Underwater archaeology

Contents

- 1 Research Potential
- 2 UNESCO Convention
- 3 Challenges
- 4 Techniques
  - 4.1 Position fixing
    - 1 Search patterns controlled by ropes and lines
      - 1.1 Circular search
        - 1.1.1 Procedure
        - 1.1.2 Variations on the circular search
        - 1.1.3 Safety
      - 1.2 Jackstay search
        - 1.2.1 Procedure
        - 1.2.2 Variations on the jackstay search
        - 1.2.3 Safety
      - 1.3 Snag-line search
    - 2 Search patterns controlled by compass directions
      - 2.1 Spiral box search
        - 2.1.1 Procedure
        - 2.1.2 Applications
      - 2.2 Compass grid search
        - 2.2.1 Procedure
        - 2.2.2 Applications
      - 2.3 Ladder search
      - 2.4 Swim-line search
    - 3 Searches directed from the surface
      - 3.1 Directed search using line signals or voice communications
      - 3.2 Towed searches
    - 4 Searches using special equipment
      - 4.1 Searches using hand held submersible sonar transponders
    - 5 Other search patterns
      - 5.1 Current drift search
    - 6 Depth contour search
    - 7 Communication
  - 4.2 Site survey

    - 4.3 Recording
    - 4.4 Excavation
    - 4.5 Archaeological science
    - 4.6 Artifact recovery and conservation
    - 4.7 Interpretation and presentation of underwater archaeology
- 5 Publications

Underwater archaeology is archaeology practiced underwater. As with all other branches of archaeology it evolved from its roots in pre-history and in the classical era to include sites from the historical and industrial eras. Its acceptance has been a relatively late development due to the difficulties of accessing and working underwater sites, and because the application of archaeology to underwater sites initially emerged from the skills and tools developed by shipwreck salvagers. As a result underwater archaeology initially struggled to establish itself as bona fide archaeological research. The situation changed when universities began teaching the subject and when a theoretical and practical base for the sub-discipline was firmly established. Underwater Archaeology now has a number of branches including, after it became broadly accepted in the late 1980s maritime archaeology: the scientifically based study of past human life, behaviours and cultures and their activities in, on, around and (lately) under the sea, estuaries and rivers. This is most often effected using the physical remains found in, around or under salt or fresh water or buried beneath water-logged sediment. In recent years the study of submerged WWII sites and of submerged aircraft in the form of underwater aviation archaeology have also emerged as bona fide activity.

Though often mistaken as such, underwater archaeology is not restricted to the study of shipwrecks. Changes in sea-level, because of local seismic events, such as the earthquakes that devastated Port Royal and Alexandria, or more widespread climatic or changes on a continental scale mean that some sites of human occupation that were once on dry land are now submerged. At the end of the last ice age the North Sea was a great plain, and anthropological material, as well as the remains of animals such as mammoths are sometimes recovered by trawlers. Also, because human societies have always made use of water, sometimes the remains of structures that these societies built underwater still exist (such as the foundations of crannogs, bridges and harbours) when traces on dry land have been lost. As a result, underwater archaeological sites can include a vast range including: submerged indigenous sites and places where people once lived or visited, that have been subsequently covered by water due to rising sea levels; wells, cenotes, wrecks (shipwrecks; aircraft); the remains of structures created in water (such as crannogs, bridges or harbours); other port-related structures; refuse or debris sites where people disposed of their waste, garbage and other items such as ships, aircraft, munitions and machinery, by dumping into the water.

Underwater archaeology is often complementary to archaeological research on terrestrial sites because often the two are linked by many and various elements including geographic, social, political, economic and other considerations. As a result a study of an archaeological landscape can involve a multidisciplinary approach requiring the inclusion of many specialists from a variety of disciplines including prehistory, historical archaeology, maritime archaeology, anthropology. There are many examples. One is the wreck of the VOC ship Zuytdorp lost in 1711 on the coast of Western Australia and where there remains considerable speculation that some of the crew survived and after establishing themselves on shore intermixed with Indigenous tribes from the area. The archaeological signature at this site also now extends into the interaction between indigenous people and the European pastoralists who entered the area in the mid 19th century.

Research Potential

There are many reasons why underwater archaeology can make a significant contribution to our knowledge of the past. In the shipwreck field alone individual shipwrecks can be of significant historical importance either because of the magnitude of loss of life (such as the Titanic), or circumstances of loss (*Housatonic* was the first vessel in history sunk by an enemy submarine). Shipwrecks, such as *Mary Rose*, can also be important for archaeology because they can form a kind of accidental time capsule, preserving an assemblage of human artifacts at the moment in time when the ship was lost.

