UNESCO Advanced Course on In-situ Preservation in Thailand. Photos: M. Manders.

52 Coenen et al. 2013, 38.
54 Coenen et al. 2013.
55 Ibid.
56 This test is being undertaken at the BZN 10 site as part of the SAGMAP project.
61 Coenen et al. 2013.
62 See, for example, Fonseca et al. 1998, 43 and also the introduction of turtle grass in Biscayne National Park: Skowronek et al. 1987, 317.
Debris netting/shade cloth

Debris netting is net-like material which is used when carrying out construction work on buildings in order to prevent any building debris falling on passers-by. Shade cloth is quite similar but used to protect plants against the full strength of the sun (Fig. 5.12 A + B). The archaeological use of debris netting was first developed in the Netherlands and was further developed in the EU MoSS project. The debris netting functions in a similar way to the artificial seagrass. The idea is that the net is loosely fastened over the structure to be protected, so that it floats in the water (Fig. 5.13). As with the artificial seagrass, the method is dependent on there being currents and sediment transport in the water. If there is sediment transport and the sediment is sufficiently fine to pass through the mesh, the sediments will be slowed due to friction, come out of suspension and subsequently become trapped under the net, creating a burial mound under water.

With the use of shade cloth/debris nets one should ensure that there is sediment transport on the site and have an idea of what kinds of sediment are being transported in terms of particle size. Debris netting which has a mesh size large enough for the sediment to pass through should always be chosen. One type of net where there is a recognized good compromise between strength and mesh size is known as the ‘Windbreak net’ of 230 gm-2, mesh size 5 x 2 mm. Most debris nets are supplied in 50 metre rolls which are 2-3 metres wide. The net is extremely buoyant and therefore should be weighted when installed under water, for example by wrapping it around a metal rod. Eyelets on the edges of the net should be inserted – but are usually already made in the factory – both to enable fixing of the net into the seabed and joining nets together. When joining the nets together, there should be an overlap between the two. In this way, potential gaps between the nets when they tighten due to the sediment build up can be avoided. Where possible, the long edge of the net should be aligned perpendicular to the direction of any current in order to trap the maximum amount of sediment. Installation on site is facilitated by ensuring that any current is behind the diver when positioning the net, allowing easier roll out of the net and also avoiding entanglement. The net must not be stretched tight on the seabed but should be loose. For example, when covering a length of 5 metres, at least a few metres of net more (>2mtr) should be rolled out so that there is enough loose material to float in the water column.

The net can be fixed to the seabed either with long pegs which penetrate the seabed or heavy material such as anchor chain or sandbags (Fig. 5.14). Small fishing buoys, designed to give the net buoyancy when fixed on the seabed, have been trialled as a method of keeping the net off the seabed (Fig. 5.15). After initial installation, monitoring of the net is very important. Shortly after installation, the net should be checked and shaken to remove any sediment which is lying on top and attach further buoys if necessary for more buoyancy. The net is vulnerable to tearing, particularly where it is held down or anchored with pins and where two mats are joined together. It is important to check this as well because tears may quickly undo everything that has been achieved.

69 In the Wadden Sea, old (anchor or fishing) chains have been used to weigh down the nets. On the Avondster site in Sri Lanka, sandbags were rolled into the sides of the nets and fixed with cable ties to weigh the nets down, Manders 2006 (2) and Manders & Weerasinghe, 2007.
70 See Manders (ed.) 2011, 32–33.
Parts of the wreck that protrude from the seabed may initially damage the nets which are loosely placed on the site. To avoid this, one can cover these parts with sandbags or add sediment with a water pump before or just after installing the nets.\(^{70}\)

The method has been used successfully on several sites, notably the wrecks of the Burgzand Noord, that is, BZN 2, 3, 4, 8, 9, 10 and 17 in the Netherlands,\(^ {71}\) the Avondster in Sri Lanka\(^ {76}\) and the Darsser cog in Germany,\(^ {73}\) a test site in Thailand,\(^ {74}\) and it was successfully trialed around the wreck of the Hårølle site in Denmark\(^ {75}\) (Fig. 5.16). However, trials of the netting on the HMS Colossus\(^ {76}\) and the Swash Channel wreck\(^ {77}\) were not deemed successful. It is most likely that this was due to the incorrect use of the materials on site. This again emphasizes the need to understand the way in-situ stabilization methods work and that they will not necessarily be effective on every site.

Damage to shipwreck sites in the Netherlands are frequently caused by the often violent natural conditions, fishing or sports divers. Although the initial protection by debris nets seems to be very effective in this area and under these conditions, long-term management requires more than just this solution. Currently, the RCE and the ‘Programma naar een Rijke Waddenzee’ (Programme for a Rich Wadden Sea)\(^ {78}\) are in the process of developing a method to stabilize wreck mounds after sand has been caught by the nets, by promoting the colonization of bio-builders such as mussels and oysters on site.\(^ {79}\)

### 5.3 Reburial underwater

Shipworm cannot survive for long periods in the absence of dissolved oxygen and it is a fact that wood, when buried in the seabed, will only be susceptible to slow microbial degradation caused by bacteria, due to the lack of oxygen in marine sediments.\(^ {80}\) Thus, covering or reburying wood is one way of preventing further attack by shipworm, the main degrader in a salt water environment. Covering or reburial has been achieved by several methods, as has already been explained in Section 5.2, but may also include natural or intentional backfilling of timbers after excavation, sediment dumping or deflection of sediment to cover a site in situ. Furthermore, artefacts have been reburied after raising and documenting. Reburial can thus be a management solution.

#### 5.3.1 Backfilling after excavation

A shipwreck site is rarely completely excavated during the course of a single excavation period (See also Chapter 4).\(^ {81}\) Alternately, a site may not be completely excavated if the whole hull is not to be removed. Thus, between excavation periods, sites are often either purposely re-covered with sediment or left to be naturally covered by sediment. This covering is essential to protect the archaeological information against erosion and especially if the...
area is known to be affected by shipwrecks. The summer months, when most excavations take place, are a prime breeding time for shipwrecks; thus, it is extremely important that sites are not left uncovered. However, for backfilling to be successful, it should be determined that these sediments will not be removed due to natural sediment transport.

5.3.2 Reburial and redeposition

A frequently used word in the context of in-situ preservation is ‘reburial’. Before discussing the ways to do this, we should ask ourselves what the word actually means in an underwater archaeological context. The word can be used for different situations. A site may be in need of reburial because it has been uncovered by natural or direct/indirect human activity. This is the case for a vast majority of the sites that are currently being conserved in situ, since most sites were found because they surfaced the seabed. Moreover, if sites are fully covered, there is usually no need for active in-situ protection and reburial. This kind of reburial of cultural-historical material that is under threat fits perfectly with the aims and definitions of in-situ preservation and management.

Sometimes, however, reburial is used for mitigation after excavation. This may be part of the overall management plan; a way of taking care of a site. Reburial may then mean, for example, temporary protection, covering exposed timbers between excavation seasons, but also semi-permanent reburial after the termination of an excavation or even relocation of a site that has not undergone any excavation. These kinds of reburial may not fully coincide with the definition of in-situ preservation as previously laid out in this thesis.

