

Swath Bathymetry Application for Underwater Archaeology in Indonesia

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ABSTRACT

Mapping the depth of the ocean for supporting underwater archaeological works can be carried out by utilizing acoustic technology that converts electromagnetic waves into sound waves. Acoustic technology can be used to detect the structure of the soil layer and the thickness of sediments in seawaters area. The Research Institute for Coastal Resources and Vulnerability have identified several underwater heritage sites scattered throughout Indonesian waters and utilized this technology through a bathymetry survey to determine the depth and the structure of the seafloor where underwater cultural heritage sites are located. The Echosounder Ecotrack Teledyne Dual Frequency Odometer has been used in this bathymetry survey. The sea depth data will be corrected to Mean Sea Level (MSL) using the tidal data of the local station for 30 days. The underwater topography is processed and displayed in 3D. The use of in-situ bathymetry application to determine the shape of the seabed at the identified sites can be used as part of the assessment process to determine the next research steps, to provide recommendations regarding diving activities, as well as to determine proper site preservation and appropriate management measures, for example, for diving tourism and marine conservation area in Indonesia.

Key words: Swath Bathymetry, Underwater Archaeology, Site Management, Indonesia

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INTRODUCTION

Maritime resources in Indonesian waters are rich in historical and cultural values. Some significant events in Indonesia which are divided into historical, prehistoric, classical, Islamic, colonial, and revolutionary periods are used to understand the historical process to the present which forms the national identity (Handoko, 2007). The territorial waters of Indonesia in the World War I and II eras

have become the battlefield resulting many wrecks and air planes sank in Indonesian waters. In addition, Indonesia's territorial waters are the main waterways that are traversed by ships from various nations for the purposes of communication, trade, migration, and the spread of religion (Julianto, 2015).

According to various sources, the territorial waters of Indonesia which flanked by two oceans, namely the Pacific Ocean and the Indian Ocean, are strategic routes for international shipping and battlefields (Sasongko, 2019). The Indonesian archipelago as a maritime country has a lot of potential underwater archaeological sites or underwater cultural heritage. However, some obstacles and challenges could make the management and the preservation of underwater cultural heritage very difficult (Carducci, 2002). Underwater archaeology can be used as a tourist destination that attracts tourists, both domestic and foreign. In addition, some knowledge can be extracted from the archaeological site. However, its use also needs to be considered, due to the fact that this heritage cannot be renewed and is fragile against some external and human threats (Ariadi et.al, 2018).

Some of the problems that arise related to shipwreck site sustainability come from the natural environment such as sedimentation, weathering, and corrosion as well as external threats in the form of site salvage by unauthorized parties for mere profit (Ridwan, 2019). Globally, the greatest threat to underwater archaeological sites comes from humans (Fleeming, 2011). The distribution of underwater archaeology in Indonesia has not been mapped entirely so that it becomes an obstacle due to the lack of information available about the presence of Indonesian underwater archaeological sites at this time.

Some technologies such as Side Scan Sonar and magnetometer are used to detect the presence of underwater archaeological sites by detecting the material and shape of the site. In addition, there is another sophisticated technology to support these activities with the use of acoustic technology that uses a transducer to determine the depth of the water base.

This paper will discuss the application of the use of Single Beam Bathymetry Technology Echosounder Echotrack CVM Teledyne Odom Hydrographic Single Beam to map underwater conditions around some underwater archaeological sites in Indonesian waters so that it is expected to be useful for planning some development projects such as diving and snorkeling tourism activities, the proper management of underwater heritage, the development of surrounding area of shipwreck site, as well as for the preservation of the maritime cultural heritage objects themselves.

SWATH BATHYMETRY METHOD

The method used to estimate the depth of the location point of the sinking wreck is to conduct a bathymetry survey that utilizes acoustic technology (transducer) and is connected to the global positioning system to record the position at each depth (Fig. 1). Measurements were made using an Echosounder Echotrack CVM Teledyne Odom Hydrographic Single Beam survey tool.



Figure 1: Swath Bathymetry Survey Activities. (RICRV, 2019)

The process of collecting bathymetry data is carried out at different times and locations by considering a rating channel to improve the accuracy of the data obtained. There are a number of locations of underwater archaeological sites in Indonesia where Swath Bathymetry was used by Research Institute for Coastal Resources and Vulnerability (RICRV) include MV. *Boelongan Nederland* shipwreck site in Mandeh Bay (2015), the *Duke of Sparta (SS Aquila)* site in Ambon Bay (2016), MS. *Sophie Rickmers* in Weh Island (2017), VOC shipwreck sites in Karawang waters (2018), and some other site in Ternate and Tidore Islands (2019) where there are several shipwreck sites from the Portuguese and Spanish colonial periods in Indonesia.