Sometimes it is not the wrecking of the ship that is important, but the fact that we have access to the remains of it, especially where the vessel was of major importance and significance in the history of science and engineering (or warfare), due to being the first of its type of vessel. The development of submarines, for example, can be traced via underwater archaeological research, via the *Hunley* which was the first submarine to sink an enemy ship (*Hunley* also had unique construction details not found in previous vessels and was one of the only historic warships ever raised intact), the Resurgam II, the first powered submarine, and Holland 5, which provides insight into the development of submarines in the British Navy.

UNESCO Convention

All traces of human existence underwater which are one hundred years old or more are protected by the UNESCO Convention on the Protection of the Underwater Cultural Heritage. This convention aims at preventing the destruction or loss of historic and cultural information and looting. It helps states parties to protect their underwater cultural heritage with an international legal framework.

Challenges

Underwater sites are inevitably difficult to access, and more hazardous, compared with working on dry land. In order to access the site directly, diving equipment and diving skills are necessary. The depths that can be accessed by divers, and the length of time available at depths, are limited. For deep sites beyond the reach of divers, submarines or remote sensing equipment are needed.

For a marine site, while some form of working platform (typically a boat or ship) is often needed, shore-based activities are common. Notwithstanding, underwater archaeology is a field plagued by logistics problems. A working platform for underwater archeology needs to be equipped to provide for the delivery of air for example, recompression and medical facilities, or specialist remote sensing equipment, analysis of archaeological results, support for activities being undertaken in the water, storage of supplies, facilities for conservation for any items recovered from the water, as well as accommodation for workers. Equipment used for archaeological investigation, including water dredge and air lifts create additional hazards and logistics issues. Moreover, marine sites may be subject to strong tidal flows or poor weather which mean that the site is only accessible for a limited amount of time. Some marine creatures also pose a threat to diver safety.

Underwater sites are often dynamic, that is they are subject to movement by currents, surf, storm damage or tidal flows. Structures may be unexpectedly uncovered, or buried beneath sediments. Over time, exposed structures will be eroded, broken up and scattered. The dynamic nature of the environment may make in-situ conservation infeasible, especially as exposed organics, such as the wood of a shipwreck, are likely to be consumed by marine organisms such as piddocks. In addition, underwater sites can be chemically active, with the result that iron can be leached from metal structures to form concretions. The original metal will then be left in a fragile state. Artifacts recovered from underwater sites need special care.

Visibility may be poor, because of sediments or algae in the water and lack of light penetration. This means that survey techniques that work well on land (such as triangulation), generally can not be used effectively under water.

In addition it can be difficult to allow access to the results of the archaeological research as underwater sites do not provide good outreach possibilities or access for the general public. Work has been done to bridge this difficulty with the advent of the WWW and direct streaming of projects. Another example is the excavation of the *Queen Anne's Revenge*.

Techniques

Although specialised techniques and tools have been developed to address the challenges of working under water, the archaeological goals and process are essentially the same as in any other context. Investigating an underwater site however, is likely to take longer and be more costly than an equivalent terrestrial one.

An important aspect of project design is likely to be managing the logistics of operating from a boat and of managing diving operations. The depth of water over the site, and whether access is constrained by tides, currents and adverse weather conditions will create substantial constraints on the techniques that can feasibly be used and the amount of investigation that can be carried out for a given cost or in a set timescale. Many of the most carefully investigated sites, including the *Mary Rose* have relied substantially on avocational archaeologists working over a considerable period of time.

As with archaeology on land, some techniques are essentially manual, using simple equipment (generally relying on the efforts of one or more scuba divers), while others use advanced technology and more complex logistics (for example requiring a large support vessel, with equipment handling cranes, underwater communication and computer visualisation).

Position fixing

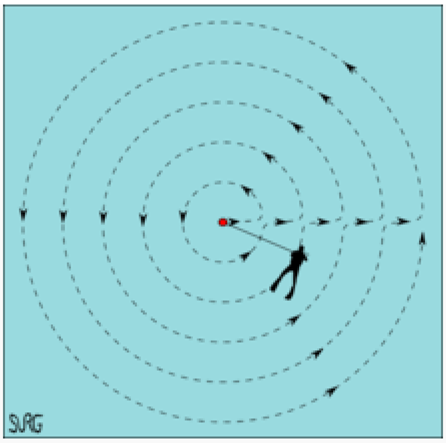
Knowing the location of an archaeological site is fundamental to being able to study it. In the open sea there are no landmarks, so position fixing is generally achieved using GPS. Historically, sites within sight of the shore would have been located using transects. A site may also be located by visually surveying some form of marker (such as a buoy) from two known (mapped) points on land. The depth of water at a site can be determined from charts or by using the depth sounding sonar equipment that is standard equipment on ships. Such sonar can often be used to locate an upstanding structure, such as a shipwreck, once GPS has placed the research vessel in approximately the right location.