Reburial of excavated sites may take place precisely on the spot where the objects were found, in an attempt to preserve the integrity and/or spirit of the place and at least a part of its context, if not all. However, reburial can also take place in the area at large. Similar natural conditions may then be taken into account, but by moving the objects, the integrity of the separate elements of the site will then be lost. Reburial has also become a means of mitigation against the high costs of excavation due to the conservation of materials that is often required afterwards. With the reburial of timbers and other finds, this can be avoided. There is something to say for this, not to mention the over-full museums and archaeological depots.

There are also situations in which it is thinkable that there is no time to raise funds for conservation, subsequent long-term storage and/or display of all the finds, including the hull structure. This may be the case, for example, when, due to sub-sea development, it may be necessary to completely excavate a site and recover artefacts as part of a rescue programme. We must ask ourselves whether we should always excavate whole sites and conserve all of the objects under any circumstances. Not all objects can be put on display and sometimes it is better to preserve objects in the natural environment rather than remove them and conserve ex situ. This however also relies on the questions asked when planning an excavation. Thus, hull remains and even artefacts can also be redeposited in the appropriate environment (whether nearby or further away from the original site) to facilitate their long-term storage. Hence, the final meaning of the term ‘reburial’.

One of the first attempts at controlled reburial of archaeological remains under water was carried out in the 1980s. From 1980 to 1984, Parks Canada excavated the remains of the Basque whaler San Juan in Red Bay, Labrador. Following the excavation, raising and documentation of the wreck, the timbers were reburied to protect them against biological, chemical and especially physical deterioration due to ice flows. What made this early project different from other reburial attempts at the time was that monitoring of the reburied timbers and the surrounding reburial environment was planned from the outset. Sandbags and the ballast from the ship were used to construct an underwater...
5. How do we physically protect underwater heritage sites in situ?

A similar project recently began in Sweden, which set out to validate the efficacy of reburial of archaeological materials in the marine environment. The ‘Reburial and Analysis of Archaeological Remains’ project focuses on the reburial of artefacts from the wreck of the Fredericus (1719) in the Swedish island port of Marstrand. Archaeological investigations were initiated in the harbour because of the need to reinforce the quay. Two major investigations were undertaken. One was an excavation of the wreck of the frigate Fredericus, sunk in a battle between Sweden and Denmark, and the other was an investigation of an area alongside the quay, which revealed cultural remains dating back to the seventeenth century. These two excavations yielded approximately 10,000 artefacts. Full conservation treatment of all of the excavated artefacts was considered both impractical and unnecessary from an archaeological perspective, and it was decided that 85–90% of the finds would be reburied after proper archaeological documentation.

Among other materials (a shipwreck rarely consists of just wood), modern wood samples were left exposed to seawater and reburied at various depths down to 50 cm. Results after three years of reburial showed that the samples left exposed to seawater were rapidly and heavily degraded by wood borers, while those covered by sediments were only microbially degraded. The results reflect those on the Red Bay wreck and other experiments on the reburial of wood, all of which suggest that even a thin covering of sediment is significant enough to limit the amount of oxygen in the sediment to a degree that does not allow the shipworm to survive.

Reburial can be done using existing sediment transport over a site. One or a combination of the previously described methods to catch sediment can be applied. Reburial of the site can also be done using geotextiles, plastic geomembranes or the dumping of coarser grained material (gravel) to ensure the sediment is not removed.

Local sediment from surrounding areas is often used for reburial and is generally characterized by its suitability. However, the porosity and organic content of any sediment should be assessed, at least before applying. Sediment should ideally be fine-grained sands, which are less porous and naturally contain less organic material than larger particle sized sediment. This leads to lower rates of mineralization when the dominant process is sulphate reduction, which is typical of marine sediments (See Chapter 3). This contrasts with the higher rates of mineralization in more porous sediment with higher organic contents.

The optimal depth of burial depends on the nature of the sediment to be used. However, as mentioned above, even a thin covering of sediment will limit the oxygen content sufficiently to prevent the survival of wood borers. Reburying artefacts in one layer, as well as providing a detailed site plan, makes it easier to return to the site if objects or ship structures need to be accessed for research or monitoring. The materials used in the reburial, including labels and containers, should be durable.

In addition to the above-mentioned Red Bay and Marstrand projects, the Clarence project should also be mentioned. This project aimed specifically at reburial and finding cheaper ways to conduct archaeological research on shipwrecks.

Another reburial has been executed at a ship barrier consisting of 20 historical shipwrecks in the Bay of Greifswald. The barrier was found with aerial photography (Fig. 5.17 A + B). It was created in 1715 when the Swedish navy ballasted the ships, sinking them in alignment in water that was 3 to 4 metres deep. Together, they formed a 980 metre defensive barrier which prevented enemy fleets from entering the bay. As one of the wrecks (9 x 3 metres) needed to be removed to allow the Nord Stream pipeline to be...
A wreck near the island of Reichenau in Lake Constance, Germany, was also reburied in a certain sense. This fourteenth-century shipwreck was lying in such shallow water that the archaeologists in charge decided to temporarily remove it from the lakebed, investigate it, deepen the hollow in which it was found and put the wreck back into it. It was then further protected with geotextile and sandbags.

In the Netherlands, there is a central reburial area. This is the field depot of the Cultural Heritage Agency of the Netherlands established in the 1980s, which has been used since then for the reburial of excavated material from shipwrecks in the polder, but also from excavated underwater sites. Wood is deposited under the groundwater table. Unfortunately, no research has been done to monitor the effects.

The reburial of shipwrecks and artefacts is different from the relocation of wrecks, usually undertaken for other reasons. Some shipwrecks, such as VAL7 in the Netherlands and the Gresham Ship in the UK, have been relocated to another area to be enjoyed by sports divers, but without further protection.

The ‘single’ object vs landscape approach
Shipwrecks have been the primary focus of underwater archaeological research for a very long time. This has not only resulted in an object-focused approach but also in a narrow view regarding those wrecks as time capsules, nothing less but certainly nothing more. This perspective on shipwrecks as enclosed stand-alone objects has had an influence on the management of the underwater cultural heritage. First of all, the focus has been on the ship and the event of its wrecking. This also concerns the connection and integrity of the objects belonging to the ship, all relating to a certain event at a certain time. Less emphasis has been placed on the development of the place, the site or local marine environment. Post-depositional processes are often not taken into account in research and even less from the perspective of adding information about the history of the place. Moreover, not much emphasis has been put on shipwrecks in a wider context, as part of the maritime or broader cultural landscape. Sites are, therefore, still mainly individually assessed, in an ad-hoc approach, often not taking into account the significance they have for the surrounding area and vice versa.

Research on post-depositional processes on shipwreck sites is certainly not new. Muckelroy (1978) has written about them, and, for example, Ward et al. 1999 followed on from this. However, it is still not common practice to include this topic in research on shipwrecks.