In the Swath Bathymetry method, the ocean depth data is corrected for tides in each study area to determine Mean Sea Level (MSL) using tidal data (www.ioc-sealevelmonitoring.org) for 30 days of observation. Tidal data is then processed using the Admiralty Method (Rahmawan et.al, 2017) to produce tidal components. Tidal reduction can be formulated in the following equation (Simanjuntak, 2012):

$$rt = TWLt - (MSL + Zo) \dots \dots \dots (1)$$

rt : The amount of reduction given to depth at t time
 TWLt : The position of the sea surface at t times
 MSL : Mean Sea Level
 Zo : Surface watershed value below MSL

The actual water depth can be formulated as follows:

$$D = Dt - rt \dots \dots \dots (2)$$

D : True depth
 Dt : Depth corrected transducer
 Rt : The magnitude of the reduction given to depth at t time

SWATH BATHYMETRY SURVEY LOCATION

SS AQUILLA, AMBON BAY

The depths of Ambon Bay waters are included in the category of deep waters, especially in the parts of outer Ambon Bay to the Banda Sea with an average depth of between 100 m and 500 m. The condition of the seabed in the waters of the outer Ambon Bay is very steep. Different conditions can be seen in the waters of the inner Ambon Bay, where the basic conditions of relatively shallow waters are at depths between 0 m to 40 m with distance conditions that are almost flat at each depth (Figure 2).

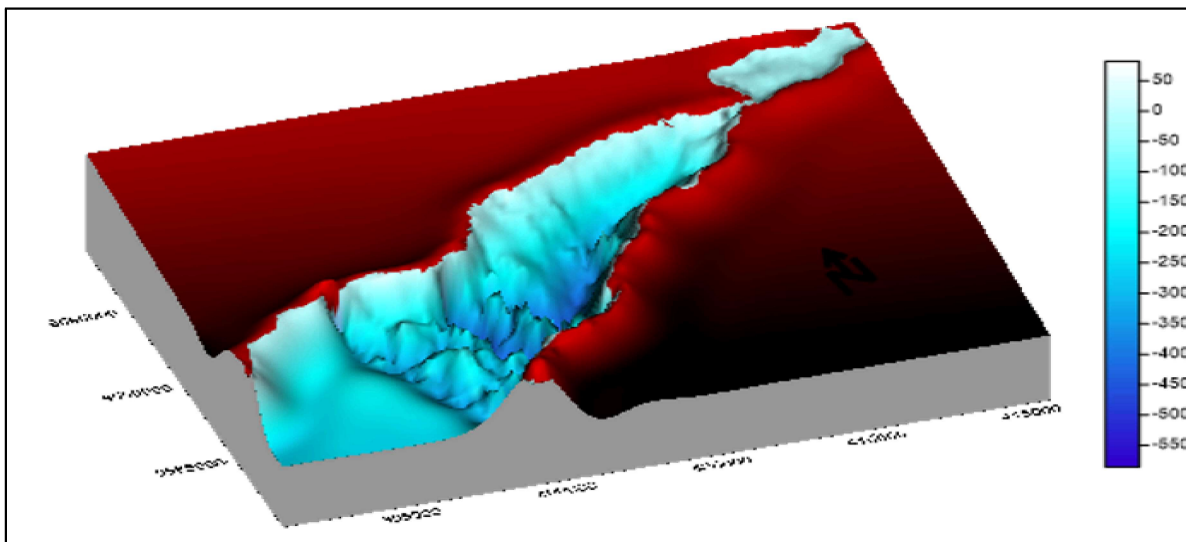


Figure 2: Seafloor Topography of Ambon Bay

The sunken ship of *The Duke of Sparta* (SS. *Aquila*) can be found at coordinate positions 407980, 9594745 in Ambon Bay with the bow direction of the ship stretching from East-Southwest. SS *Aquila* is a cargo ship with dimensions of 134.4 x 17.6 x 7.7 m. SS *Aquila* sank in 1958 because it was bombed by a Douglas B-26 Invader aircraft during the PERMESTA rebellion (Rahmawan et.al, 2019). The location of the wreck can be found at a depth of 15-35 meters (Figure 3). Ambon Bay is a place where various river mouths originate, causing sedimentation along the sea waters. Increased land use on land will cause a decrease in water quality and cause sedimentation in the Ambon Bay waters (Asyiwati et al., 2010).