Underwater searches are procedures carried out by divers in order to find a known or suspected target object or objects in a specified search area under water. There are a number of techniques in general use by Commercial, Scientific, Public service, Military, and Recreational divers. Some of these are suitable for Scuba, and some for surface supplied diving. The choice of search technique will depend on logistical factors, terrain, protocol and diver skills.

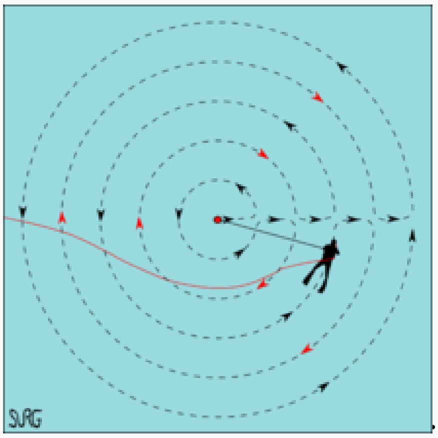
As a general principle, a search method attempts to provide 100% coverage of the search area. this is greatly influenced by the width of the sweep. In conditions of zero visibility this is as far as the diver can feel with his hands while proceeding along the pattern. When visibility is better, it depends on the distance at which the target can be seen from the pattern. In all cases then, the pattern should be accurate and completely cover the search area without excessive redundancy or missed areas. Overlap is needed to compensate for inaccuracy.

Search patterns controlled by ropes and lines

Circular search

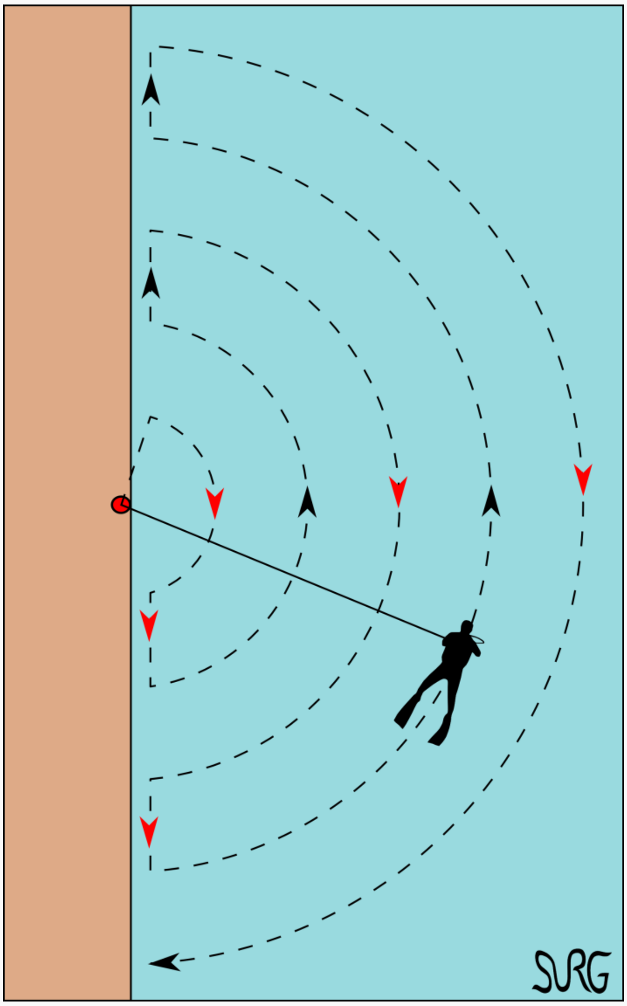


Standard circular search pattern



..

Circular search pattern modified to avoid twisting or fouling an umbilical or lifeline



Pendulum search pattern along a wall

An underwater circular search is a procedure conducted by a diver swimming at a series of distances (radii) around a fixed reference point. The circular search is simple and requires little equipment. It is useful where the position of the objects of the search is known with reasonable accuracy.

Procedure

The general procedure is to start from a fixed central point, and to search the circumference of a circle where the radius is defined by a search line anchored at the central point. The radius of the circle is dependent on visibility, and is increased after each circle has been completed, by an amount which allows the diver to either see or feel an overlap between the current arc and the previous arc.

One end of the distance line is carried by the diver and the other is attached to the datum position by any appropriate method. E.g. clipped to the base of a shot line, pegged into the bottom, tied to a fixed object on the bottom or held by another diver. The diver may tow a surface marker buoy if conditions allow.

The diver unreels a section of distance line appropriate to the visibility and mark his start position by a peg, loose marker, compass heading, or a pre-laid marker line extending outwards from the datum position. Then, keeping the line taut, the diver swims in a circle with the line as radius, searching visually or by feel until back at the start position. He then unreels another section of line of the same length and repeats the procedure until he finds the object, runs into obstacles or runs out of line, air or time.

The amount of distance line increment for each sweep should allow some overlap of sweeps to avoid the risk of missing the target between sweeps.

If a buddy is involved the most efficient place is alongside the controlling diver on the line, and the extension of distance line for each sweep can be roughly doubled.