One example that illustrates this view is the excavation and reburial of a shipwreck near the island of Reichenau in Lake Constance, Germany, that has been described previously. This sixteenth-century wreck, although clearly connected with the World Heritage island of Reichenau, was partly exposed in shallow waters and therefore under threat. It was decided to excavate the wreck parts (the ship as a construction) and then reburry the site by deepening the lake bed and ‘sink’ the site deeper into the soil, protecting it afterwards with sandbags.

See also discussion on the Pompeii premise, Chapter 4.
Although this is a very focused approach, it has not contributed to the recognition that shipwrecks are connected to societies and cultures on shore and thus that they have significance for local communities (Fig. 5.18).  

This has also led to shipwrecks being regarded as accidental finds, intrinsically concluding that there has been no connection between the wreck and the location in which it was wrecked. This perception will continue until we break the vicious circle. As long as geological, geomorphological and other environmental research is not common practice in shipwreck research, there will be no notion of the connection of the site to its historical environment, and thus this will not be taken into account.

This alone is already objectionable, but shipwrecks being regarded as enclosed stand-alone sites also makes it apparently easier to remove them from the environment, with which – in this view – they have nothing to do and nothing in common. This removal may even occur prior to any archaeological research. It is not unusual that objects from underwater cultural heritage sites are salvaged from a sea or riverbed in order to investigate them out of context, and the suggestion to do so has even been made by professional archaeologists.

As a consequence, it is not surprising that the underwater cultural heritage is still often neglected in the process of developing policies and planning. More emphasis should be given to connecting sites through a shared history in time and space. There is no better way to link larger areas (e.g. for a World Heritage listing) than the maritime connection.

**5.5 The in-situ protection of well-preserved shipwrecks**

Time and again, we are thrilled by the discovery of yet another well-preserved shipwreck. The discussion about what should be regarded as a well-preserved shipwreck was taken up in the MoSS project. Within this European project, it became clear that ‘well preserved’ had a different meaning in the Netherlands than in the Baltic Sea Area, where three partner countries of the project ‘met’ (Sweden, Finland and Germany). While in the Netherlands one criterion was that it had to be possible to fully reconstruct a shipwreck from the archaeologically investigated remains, in the Baltic, a ‘well-preserved’ shipwreck was one that was usually still standing upright on the seabed, sometimes even with the masts upright (Fig. 5.19). The condition of these ships (which can barely be called ‘wrecks’) is an indication of the stable conditions of the environment they are in. As long as nothing
changes, these ships may sit there for a few hundred years more before they fall apart. In practice, in-situ preservation consists of monitoring possible changes, and not much more. However, what if the situation changes? What if human interventions have greater effects? What if climatic and water conditions change? What if invasive species start to attack these sites? Can we then protect the ships against this and keep them preserved in situ? This is something that has concerned scientists for quite some time. The Baltic Sea is known for having excellent conditions – low salinity, cold and stable water on the seabed, slow currents – in which to preserve wooden ships, with other locations being the Black Sea in the southeast of Europe, and the Great Lakes between the US and Canada.\[116\]

With respect to iron and steel wrecks, just like wooden shipwrecks, preservation depends on the existence or lack of oxygen. The best preservation areas would be deep, still water. Many iron and steel wrecks are not yet 100 years old. For many countries, this remains a reason not to protect them.\[117\] However, time may in fact be the only reason why these wrecks have not yet collapsed.\[118\] At present, there is still a lack of understanding about how iron and steel wrecks can be well preserved in situ. Experiments with sacrificial anodes have been undertaken.\[119\] In Australia, a specific seminar was devoted to iron, steel and steamship archaeology.\[120\] In 2015, for the first time, a project proposal (ReWarShip) to manage and preserve iron and steel wrecks (WW1 and WW2 wrecks) within the scope of a program financed by the European Union was submitted.\[121\] Unfortunately, this project was not funded.

Whether wood, iron or steel, well-preserved shipwrecks protrude from the seabed for metres, or basically lie on top of it (Fig. 5.20). This makes them vulnerable to mechanical attack by natural erosion, looting or fishing activities, but also to biological threats, especially if new invasive species are introduced.\[122\] Climate change may provide a helping hand to such processes by changing the environmental conditions.\[123\]

If this occurs, it will be important to determine how we make choices about what to preserve and where. Is the aim to preserve the whole wood structure? The structural integrity of the ship (wreck)? Then the best solution may be to raise and conserve it, or to raise it and subsequently place it in a stable environment.\[124\]

Considering these difficulties of preserving sites in situ, it is important to ask ourselves the following questions:

» Does the site have to be preserved in situ?
» Might we lose part of the structure, e.g. the upright masts? If yes, then we might be able to lower the height of the construction and cover the site.
» Should the site remain in situ and, if so, does it need to be visible? And in what way?

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117 For the Netherlands, it used to be 50 years minimum, but this is no longer the case. Today, protection under the Heritage Act is only based on the significance of the site. The UNESCO Convention has a minimum of 100 years old.
119 See also Section 5.2.
120 McCarthy (ed.) 2010.
121 The project ReWarShip was proposed in summer 2015 for the Horizon 2020 call, but unfortunately was rejected.
123 Duren et al. 2011, 8.
124 To compare with the action taken for reburial. However, here it would be better to call this ‘repositioning’ rather than ‘reburial’, since no covering will take place.
In the latter case, sacrificial elements might work for a while. The site can then be investigated in situ, data collected, samples of construction can be taken here and there, depending on the questions we have. However, it should be accepted that the physical quality of the site will deteriorate and might even disappear over time. Knowing the rapid rate of deterioration caused by shipworm, a change in the environment could be disastrous. These situations require immediate handling. However, the budgets that are needed to ‘safeguard’ a well-preserved shipwreck and the process required to obtain permission to undertake ex-situ protection, unfortunately usually taking a great deal of time to negotiate, often years.

Management plans to act when extreme changes occur are usually not in place. However, this might be the best and most practical solution for these types of sites. This could be incorporated into risk assessment practices. Areas that seem to be extremely stable, may not immediately require action, but the consequences of any change may be dramatic. Areas such as the Goodwin Sands in the UK, the Southern Delta of Zeeland and the Western Wadden Sea in the Netherlands experience frequent changes in the seabed with devastating effect on present underwater cultural heritage. Even here, well-preserved shipwrecks can be discovered, especially when the situation changes drastically. It is then necessary to act quickly and preparations that anticipate potential changes may be the only way to move forward. Starting to develop mitigation strategies only after changes occur may be a strategy of too little, too late.

5.6 Choosing the method of in-situ preservation

5.6.1 Introduction

If an initial assessment of the environment of a site reveals that there are serious natural or other threats, strategies should be implemented to mitigate against them. It is at this stage that an overall evaluation should be made of whether it is desirable and feasible, both practically and economically, to leave the site in situ. As mention above, in-situ preservation and protection are options in cultural heritage management. Depending on the nature of the environment and the historical and archaeological significance of a site, excavation, followed by conservation or redeposition in a more benign environment, may be the only option to ensure that at least the information is preserved.