Figure 3 is the result of the interpretation of the position of the SS *Aquila* shipwreck against the depth of the sea, with a bottom of the water between 22-40 meters. The green color is a level 1 area with provisions for both certified and uncertified novice divers, but it needs to be accompanied by 1 certified diver. The orange color at a depth of 22-35 m has provisions for certified divers accompanied by a rescue diver. Meanwhile, the red color is a diving area with a depth of 35-40 meters with the provision only for advanced divers with 30x diving experience. In addition, they must be accompanied by a rescue diver with minimum experience of 50x dives.

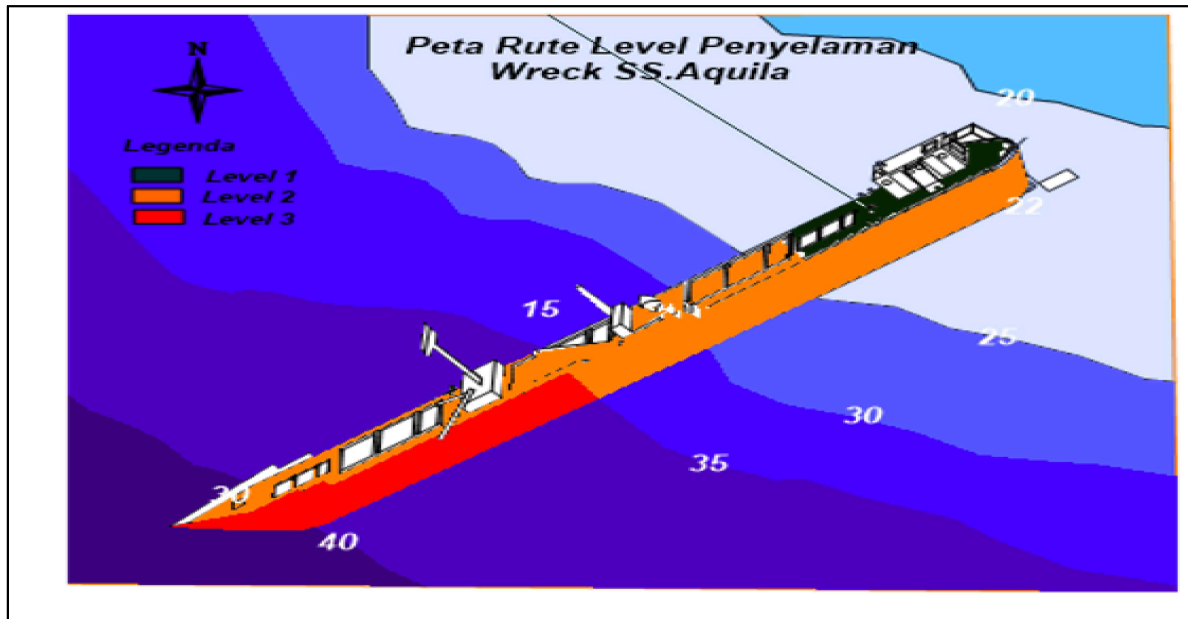


Figure 3: The Depth of SS *Aquila* Site Location (Rahmawan et.al, 2019)

MV BOELONGAN NEDERLAND, MANDEH BAY

The depth of the waters of the Mandeh Bay ranges from 0-25 meters. From the shoreline to the eastern part of Cubadak Island, the depth of the bottom of the waters has a slope of 0.02-0.72 ° and stretches as far as 1.5 km from the shoreline. The depths of the Mandeh Bay waters are included in the category of gently sloping waters. The territorial waters of the eastern Cubadak waters to the west are sloping waters that can be dived by divers at all levels. At position 658562, 9867161 at a depth of 18 meters, there is the sunken ship of MV. *Boelongan Nederland* (Figure 4). This ship was sank in 1942 due to the air raid by Japanese aircrafts (Prasetya et.al, 2018). The depth of the Cubadak Island sea waters towards Merak Island and offshore waters has an average depth of 0-90 meters. Mandeh Bay is vulnerable to sedimentation originating from the Nyalo River and Mandeh River (Rozamuri et.al, 2016).