Depending on the circumstances, control of the pattern may be from the surface, from a diver at the central point, or by the diver at the end of the search line, who would in that case control the search line reel.

Variations on the circular search

In some cases a second diver can anchor himself to the bottom and act as both the central point and line tender. The diver and line tender communicate with each other using line pull signals. When the diver has completed a full revolution of the search, the tender signals the diver and advances another section of line so the search can be expanded further from the central point.

Another variation uses more than one diver along the search line. The divers are evenly spaced at a distance depending on visibility, and the increase in radius allows overlap of search area only for the innermost diver on the line. This variation becomes more difficult to coordinate with a larger number of divers, particularly in poor visibility

A major variation on the circular search is the **pendulum search**, also known as the **arc** or **fishtail search** in which the diver stops and changes direction at the end of each arc. This is used when there is insufficient space to complete a circle, as when controlled from the shore, or when the search area is limited to a sector to one side of the control point, or there is a major obstruction limiting the extent of the searchable sector. Divers on surface supply may change direction at the end of each arc even when using a full 360° pattern to avoid twisting the umbilical. The pendulum search can also be done with more than one diver on the search line, but this requires considerable skill and co-ordination, particularly in low visibility.

Another variation is used where the target is large enough to snag the search line, In this case the diver may go out to the full radius of the search area and make a single sweep, hoping to snag the target with the line. If on his return to the start line or bearing, he finds he is closer to the centre point, he will swim back along the line in the expectation of having snagged something. With some luck it will be the target of the search.

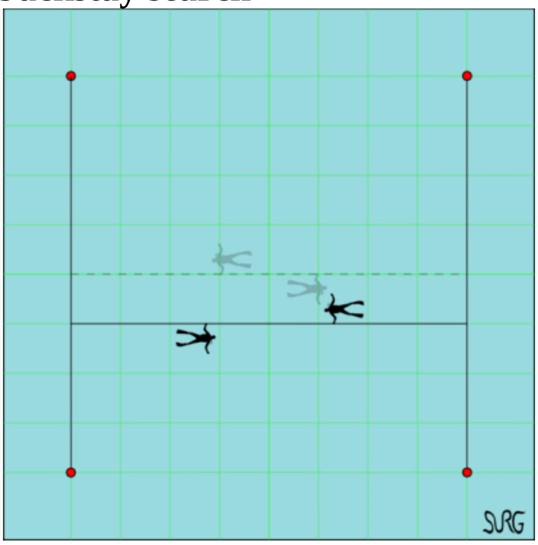
If the target is not found by the time the search pattern has reached maximum convenient radius, the centre point may be shifted and another search started. This can be repeated as often as necessary, but the positions of the centre points must be chosen to allow the full search area to be covered. This implies quite a lot of overlap, and the pattern is not efficient. The most efficienct pattern uses an equilateral triangular grid, but this may have to be modified to suit the site.

The circular search is very popular as it does not require complicated setup and can be done by most divers without a great deal of special training. It is effective where the position of the target is known with reasonable accuracy, where the bottom terrain does not have major snags, and where the depth variation during each arc is acceptable.

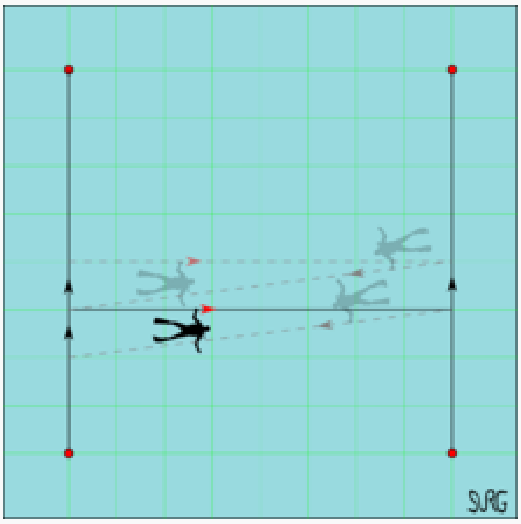
Safety

Divers should be well trained in general diving skills before attempting this type of search. The search diver is responsible for maintaining sufficient tension on the search line so the signals can be transmitted and received. If a surface marker is used, slack in the line should be kept to a minimum to avoid entanglement. This is easiest if a reel is used to control the line, or alternatively the line should be buoyant, to keep it as far from the divers as possible, but buoyant lines will still tend to wrap around the shotline in the centre if there is enough slack.

Jackstay search



Jackstay search pattern



Jackstay "J" search pattern

An underwater **jackstay search** is a procedure conducted by divers swimming along a search line - the jackstay.

There are various techniques for performing a jackstay search.

Procedure

The procedure for a search using two fixed jackstays and a movable search line is described

The distance between the fixed jackstays will depend on circumstances, but should not be so long that reliable overlapping of sweeps is prevented. This will depend on the bottom terrain.