For wooden wrecks, significant threats include the possibility of further physical deterioration and biological deterioration caused by bacteria, fungi or wood-boring organisms. The bacterial decay is continuous even in environments with very little or no oxygen present. Although we can still learn, it has become clear by now that in low oxygen or anoxic conditions the deterioration rate will be very low and of no comparison to the rapid and high level impact of deterioration by wood borers such as shipworm. To mitigate these deterioration processes, sites are often covered using the different methods mentioned above (Section 5.2). In the right circumstances, this can both alleviate scour and prevent the activity of wood-boring organisms.

Most in-situ protection techniques are developed specifically for use at one particular site or in a specific environment, thus they are tailor-made and therefore not always easy to compare. However, the techniques used may often be partially applied to other situations. Below are two tables that present an overview of the factors on the basis of which an appropriate method can be chosen.

1. Table 5.1 outlines the effectiveness of different methods for different types of environments.

2. Table 5.2 shows how different methods of in-situ preservation mitigate against specific threats.

For example, geotextiles may be used in different ways: as a layer placed between the sediment and the archaeological objects, or as a barrier method, wrapping objects or a structure. These different uses mean it may be effective in different scenarios. The rubber sheeting method that was used on the Stora Sofia in Sweden represents various methods that cover a site, but which do not actively capture sand. These kinds of methods should be used in combination with, for example, additional sand deposits.

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126 See, for example, the devastating effect of the *Teredo navalis* on the wrecks in the Oostvoornsemeer. [http://www.maritiemprogramma.nl/magazine/MP03/MP03_051.htm](http://www.maritiemprogramma.nl/magazine/MP03/MP03_051.htm) (accessed 30-01-2017).

127 See Chapter 3.

128 See, for example, the natural conditions around the well-preserved shipwrecks in the Baltic Sea such as the Ghost Wreck or those in the Black Sea.

129 See Chapter 3 on mitigation against multiple threats.
5.6.2 A Western Wadden Sea example: the Burgzand Noord 10 site

The BZN 10 site consists of a sandy seabed, some flat areas and undulating seabed with salt water and strong tidal currents. It also lies completely submerged in 9 metres of water. It has primarily been protected physically with polypropylene debris nets. These nets score ++ on all parameters and, in practice, the polypropylene nets work excellently. The artificial seagrass that was installed in 2013 and 2014 should also be suitable for the environment, except for the height differences on site.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Type of method</th>
<th>Sandbags</th>
<th>Debris nets</th>
<th>Geotextiles</th>
<th>Added sand layer</th>
<th>Added stone layer</th>
<th>Cages</th>
<th>Rubber sheeting</th>
<th>Artificial seagrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy seabed</td>
<td></td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>(+)₈</td>
<td>x</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Rocky seabed</td>
<td>++</td>
<td>-</td>
<td>++ (as barrier method)</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pebbles</td>
<td>++</td>
<td>-</td>
<td>++ (as barrier method)</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Clay</td>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>(+)₉</td>
<td>(+)₈</td>
<td>x</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Salt</td>
<td></td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>(+)₉</td>
<td>(+)₈</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Tidal movements</td>
<td></td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>(+)₈</td>
<td>x</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Currents</td>
<td></td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>(+)₈</td>
<td>x</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Still water</td>
<td></td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wave action</td>
<td>++</td>
<td>(+)₁₁</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>(+)₈</td>
<td>x</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Brackish water</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fresh water</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>x</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Salt water</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>x</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Shallow water (0-10 m)</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>(+)₃</td>
<td>++</td>
<td>+</td>
<td>x</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Partly submerged</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>(+)₄</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Temporarily submerged</td>
<td>++</td>
<td>(+)₁₃</td>
<td>+ (not as barrier method)</td>
<td>(+)₉</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Depth range 10-50 m</td>
<td>[+1]</td>
<td>--</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Deep water (below 50 m)</td>
<td>[+1]</td>
<td>[+1]</td>
<td>++</td>
<td>(+)₂</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Flat seabed</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Undulating seabed</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Object slightly protruding from seabed</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Object strongly protruding from seabed</td>
<td>-</td>
<td>+ as barrier method</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ice forming (icebergs)</td>
<td>++</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(+)₁₀</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

5 As long as these shallow waters are calm. However, in shallow waters the effects of storms are usually great.
6 'Temporarily submerged’ means there is water movement, the less intensive this is, the better.
7 It may be difficult to deposit the sand in the right place.
8 Stone coverage on soft soil is usually unstable.
9 Stones may offer some protection; however, icebergs often have enough force to push the blocks away.
10 Cages protrude from the seabed and are thus vulnerable to all sorts of things becoming entangled in them. If used, a good foundation should be created, especially in soft sediments.
11 Polypropylene nets and seagrass need tidal movements to be really effective. These do not exist in fresh water.
12 We consider rubber sheeting not to provide a specific in-situ preservation method on its own. It does keep sediment on the site but will actively promote sedimentation on it. The sheeting on its own does not make the environment anaerobic.
5.7 The costs of in-situ preservation

Within the framework of the overall evaluation and decision-making process with respect to preserving in situ or not, a cost-benefit analysis should also be undertaken. This starts by providing an indication of the costs of the protection measures that may be taken. When defining the costs of in-situ preservation of a shipwreck there are many parameters to keep in mind. Some of them are very obvious, while others are not, as they may have a delayed and/or indirect effect on the site. The development of laws to protect sites, the organization of law enforcement, and the setting up of a registration system all have to be considered. Furthermore, costs may vary from country to country and over time. It is important to know if certain circumstances already exist for other reasons, for example, on the stability of the environment, the quality of the site, the condition of the wreck and the method of protection that has been chosen. At the same time, the method of protection depends on the environment, the type and the significance of the site.

Many of the above parameters are more or less connected to each other. The frequency of monitoring visits depends, for example, on the stability of the environment, the quality of the wreck and the method of protection that has been chosen. Within the WreckProtect project, financial data on in-situ protection projects was collected from different parts of Europe. It became clear that the personnel costs for professional divers and maritime archaeologists were the major expenses for each project, followed by costs for the rental of diving vessels and the equipment necessary for diving. The material costs of the protection measures were usually the cheapest. This may be different in other countries where salaries are much lower and equipment and materials more difficult to acquire. In any case, we should keep in mind that only a relatively small number of wrecks have been preserved in situ.

Table 5.2. Various physical protection methods and the way they mitigate against specific deterioration processes.

<table>
<thead>
<tr>
<th>Mitigating</th>
<th>Sandbags</th>
<th>Debris nets</th>
<th>Geotextiles</th>
<th>Added sand layer</th>
<th>Added stone layer</th>
<th>Cages</th>
<th>Rubber sheeting</th>
<th>Artificial seagrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Site erosion</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>Area erosion</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shipworm</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Gribble</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fungi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bacteria</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Looting</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>++</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fishing</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

(Legend: + to our knowledge the method works in this typical environment; ++ the method works excellently; - the particular in-situ method has a negative effect on the site for this environment; 0 neutral, it has no specific effect).