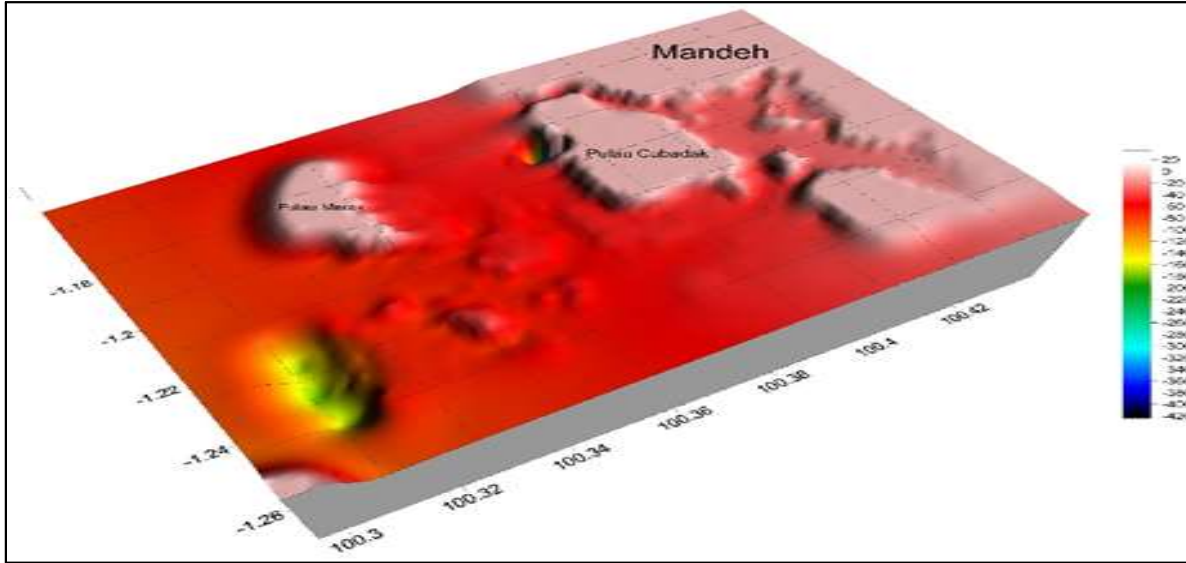


Figure 4: Seafloor Topography of Mandeh Bay. (RICRV, 2015)

MS SOPHIE RICKMERS, SABANG BAY

The site location of MS *Sophie Rickmers* can be found in the waters of the Pria Laot Bay, Sabang, Weh Island at position 754434.33; 646748.23 46. The shipwreck is located at a depth of 35-70 m below sea level. MS *Sophie Rickmers* was a German ship that was deliberately submerged by her crews during World War II in Sabang Bay to avoid the seizure from the Dutch at that time.

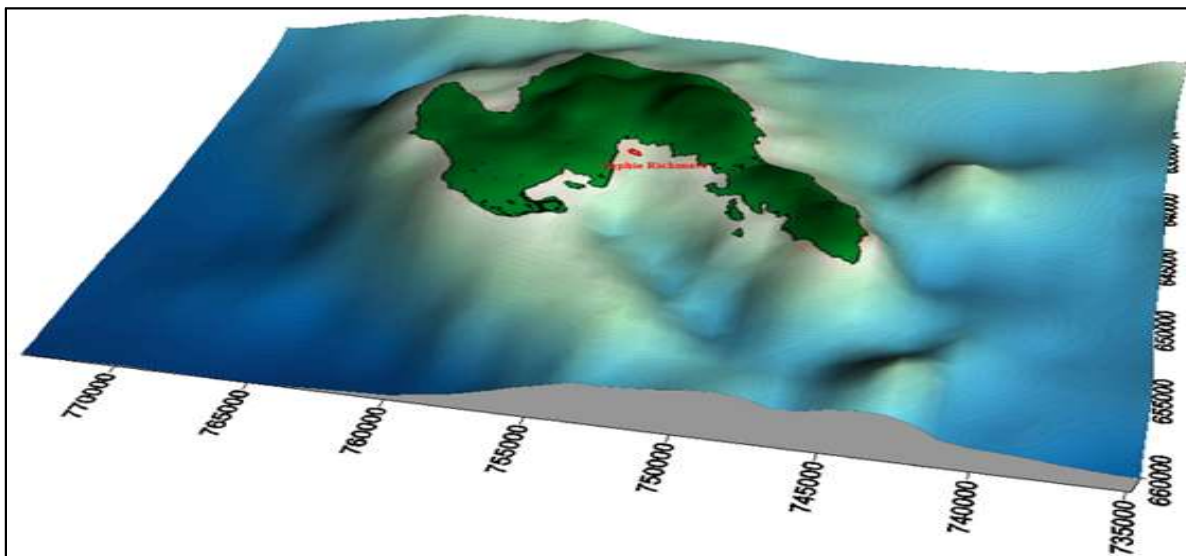


Figure 5: Seafloor Topography of Weh Island. (RICRV, 2017)