Two divers are generally used on this search system. Two heavy jackstays are laid parallel to each other across the bottom of the search area. A lighter movable jackstay is used to connect the fixed jackstays at one end of the search area. This line is kept reasonably taut, but must not pull the fixed jackstays together.

The divers start at opposite ends of the movable jackstay and swim along it, each diver holding the line with his left hand (or right, but both must use the same hand to keep them on opposite sides of the line) and searching the bottom visually or by feel on his side of the line until he passes the other diver and reaches the other fixed jackstay, at which point he will signal to the other diver that he has reached this point by a pull signal on the movable jackstay.

When both divers are at the fixed jackstays they will shift the movable jackstay along the fixed jackstays by an agreed distance depending on conditions. The distance should be large enough to reduce excessive overlap, but small enough that there is no risk of missing the target between traverses. This usually means that the distance is between the reach of the divers searching by feel in low visibility, and the distance they can see to the sides plust width of the target in good visibility. Care must be taken to always shift the movable jackstay in the same direction. This can be easily confused in low visibility, so a compass can be used to prevent this problem.

The divers then repeat this process until they find the object or run out of fixed jackstay, time or air. When a diver finds the object he should signal this to the other diver by rope pulls. The second diver can join him to confirm the finding and mark it or continue the search. If the movable jackstay snags it should be freed by the divers as the pass the snag. The sweep may have to be repeated after freeing a snag. The method of attaching the movable jackstay should be easily adjustable, but reliable.

If a series of sweeps does not find the object, one of the fixed jackstays may be lifted and re-laid on the opposite side of the remaining one, and the process repeated until the target is found or the entire search area has been searched.

Variations on the jackstay search

If the body of water is narrow enough, a surface team can lay a single jackstay across the width of the bottom, and the diver/s swim from one side to the other. When they reach the end of the line in the water, the surface team advance the jackstay by an appropriate amount by lifting it, moving it parallel to the original position and laying it down again, at which stage the divers make another sweep. This is repeated as often as necessary.

Another method, sometimes called a "J" search, and suitable for a solo diver, involves the diver or divers starting at the *same* end of the search line, which is similarly set along the edge of the search area. The two divers swim together, one on each side of the line, thereby searching the area immediately to either side of the line.

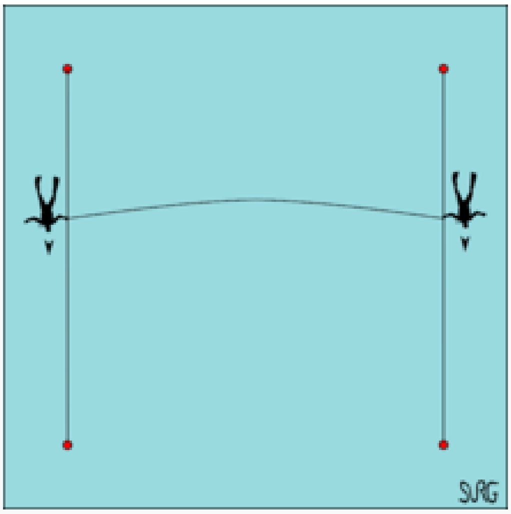
Once they have completed the sweep, they reset the end of the line a few meters further into the search area, so that the line now runs at a slight angle to its original course. They then sweep back along the line, either searching much of the same ground over again, or simply returning to the start point. Once they reach the start point, they then move the other end of the line a few meters further into the search area so that the line is once again parallel to its original position.

They repeat this pattern until the object of the search is located, or until they cover the entire search area. This second method is longer and slower, and is used more frequently either in extremely limited visibility, where the divers do not wish to lose contact with each other, or where the object sought is particularly small, and they wish to run the pattern twice, once from each side, in case the object is masked by a larger object on the sea bed when approach from one side, and particularly where only one diver is available to do the search.

Safety

It is important to note that divers should be well trained before attempting this type of search. Solo divers should be used only when a risk assessment indicates that the risks are acceptable, and preferably should indicate their position with a surface marker or be in communication with the surface by line or voice.