This table reveals that cages are effective against looting, but not against any other deterioration factors. They may even have a more negative effect, especially when there are currents around the site (see also Table 5.1). This table demonstrates that none of the methods have much effect on the levels of bacterial deterioration. Some erosion bacteria can continue to degrade the wood in near-anaerobic conditions. We should keep in mind, however, that these processes are slow.

5.7.1.1 The environment in which a shipwreck lies

Many of the above parameters are more or less connected to each other. The frequency of monitoring visits depends, for example, on the stability of the environment, the quality of the wreck and the method of protection that has been chosen. Within the WreckProtect project, financial data on in-situ protection projects was collected from different parts of Europe. It became clear that the personnel costs for professional divers and maritime archaeologists were the major expenses for each project, followed by costs for the rental of diving vessels and the equipment necessary for diving. The material costs of the protection measures were usually the cheapest. This may be different in other countries where salaries are much lower and equipment and materials more difficult to acquire. In any case, we should keep in mind that only a relatively small number of wrecks have been preserved in situ.

5.7.1.2 The costs of ship rental, work-related policies and legal frameworks

Salaries, costs of ship rental, work-related policies and legal frameworks vary across the world. Their implications for the cost of in-situ management can be huge. Within the WreckProtect project, financial data on in-situ protection projects was collected from different parts of Europe. It became clear that the personnel costs for professional divers and maritime archaeologists were the major expenses for each project, followed by costs for the rental of diving vessels and the equipment necessary for diving. The material costs of the protection measures were usually the cheapest. This may be different in other countries where salaries are much lower and equipment and materials more difficult to acquire. In any case, we should keep in mind that only a relatively small number of wrecks have been preserved in situ.

Footnotes:
129 One can think of the need to sail under class (for insurances) and the consequent costs for renting a ship, but also the differences in dive regulations.
131 In China, the costs for renting a ship during the excavation of the Nan’ao No.1 shipwreck was 80,000 Yuan ($12,310) per day (www.whatsonxiamen.com/news19118.html accessed 30-01-2017).
situ, in different environments and mitigating against different threats. This is reflected in the methods and techniques chosen and also the costs of protection.

The Stora Sofia in Sweden has been preserved in situ against the oxygen-rich environment, the dynamic seabed and attack by shipworm by covering the site with gravel and rubber matting.\(^{133}\) The work on this 40 metre long wreck took 10 days and cost 71,000 euros. This is very much in line with the costs for the protection of the BZN 10 wreck in 2009, also approximately 40 metres long, using debris netting. Although work was done on site prior to this and also afterwards,\(^{134}\) the protection measures took 10 days with a total cost of approximately 70,000 euros (See Table 5.3). The reasons for protecting the site were also similar: it was a shipwreck that had partly emerged from the seabed in a dynamic environment, with abrasion and the Teredo navalis as the main degraders.

In comparison, smaller wreck sites seem to be more expensive to preserve per metre in length. The Zakynthos Wreck in Greece, for example, is only 15 metres long. Its protection of geotextile, sandbags and gravel required 35,000 euros, while the protection of the 8 metre long Hårbølle Wreck in Denmark cost 46,000 euros.\(^{135}\) However, interestingly, if we take the GDP of Greece and Denmark into consideration and the length of the wrecks as well, then suddenly the costs of these two wrecks are very much comparable.\(^{136}\) Fieldwork in both cases took 7 days.

### 5.7.1 A breakdown of costs: the Burgzand Noord 10 example

As noted above, the in-situ protection of the BZN 10 wreck executed in 2009 in the Dutch Western Wadden Sea cost roughly €70,000. The site was first protected in situ in 2001. Geophysical monitoring of the area in 2009, however, revealed strong erosion and damage around the already physically protected site. The Cultural Heritage Agency of the Netherlands thus decided to act by repairing and extending the physical protection of the BZN 10 wreck. A diving team was appointed to protect the wreck from erosion due to the tidal currents. The method applied to the site was the same as before: debris netting (scaffolding nets), aimed to accumulate and cover the remains with sediments. The team was made up of 4 professional divers and 1 maritime archaeologist. The work was done in 2 weeks (10 diving days) and in that period a protected layer of debris netting was re-installed over the whole site. The largest expenditures were the personnel costs, ship and diving equipment.

The list above clearly shows the differences in expenditure between personnel (42%), boat rental (25%), dive materials (20%), travel, food and lodging costs (10%) and material costs (no more than 3% of the total cost).

Artificial seagrass was also tested on the BZN 10 site in 2013 and 2014.\(^{137}\) The methodology of placing mats of 2.5 x 5 metres prepared with artificial seagrass fronds was developed for the offshore industry, initially for the protection of underwater pipelines. With a large frame, mat after mat can be installed on the seabed by just one diver. This considerably lowers the personnel costs. The mats themselves are, however, still very expensive, costing approximately 80 times more than polypropylene nets.\(^{138}\) These huge initial costs make them too expensive for most archaeological projects to use at the moment.\(^{139}\)

### 5.8 To excavate or not, that is the question

Whether to excavate and ultimately raise a historical shipwreck or not, is a topic that generates long discussions, and the decision is often dependent on many parameters. The reality is that in addition to intrinsic values, economics and budgets are also important factors. Working professionally, for example according to the Annex of the UNESCO Convention, demands the planning and full financing of the project in advance.\(^{140}\) Careful analysis of

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Specific costs (€)</th>
<th>Total Cost (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel, food and lodging</td>
<td></td>
<td>7,000</td>
</tr>
<tr>
<td>Personnel</td>
<td></td>
<td>30,000</td>
</tr>
<tr>
<td>Professional diver/ day</td>
<td>6,50</td>
<td></td>
</tr>
<tr>
<td>Maritime archaeologist/day</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>Ship (excluding outward/return journey)</td>
<td></td>
<td>17,500</td>
</tr>
<tr>
<td>Equipment (diving gear, containers, compressor, etc.)</td>
<td></td>
<td>14,000</td>
</tr>
<tr>
<td>Material for protection (cable ties, scaffolding nets, labels, etc.)</td>
<td></td>
<td>1,500</td>
</tr>
<tr>
<td>Scaffolding nets (roll of 3 x 50 m)</td>
<td>120</td>
<td>70,000</td>
</tr>
</tbody>
</table>

\(^{133}\) See Chapter 3.

\(^{134}\) Coenen et al. 2013.

\(^{135}\) Manders (ed.) 2011, 42.


\(^{137}\) See Annex, Rules 9, 10, 17, 18 & 19.

\(^{138}\) Denise net are approximately €0.80 per square metre, while commercially made seagrass fronds cost €64 per square metre.

\(^{139}\) For example, protection of 2000 m² (40 x 50 metres) would cost €1600 with debris nets, but €128,000 with artificial seagrass mats.

the economic consequences of excavation and subsequent raising of the wreck or certain parts is important. What will be done with the parts after removal? Will they be preserved? Restored? Or will they be reburied or even destroyed? The calculation of the costs of an excavation and subsequent treatment is not yet standard procedure but generally the costs will be known or estimated to some extent. However, the real costs of in-situ preservation are often less known and also not formally considered before making a decision. Funding needed for conservation and especially restoration of these kinds of large objects often depend on public participation.  