To facilitate the creation of a depth profile around MS *Sophie Rickmers* site, an area of 150 Ha was created to obtain a cross section of this sea water area (Figure 6).

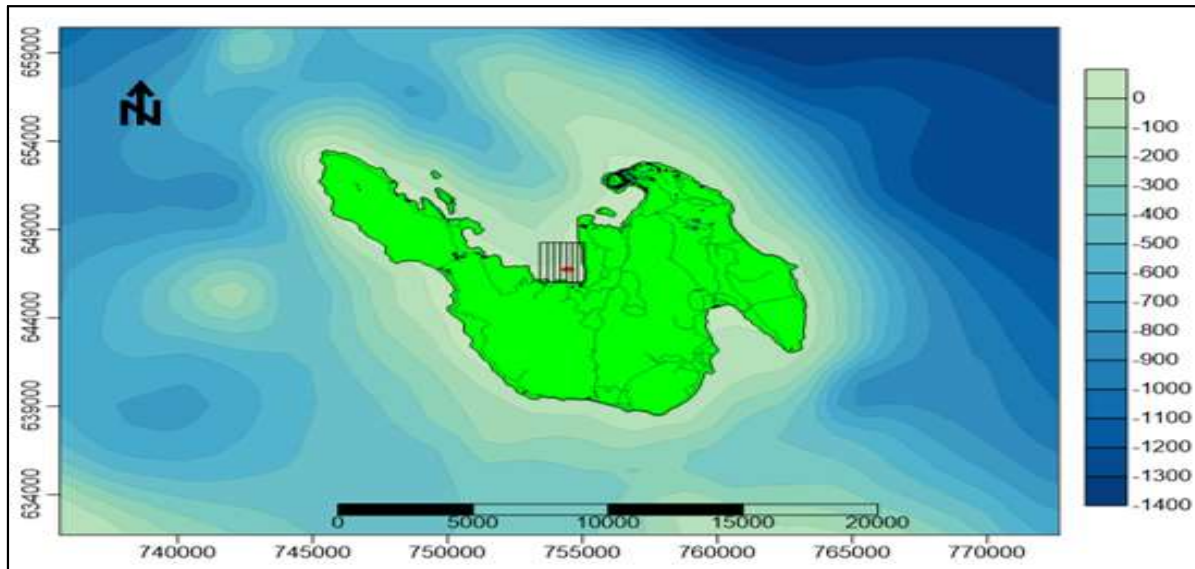


Figure 6: The location of the Cross Section 1 km x 15 km.

The depth of the sea on the east side of Sophie Rickmers site with the deepest depth is around 20 meters. This depth can be found 300 meters from the beach. The depth of the sea at Sophie Rickmers site is around 35 - 40 m which was found around 750 m from the coast. The deepest part of the site location is at a depth of 60 m where the depth is sloping to the site boundary. Try al tanto et.al, 2018 states that the condition of the sea waters around *Sophie Rickmers* is still in good condition, especially for the life of marine life and tourism in accordance with the standards of the Indonesian Ministry of Environment.

VOC SHIPWRECK SITE, KARANG BUI WATERS, KARAWANG

The depth of Karang Bui sea waters in Karawang Regency, West Java Province in the research area ranges from 4 m to 31 m. On the water contour, an extreme decrease from 5 to 15 meters is seen and appears as a mound like a circular rock at that depth (Figure 9). The width at that depth is pretty small compared to depth data between 15-31 meters with its sloping position and spread evenly over each water area. The mound is a group of coral where the ships run aground and then sink in that location. The location of this site is thought to be the sinking place of several ships from the VOC era and the occupation of the Dutch colonial government in Indonesia. At this location, a large amount of VOC and Dutch colonial coins were found and also several cannons with VOC monograms.