Snag-line search

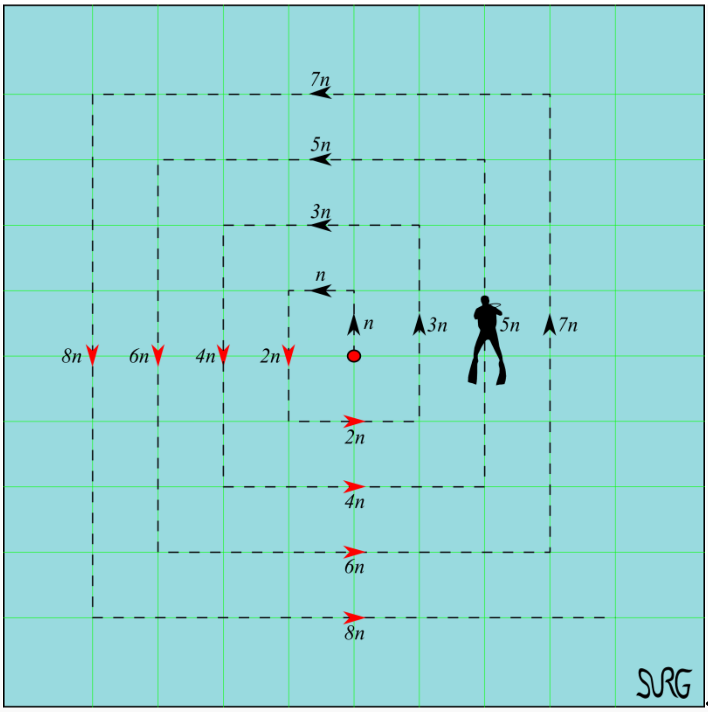


Snagline search pattern using jackstays to define the search area

When the object of the search is large enough and of suitable form to snag a dragged line, a snag-line may be used to speed up the process. The snag-line may be used with a pair of fixed jackstays or as a distance line for a circular search. It is often a weighted line, though there may be times when this is not required. The snag-line is held taut by the diver or divers, who will then drag it along the bottom as they either follow the jackstays or swim the arc until it hooks on something. When this happens the divers fasten their snag-line ends in position by tying them to the jackstays or pegging to the ground and swim along the snag-line to identify the target, If it is the object of the search, they will mark it, otherwise they free the line, move it over the target, return to their ends and continue the sweep.

Search patterns controlled by compass directions

Spiral box search



The spiral box search pattern

An underwater spiral box search is a search procedure conducted by a diver swimming around a starting point on a pattern based on compass directions and increasing distances. The pattern resembles an outward spiral with straight sides and equal distances between legs swum on the same bearing. The legs are normally swum with 90 degree change in direction between them, and very often the cardinal directions are used for ease of navigation. The spiral may be clockwise or anticlockwise, and in theory there is no limit to the area which can be covered. In practice, the diver may encounter an obstacle such as the shore, or will run out of air or energy, which will terminate the pattern. Finding a specified target would also result in the termination of the search in most cases.

Procedure

The technique is to start at the estimated position of the target, at a distance above the bottom to provide the best view, and to swim in a cardinal direction a distance roughly equal to or slightly greater than the visibility range. The estimate of distance is commonly by kick counts, so using a whole number of kicks is necessary, and preferably a number which can be mentally accumulated by the diver. Call this distance n kicks, where n is usually 2, 4, 5, 10 or 20 as these are easy numbers to multiply mentally. The direction of turn may be clockwise or anticlockwise as best suits the search.

For example: The diver swims n kicks to the north, turns left and swims n kicks to the west, then turns left and swims 2n kicks to the south, left again and 2n kicks to the east. Then left again and 3n kicks to the north, left and 3n kicks to the west. The pattern is repeated by adding an extra n kicks every second turn, and always turning the same way. If at any stage the diver wants to return to the start point, he will swim a half leg count followed by the usual turn and anothef half leg count.

Applications

This search pattern is particulatly suited for occasions when the approximate position of the search target is known, but the divers have no facilities for setting up a position marker or search lines, but have a compass and the skills to use it effectively. The pattern is not greatly affected by obstructions and potential snags, bur works best with targets that are relatively easy to see, and that usually implies fairly large size and fairly good visibility. The gap between the patallel legs is chosen for easy counting and sufficient overlap to provide a good chance of spotting the target.

The pattern is not suited to water where there is a current, though moderste surge does not make a lot of difference to the accuracy, provided the horizontal movement due to the surge is not bigger than the overlap between two adjacent parallel legs. Errors are cumulative: A return to the centre is a good check for accuracy. If the diver ends up close to the start point, the pattern was swum accurately.

Compass grid search

An underwater compass grid search is a search pattern conducted by a diver swimming parallel lines on a compass bearing and its reciprogal while conducting a visual search of the area bordering the track. The separation between lines is chosen to allow sufficient overlap to ensure a high probability of the search target being seen if the diver passes by. Cardinal directions are often chosen for ease of navigation, but topographical constraints may dictate bearings that suit the site better.

Procedure

The diver or divers swim pre-arranged compass courses arranged in a grid pattern to cover the search area.