More often than being physically protected, sites are left in place unmonitored and without any mitigation measures taken. The consequence is that many wrecks are subject to continuous degradation until they disappear. The process is often invisible as it takes place in the sea, out of the public eye. This is the cheapest option of all, as any mitigation measures cost money. The costs of in-situ protection can only be roughly compared to those associated with the physical raising of a shipwreck, its full conservation and display to the public in a suitable museum setting. There are some difficulties in determining the true costs of such activities as only a few wrecks worldwide have been protected in situ, and only a few large size wrecks have been excavated, raised, conserved and exhibited.

However, we have indications that there is a great difference between the initial costs of in-situ preservation, ongoing in-situ protection itself and the costs of the raising and ex-situ conservation of a wreck. Nevertheless, again there are also huge differences depending on the site. The physical protection of a wreck with polypropylene nets in the Western Wadden Sea costs about 70,000 euros (as we have seen in Table 5.3), while an excavation will cost millions. In-situ preservation also means regular monitoring and maintenance (the frequency is dependent on such factors as the type of protection, activities in the area, climate and environment). Each monitoring visit costs at least 3,000 euros (see Chapter 6). While this may add up in the long run, excavation and conservation, storage or display of artefacts and maintenance of a collection throughout the years will also incur ongoing costs.  

With respect to in-situ protection, it is always important to have a management plan to keep track of activities and changes on site. Active in-situ protection implicitly means that a site has been valued highly and is ‘worth’ preservation. Therefore, it should be taken care of: monitoring will always be required afterwards. Measures to mitigate against threats will also have to be taken. Physical protection or site stabilization may have to be deployed. In-situ preservation, in general, and protection in particular, not only maintain the site in the environment that has preserved it for many years – thus, if not changed, in favourable conditions – it also keeps it connected to the environment, the landscape it belongs to.

If we take this into consideration, this also means that management should be executed on a larger scale, exceeding the site (e.g. wreck) alone. In-situ preservation should, therefore, not just concern the management of a single site, but take an area approach to preserving sites in their context. This may concern a multiple number of sites, or a chain of sites that are geographically or historically related. Keeping this in mind, the costs of in-situ preservation add up. To be able to accredit values to sites, one needs to have knowledge, which can only be gained through research. Therefore, although in-situ preservation may be considered the first option, it does not absolve us from doing research.

141. See, for example, the public financial support for the Mary Rose in the UK (http://www.maryrose.org/why-we-need-your-support/, accessed 16-10-2015), but also the conservation of the Zwammerdam ships in the Netherlands (Leidse Courant, 7 October 1985, 8 [http://leiden.courant.nu/issue/LLC/1985-10-07/edition/0/page/8?query=Romeins%20Castellum&sort=relevance, accessed 30-01-2017]).
142. See also Chapter 7.
143. See, for example, the Mary Rose in the UK and the Vasa in Sweden as examples of large ships that have been excavated, conserved and exhibited. A much smaller example is the Bremen cog in Germany.
144. See Chapter 6.
145. See Chapter 3.
146. See Chapter 5.
147. See Chapter 5.
5.8.1 Costs of ex-situ preservation

Only a few shipwrecks in the world have been raised from a sea, river or lakebed and subsequently conserved and put on display. The warships Vasa in Sweden and the Mary Rose are probably the best known examples (Fig. 5.21). In northern Europe, there is also the Bremen Cog and the Viking ships from Roskilde (Fig. 5.22 A + B). In early 2016, a medieval cog was raised from the IJssel river, it will be conserved, restored and put on display in the municipality of Kampen (Fig. 5.23). Well-known examples are the Kyrenia, Yassi Ada I and Serçe Limani in Turkey, the Ma’agan Mikael in Israel, and the Grado and Gela in Italy. Outside Europe, we can think, for example, of the stern section of the Batavia in Australia (Fig. 5.24) and the Nanhai 1 wreck in China. This small number of shipwrecks exhibited to the public today, indicate the high costs involved and the long-term commitment to such a process. This commitment often absorbs all capacity within an institute, which may lead to a monological approach within a country, focusing on one site. This may create problems for the overall management of the underwater cultural heritage in a country.

When attempting to estimate the costs of raising a wreck, we must rely on the facts and figures related to previous projects and the costs of subsequent steps in the ongoing process. As most of these projects have been extremely large and the finances never fully secured, they were executed over several decades, using many different sources of funding and also the voluntary aid of many people. The decision to raise the Vasa in 1961, for example, was not determined by economic factors, but rather driven by enthusiasm and patriotism. The Viking ships in Roskilde fjord were a similar case, excavated in 1962, as was the Mary Rose in 1980. The decisions we make today may be no different; however, the long-term financial implications will often need to be known before taking the step to raise the wreck. Risk assessments are a very important part of this exercise. Looking at the cases of the Mary Rose and the Vasa, it is apparent that the well-known examples have been undertaken if they had to do so in advance.

References

148 This is the idea at the moment. Research on the quality of the wood and the additional information acquired from excavation should reveal if this is plausible.


150 For the Viking ships in Roskilde, see Olsen & Crumlin-Pedersen 1990. For the Mary Rose, see, for example, Marsden 2003.

151 The decision to raise the Vasa in 1961, for example, was not determined by economic factors, but rather driven by enthusiasm and patriotism. The Viking ships in Roskilde fjord were a similar case, excavated in 1962, as was the Mary Rose in 1980. The decisions we make today may be no different; however, the long-term financial implications will often need to be known before taking the step to raise the wreck. Risk assessments are a very important part of this exercise. Looking at the cases of the Mary Rose and the Vasa, it is apparent that the
5. How do we physically protect underwater heritage sites in situ?


However, for other shipwrecks, the situation may not be as positive. The fact is that the daily costs of storage, maintenance and display might severely strain the budget of a smaller museum.

Not all negative or positive effects can be sufficiently anticipated when deciding whether to excavate, conserve and display a wreck. Indirect positive effects might for example also include the creation of awareness, identity building and capacity building in underwater cultural heritage, as well as in underwater archaeology and conservation. It is also difficult to quantify the effect of gaining knowledge. We can only estimate the economic effect of a country or city becoming known for some reason and thus triggering tourist traffic. Promotion and pride related to the raising of a ship should be part of the strategy of promoting an area for example. All these factors have a long-term effect and cannot always be easily identified and related directly to investment in excavating, raising and conservation of a specific wreck.

The whole process of ex-situ conservation, restoration and exhibition thus encompasses many parameters. Firstly, there is the underwater work before the decision is even made to raise a wreck. Secondly, the wreck and its content needs to be investigated and a decision about whether to raise the wreck completely, excavate first and/or only remove parts must be made. Thirdly, it is also important to determine the condition of a wreck (its structural condition and the condition of the wood and metal elements itself), as this can help us determine what kind of support is required and what kind of conservation strategy is demanded. This may require extensive sampling and laboratory research. The depth of the find layers in the wreck will also help to determine the weight of the wreck and also how many objects may have to be raised and conserved. The question connected to this is whether these objects will be conserved, reburied or destroyed after they have been removed.