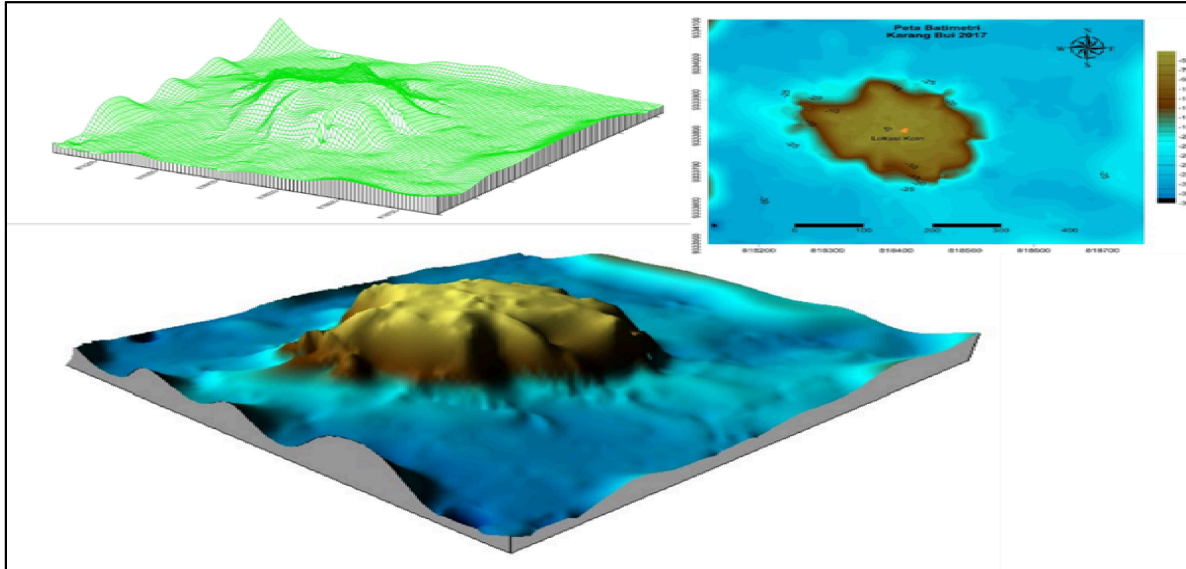


Figure 7: Seawater Topography of Karang Bui Site, Karawang. (RICRV, 2017)

TIDORE ISLAND

The depth of Tidore waters ranges from 0 to 150 m from the area of the shipwreck site from the Portuguese and Spanish era in Indonesia. The depth of 150 meters can be found at a distance of 500 meters from the coast with an average slope of 11.6° . The seafloor topography of Tidore waters includes slopes with increasing depth as it heads towards the sea. The maximum slope is 19° from the coast to 250 meters towards the sea and has a maximum depth of 75 meters. Topographic maximum slope of 30° with varying slope distances. From the results of the bathymetry of the research area, it can be concluded that the seabed in Tidore waters at the is included in shallow water type (neritic zone) with a depth of less than 200 meters. At a depth of 30-70 meters (red dot in Figure 10), there are 2 shipwreck sites. Since the shipwreck location is quite deep for diving activities, so it is only divers with special classification could dive the shipwreck site.