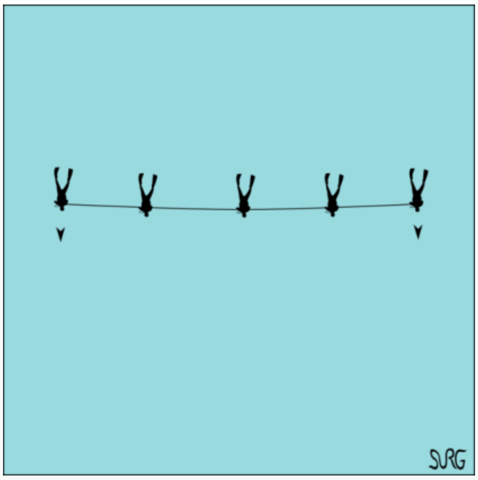
Applications

A large number of divers can be simultaneously deployed to cover a large search area quickly, or a single diver can methodically work through the same area. The pattern is limited to relatively low current speeds, as the current will set the divers off their planned paths.

Ladder search

This pattern is a version of the grid search where the length of the leg is relatively short. It is more limited, but works well in narrow passages, like a river or canal. The search pattern is swimming back and forth on reciprocal headings with an equal offset in the same direction at the end of each leg. Direction of the legs is usually determined by some geographical feature, and the bezel of the compass can be set to those directions. If the direction of the channel changes it may be necessary to change the search leg headings accordingly, so that they remain roughly transverse to the channel. The offset is not critical for direction, and so long as it is roughly correct will be OK. The length of the search legs will usually also be determined by some physical feature like the width of the canal, or reaching a depth of 10m, and the legs may not be of constant length. What is important is that they are parallel and each is offset the same amount in the same direction, so that the search area is covered completely. The search pattern corresponds closely to that of the Jackstay grid search.

Swim-line search



Swimline search pattern

This is the visual equivalent of the snag-line search. A team of divers spreads out along a length of rope at spacing suited to the visibility, terrain and size of the target. The team leader may theoretically be anywhere on the rope, but is usually at one end or in the middle. He swims on a constant heading which is known to all the divers, who swim on the same heading. Each diver must ensure that he does not get ahead of or lag behind the diver to his side who is closer to the leader, and that the rope is kept taut. In this way an evenly spaced line of divers swims a straight sweep with a width equal to the length of the swim line. It can work but requires concentration and a bit of practice, as all the divers are also supposed to be diligently searching for the target. The swim line method can also be applied to a circular pattern, but this is inefficient and usually badly co-ordinated as the direction is constantly changing. A variation on this pattern that can work is in a river or canal where the ends are controlled by line tenders on the banks, who can communicate and can sweep the line round curves. Complications arise with variations in width but most of these can be dealt with by planning ahead. Line signals can instruct the divers to adjust their spacing to suit conditions.[2]

Searches directed from the surface

Directed search using line signals or voice communications

A diver who is in communication with the surface by line signals or by voice communication may be directed to and around a search area from the surface. This has a relatively limited scope, but can work in some cases, particularly when the surface team has a real time sonar picture of the target and the diver in bad visibility. This may be considered not to be a search, as the target can be seen, and the position known, but it is not always possible to get a positive identification until the diver gets there, and there may be several potential targets to check. The technique is also sometimes used when the approximate position can be judged from the surface, but the diver still needs to do some searching once in the desired position.

Towed searches

Searches using special equipment

Searches using hand held submersible sonar transponders

US Navy diver training in the use of a hand held sonar device

Active (transponders that emit a signal and measure the return signal strength to determine obstructions in a given direction) or passive (transponders which measure a signal emitted by the target) sonar can be used by divers on underwater searches.

A signal transmitter attached to the target instrumentation package is often used to allow scientists to recover instrumentation relatively quickly, where the position can not be marked at the surface by a buoy. The diver carries a receiver which is tuned to the frequency of the transmitter, and is usually capable of indicating signal strength and the direction it comes from, allowing the diver to proceed towards it on a fairly direct route. The transmitter may be triggered by a coded sonar signal from the surface or a timer.

Inertial navigation instruments which can be used to give a precise position to the diver can be used to follow a planned search pattern in much the same way that a compass is used, but are better in currents, as they give an absolute position and directions.

Other search patterns

Current drift search

Divers are spaced out across the direction of current flow and search as they are carried over the bottom by the current. They would usually be monitored from the surface using marker buoys so that the effectiveness of coverage can be assessed, and the search is likely to be most effective in good visibility and in areas where the current velocity is reasonably consistent. This is very similar in effect to the swimline visual search, and the techniques can be combined.

Depth contour search

Steeply sloping bottoms can sometimes be effectively searched by divers swimming at constant depth, following the contours of the bottom. Depth control may be by gauge, but is very effectively managed by towing a surface marker buoy with the line length set to the desired depth, provided that the surface is not too rough.

Communication

Most public safety divers and many recreational divers communicate by line signals while conducting searches underwater.

Site survey

The type of survey required depends on the information that is needed to resolve archaeological questions, but most sites will need at least some form of topographical survey and a site plan showing the locations of artifacts and other archaeological material, where samples were taken and where different types of archaeological investigation were carried out. Environmental assessment of archaeological sites will also require that environmental conditions (water chemistry, dynamic properties) as well as the natural organisms present on the site are recorded. For shipwrecks, particularly post-industrial age shipwrecks, pollution threats from wreck material may need to be investigated and recorded.