Determining the reasons for removal will help to identify the essential elements of the wreck site. This, in turn, will help keep costs down and focus on what is of real importance. Scientific questions (often related to why a wreck will be raised) have to be addressed for the same reason: What do we really need to know and what would be nice to know? Physical circumstances are of course important when raising and investigating a ship (visibility, currents, depth, temperature). They will, for example, determine...
your time underwater, your ‘perception grid’ (how much you can know before you start removal). The same can be said in relation to other issues related to diving, such as policies and laws.

Archaeologists can research, document and register every part of the ship on land or under water. Working on land is often quicker, safer and provides more detail (larger perception grid). All these decisions also have to be made. Conservators start by cleaning and storing the wood in water tanks. After cleaning and documenting, the conservation treatment can start. This may be done by impregnation with polyethylene glycol (PEG), but other methods are also used. This process could take from two to ten years, depending on the physical state of the wood, the method used and the process of drying, either by freeze-drying or controlled drying. After treatment, the wooden parts are again cleaned and the restoration process starts. This is the moment that parts of the construction, if necessary, are put together and the wreck is remodelled with attention to the aesthetic elements: it is prepared for exhibition. Special support construction for the timber and climatic control of humidity in the building is a requirement.

Wrecks can be conserved for storage or display. In the latter case, conservation must be followed by the restoration process. The work connected to the display of a wreck creates an enormous difference in costs. For example, the exhibition of a wreck will – if it is as complete as expected and the condition of the wood is good – be conserved afterwards. For more information, see http://www.mandersonline.com/ (accessed 30-01-2017). The IJssel cog was excavated in 2015 and raised in February 2016. The total cost is about €77 million. This is excluding the new building for the display, while the in-situ protection of the BZN 10 wreck on the Burgzand in 2009 cost around 0.07 million euro. While the BZN 10 will be kept in its ‘original’ context, and in some cases this even provides better temporary protection against degradation than the raising of a wreck, it may not fulfill the wishes of a larger group of stakeholders who would like greater enjoyment of it. The ‘power’ of enjoyment is discussed in Chapter 7.

It is important to understand that the costs of in-situ protection, as is shown above in relation to the BZN 10, concern only one step in the entire in-situ protection strategy, as laid out in the Croatian, Christopher Dobbs of the Mary Rose Trust outlined the total costs related to the Mary Rose. He was able to divide them into following categories: £2.8 million (€3.9 million) for the raising of the ship £6.1 million (€8.5 million) for management to date £4.2 million (€5.8 million) for impregnation/conservation of the hull (estimation) Thus, a total of £13 million (about €18 million) for raising and conservation. Much of the underwater excavation work was done on a voluntary basis, and was not included. This work was estimated at 11.5 person months in active diving time, which can be roughly estimated to cost £8 million (€11 million). Future costs for an adequate building for display are estimated at £35 million (about €48 million) not including all services. If we summarize the costs and include diving and building, the estimated total cost is about £77 million. This is excluding the new building for the Mary Rose that opened its doors in 2013. The £70,000 for the BZN 10-wreck does not include the costs of other protection measures and monitoring.
management plan for the site (Fig. 5.26). For some wrecks, a single protective action may be sufficient, alongside regular monitoring and repairs. However, for the BZN 10 wreck, several such actions were needed and will be needed in the future. Long-term commitment will thus increase the overall cost of in-situ preservation. At the same time, this can also be argued in the case of the Mary Rose and other cases of ex-situ preservation. One important difference, however, is that these wrecks can be easily seen and will provide income for a larger group of people, while shipwrecks protected in situ often remain out of sight and, if accessible, then only to a small number of people. A small income stream may be generated by accommodating specialized programmes for sports divers, etc. (see Chapter 7). The success of these activities, however, also relies on other parameters, such as accessibility of the area and the site, visibility under water and local dive operators.

5.9 Avoiding the dualism: excavation is an option

Although most legal and policy frameworks emphasize that protection of the underwater cultural heritage in situ should be seen as a first option (and priority), excavation is still an option. Excavations may be expensive – as we have seen – but they also serve an important purpose. One significant aspect of archaeology includes investigating material culture in order to learn from the past. Ultimately, this is what archaeologists want and what they are trained for. Investigation may result in partial or complete excavations. After on-site recording, objects are retrieved for later archaeological analyses, conservation, storage and display. The same principles theoretically apply to underwater archaeology. However, underwater archaeologists are subjected to many practical difficulties in the aquatic environment which require specific personnel and technical equipment.

When a new underwater site is located, priorities have to be set. As we have seen above, the costs associated with the retrieval of a shipwreck are huge and, therefore, stakeholders who are responsible for the protection and management of cultural heritage must make decisions on the best approach to a specific object or site.

There are at least six obvious alternatives for managers of cultural heritage to consider, including excavation:

1. A wreck can be preserved for future generations in situ
2. A wreck can be preserved in situ temporarily until planned excavation
3. A wreck can be excavated, raised and conserved
4. A wreck can be excavated and reburied
5. A wreck can be excavated and the physical material destroyed afterwards
6. A wreck can be left under water without intervention

The decision about what to do often depends on the funding available for the project, but there are many ways to make good and acceptable decisions. Most important is that the project is managed and discussed in a cross-disciplinary context involving multiple stakeholders such as archaeologists, conservators, divers, engineers, geophysicists and cultural heritage managers.

Internationally, the Annex (or code of good practice) of the UNESCO Convention for the Protection of the Underwater Cultural Heritage (Paris, 2001) stipulates all the steps that should be considered when dealing with intrusive research. In the

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165 See Chapter 3.
166 See also Catsambis et al. 2011, 1045.
167 See, for example, the arrangements made with local dive shops in Croatia: http://icu.hr/en/underwatersitesandmuseums (accessed 30-01-2017).
168 See, for example, the international agreements of the UNESCO Convention for the Protection of the Underwater Cultural Heritage (Paris, 2001), and the Valetta Treaty (Valletta, 1996).
169 See also the discussion on archaeology vs cultural heritage management in Chapter 2.
170 Either selected as being worth protecting or deselected and not taken into consideration.
Netherlands, the Quality Standards for Dutch Archaeology do the same. 172

There are thus several reasons to choose in-situ protection or excavation. In-situ preservation, protection, conservation and stabilization are – as is excavation – tools for the management of our enormously rich cultural heritage. It is important to look for a balance between the different measures that can be taken. Excavation is part of the archaeology toolbox, while in-situ preservation, conservation or site stabilization are not. 173 These are tools of cultural heritage management. Thus, there is an essential difference between the two. While archaeology strives to reconstruct what has happened by studying the material witnesses of this past, cultural heritage management is the profession that deals with the management of these material witnesses in the present. In-situ preservation is one of the tools of cultural heritage management and essential when dealing with this extreme abundance of heritage in a responsible way.

5.10 Conclusions on methods used for in-situ preservation and future directions

In the last two decades, the predominant focus in underwater archaeology has been on in-situ preservation and the development of appropriate policies and legislation to politically galvanize these trends. However, in-situ preservation is not as straightforward as it seems, posing many significant questions for those considering this option. For example, what are the major degradation factors affecting a shipwreck site and what techniques can be suitably employed to halt or at least decrease the rate of deterioration? It should be clear that in-situ preservation often requires active involvement, using different – often tailor-made – conservation and protection methods.

In the last 20 years, many experiments using different protection techniques have been undertaken in as many different environments. Some of these protected sites have been little monitored, while almost no pre- nor post-reburial monitoring has been undertaken, which makes evaluation of this particular technique extremely difficult and almost impossible. Some general rules, however, can be drawn up based on the many projects executed, including those in the Western Wadden Sea.

Firstly, mitigation must focus on the most degrading factors. If possible, different threats should be prevented or inhibited using one method. Secondly, in addition to mitigation against the most significant physical-mechanical, biological, chemical and human threats, it is also very important to determine why the site should be preserved and what value(s) we think should prevail, because a site will be preserved in a different way depending on whether it needs to be protected for future research or so it can be enjoyed by sports divers. The protection of underwater archaeological sites will always be, in part, individually customized to accommodate the unique qualities of each site.

The in-situ preservation or reburial of archaeological remains should be envisaged as a tool that may be utilized in an overall management strategy and not as a means to an end in itself. At present, in-situ management strategies are often reactive, that is, a site is discovered because it has been exposed and then a decision about how the site will be managed must be made. Therefore, in the coming years, the search for techniques that can discover sites before they are exposed and begin to deteriorate will be the challenge. If successful, we will be able to better protect archaeologically valuable sites before active deterioration occurs. In addition, by being able to look into the seabed, the site may be better connected to the surrounding area with its former contemporary seabed surfaces. Its value – being truly in situ and still part of the historical seabed layers – can be established without excavation.

An issue that must be discussed among scholars is the possibility of the in-situ preservation of intact sunken ships. These vessels can hardly be considered ‘wrecks’, since they stand almost completely upright on the seabed. This issue is more relevant in some parts of the world. For example, the Baltic, the Arctic, the Black Sea and the Great Lakes are known to have such well-preserved sites. They are in very stable environments with near anoxic conditions. Due to climate change, these vessels may be threatened by new degradation factors and burial may not be a logistically viable option. Well-preserved shipwreck sites may also be found in other areas. Dynamic areas such as the Goodwin Sands in the UK, the Southern Delta and the Wadden Sea in the Netherlands may have led to wooden shipwrecks being rapidly buried by natural processes. Examples include the Stirling Castle (1703) on the Goodwin Sands and the Roompot (1853) in the Southern Delta of Zeeland in the Netherlands. The Stirling Castle has been well preserved for almost two centuries, but is now under major threat due to natural erosion on site, while the Roompot has managed to stay covered by sediment for about 150 years. The same kinds of well-preserved shipwrecks may be found in the Western Wadden Sea at those places where the seabed has been stable for a long period of time. In fact, this potential has already been proven by the discovery of the seventeenth-century BZN 17 wreck, which is preserved up to its first deck. 174

173 This view is not supported by all archaeologists. See, for example, Schute et al. 2011, 22. A parallel can be seen in the commonly used expression that ‘…the archaeology in the ground has to be preserved’. This is, in my view, a misreading of definitions, since objects and traces (and when assessed, cultural heritage) can be found in the ground and archaeology is the methodology used to investigate this.
Even if well-preserved ships remain in reasonably stable environments, the question of what to do with them still remains. At great depths (e.g. the Ghost Wreck, the Titanic), in remote places (e.g. the Arctic) and covered in sediment, it is not likely they will be easily enjoyed by sports divers, and should this be the case, it would pose an immediate threat to the sites. The main threat to well-preserved sites in stable environments may well be the slow but continuous bacterial degradation. Even metal shipwrecks face such threats. Ex-situ preservation in the form of removal and conservation is extremely expensive, but the different options have to be considered and a management plan, including a decision-support system, should be in place. The reasons for protecting a site in situ or not, should be clear to archaeologists, conservators, scientists, policymakers and the general public. This means that universal criteria should be developed and adopted by the maritime archaeological community.

If we look at the cost of in-situ preservation it is evident that, especially in Europe, personnel costs are the highest, while the in-situ protection materials (not produced in Europe) are often the cheapest. When we consider preservation in situ, there are a few other key issues that need to be addressed, some before we take the decision to do so, some during and some afterwards.

A discussion may arise on the difference between reburial and in-situ protection. In a way, most in-situ protection techniques will result in the reburying of a site. Most of the sites that have been discovered are uncovered due to erosion processes. After excavation seasons, sites have to be protected and reburial often takes place. Entire wrecks or various objects may also be removed and reburied at a different location from where they were found. Here, there is a difference between the two, since in-situ protection entails the preservation of the site itself, the original place of deposition.

This brings us to the issue of shipwrecks as sites versus archaeological landscapes that include shipwrecks. Shipwrecks are connected to the location in which they are found, in one way or another. They are connected to the landscape and combined with it they form the history of the place. If we consider shipwrecks as accidental finds, then there is no connection whatsoever to the place and only the wrecks themselves are the focus of concern, orphaned from their surroundings.

Although well-functioning techniques have been developed for underwater in-situ protection, there is still a major problem with how to deal with well-preserved shipwrecks that are surfacing the seabed for several metres. Ships standing with their masts still upright can be found in some places in the world, but usually not in the Wadden Sea due to its more violent conditions. However, even here, large well-preserved constructions might be found. The fact that there are such examples in the comparable Southern Zeeland Delta and the Goodwin Sands suggest this could well be the case. It may not happen that often, but when it does the mitigation activities should be focused on the fact that these sites are unique and thus that a unique response is required, such as the decision to raise the wreck.

The choice of whether to preserve in situ or not, will not only depend on the comparison of the direct costs of in-situ preservation and excavation. There are other issues and costs involved as well. They may, for example, concern the costs of avoiding the site (see Valletta Treaty), or the possible dangers a wreck creates by leaving it on the seabed. However, there is also the question of what we might gain by exhibition. Here, it is apparent that excavation will remain an option. Thus, in-situ preservation and excavation are both tools of cultural heritage management.

It is important to constantly ask: Why do we want to preserve sites in situ? Moreover, it is also important to identify who wants to do so. We have to acknowledge that there are different views about what in-situ preservation entails. These views may change from stakeholder to stakeholder, because definitions have not been set in stone and different actors will have their own ideal system. This may range from a cheap method to deal with cultural heritage, to the need to have a decision-support system with management plans in place to responsibly manage our underwater cultural heritage. The reasons behind a decision to undertake in-situ preservation may therefore not be exactly the same for each stakeholder or for each site. We need, therefore, to determine what these reasons are and start discussions with different stakeholders before implementing any in-situ protection methods. If we do not, we may end up with a heritage that is too expensive to maintain or that is managed against the wishes of other stakeholders. Ultimately, this may mean losing them as shareholders of this heritage.


176 See Pater & Manders 2009.