The simplest approach to survey is to carry out three dimensional surveying by divers using depth gauges and tape measurements. Research shows that such measurements are typically less accurate than similar surveys on land. Where it is not practical or safe for divers to physically visit a site, Remotely Operated Vehicles (ROVs) enable observation and intervention with control by personnel located at the surface. The low technology approach of measuring using tape measures and depth gauges can be replaced with a more accurate and quicker high technology approach using acoustic positioning.

Remote sensing or Marine Geophysics is generally carried out using equipment towed from a vessel on the surface and therefore does not require any one, or any equipment to actually penetrate to the full depth of the site. Sensitive sonar, especially side-scan sonar or multi-beam sonar may be used to image an underwater site. Magnetometry can be used to locate metal remains such as metal shipwrecks, anchors and cannon. Sub-bottom profiling utilizes sonar to detect structures buried beneath sediment.

Recording

LAMP archaeologist recording a scaled drawing of the ship's bell discovered on the late 18th century "Storm Wreck" off St. Augustine, Florida

A variety of techniques are available to divers to record findings underwater. Scale drawing is the basic tool of archaeology and can be undertaken underwater. Pencils will write underwater on permatrace, plastic dive slates, or matt laminated paper.

Photography is the mainstay of recording, and with the advent of digital cameras is cheap and convenient. For underwater use, cameras, including video cameras can be provided with special housings that enables them to be used underwater. Low visibility underwater and distortion of image due to refraction mean that perspective photographs can be difficult to obtain. However, it is possible to take a series of photographs at adjacent points and then combined into a single photomontage or photomosaic image of the whole site.

Excavation

Where intrusive underwater excavation is appropriate, silts and sediments can be removed from an area of investigation using a water dredge or airlift. When used correctly, these devices have an additional benefit in tending to improve the visibility in the immediate vicinity of the investigation. It is also important to note that for very deep sea excavation submarines are sometimes used to view sites. Underwater photography can also be conducted from these submarines which assists the recording process.

Archaeological science

A variety of archaeological sciences are used in underwater archaeology. Dendrochronology is an important technique especially for dating the timbers of wooden ships. It may also provide additional information, including the area where the timber was harvested (i.e. likely to be where the ship was built) and whether or not there are later repairs or reuse of salvaged materials. Because plant and animal material can be preserved underwater, archaeobotany and archaeozoology have roles in underwater archaeology. For example, for submerged terrestrial sites or inland water, identification of pollen samples from sedimentary or silt layers can provide information on the plants growing on surrounding land and hence on the nature of the landscape. Information about metal artifacts can be obtained through X-ray of concretions. Geology can provide insight into how the site evolved, including changes in sea-level, erosion by rivers and deposition by rivers or in the sea.

Artifact recovery and conservation

Artifacts recovered from underwater sites need stabilization to manage the process of removal of water and conservation. The artifact either needs to be dried carefully, or the water replaced with some inert medium (as in the case of The Mary Rose). Artifacts recovered from salt water, particularly metals and glass need be stabilized following absorption of salt or leaching of metals. In-situ conservation of underwater structures is possible, but consideration needs to be given to the dynamic nature of the site. Changes to the site during intrusive investigation or removal of artifacts may result in scouring which exposes the site to further deterioration.

Interpretation and presentation of underwater archaeology[edit]

Diver trails also called wreck trails can be used to allow scuba-divers to visit and understand archaeological sites that are suitable for scuba-diving Otherwise presentation will typically rely on publication (book or journal articles, web-sites and electronic media such as CD-ROM). Television programmes can attempt to provide an understanding of underwater archaeology to a broad audience.

Publications

Publication is an essential part of the archaeological process and is particularly crucial for underwater archaeology, where sites are generally not accessible and it is often the case that sites are not preserved in-situ.

The specialist journals on maritime archaeology, which include the long established International Journal of Nautical Archaeology, The Bulletin of The Australasian Institute for Maritime Archaeology (AIMA) and the recently launched Journal of Maritime Archaeology publish articles about maritime archaeological research and under water archaeology. However, research on underwater sites can also be published in mainstream archaeological journals, or thematic archaeological journals. Some institutions also make their unpublished reports, often called 'Grey Literature', accessible thereby allowing access to far more detail and a wider range of archaeological data than is otherwise the case with books and journals. An example is the works of the Department of Maritime Archaeology at the Western Australian Museum.

The public interest market is covered by a number of diving, shipwreck and underwater archaeology books, beginning with the works of Jacques Cousteau.

The techniques of underwater archaeology are also documented in published works, including a number of handbooks, and Muckelroy's classic work on Maritime Archaeology.