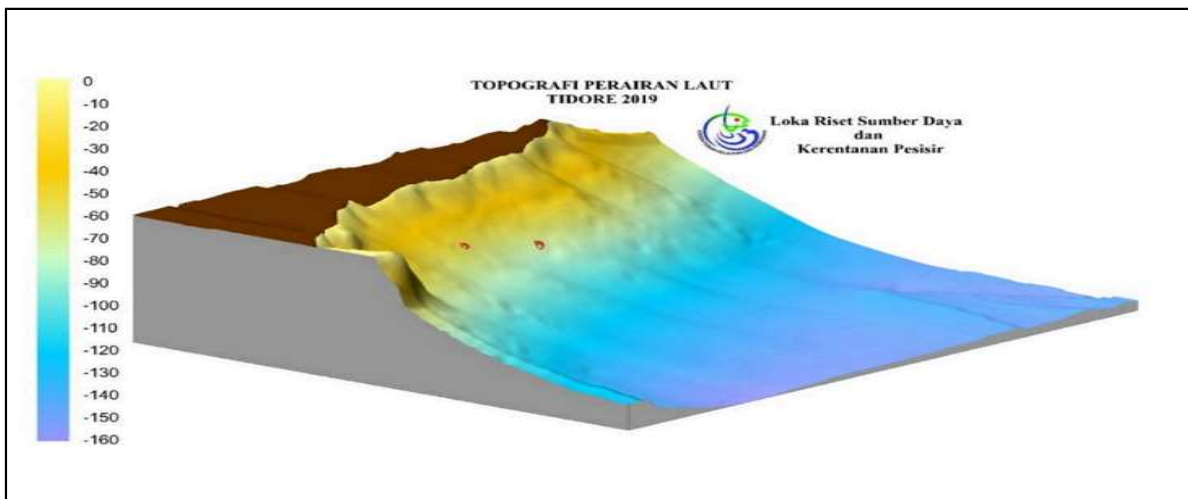


Figure 8: Seafloor Topography of Tidore Waters. (RICRV, 2017)

TERNATE ISLAND

The depths of Ternate waters in the research area of *Trinidad* shipwreck ranged from 0 to 150 meters with steep depths in the depth range of 0-75 meters. The slope is formed at 13.5° along 500 meters towards the sea. The seafloor profile shows formations such as the morphology of the foot of a volcano. The red dot in Figure 11 is the searching location of *Trinidad* shipwreck with a sloping bottom and at a depth of about 75 meters. Due to the depth of the seabed, special provisions and specifications are required for divers to perform dive activities at the site.

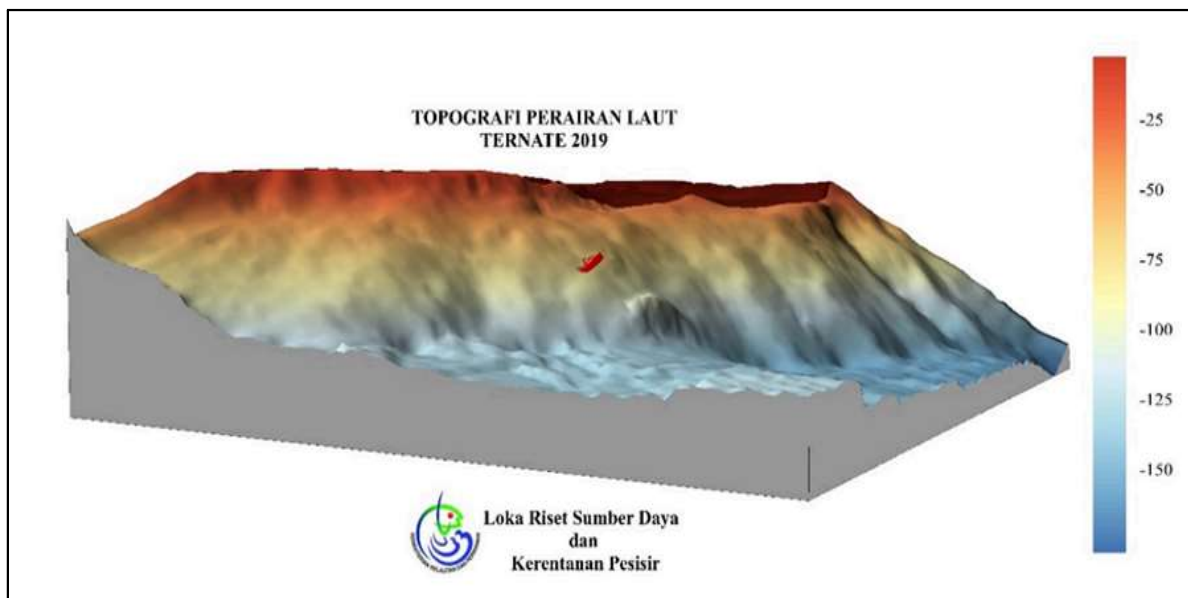


Figure 9: Seafloor Topography of Ternate Waters (RICRV, 2017)

DISCUSSION

Some underwater archaeological surveys in Indonesia conducted by RICRV, the Ministry of Marine Affairs and Fisheries with the support of the Swath Bathymetry survey showed promising results because the Swath Bathymetry data can accurately pinpoint the profile of seabed area and determine the depth of the shipwreck sites accurately. This is very helpful in diving activities where the survey team and divers could figure out the certainty of the depth of the site. Therefore, the diving preparations can be carried out properly. Bathymetry data and topography of the seawaters are also imperative for the site management plan so that the team can determine whether the site needs to be preserved in-situ, to be excavated, as well as to be developed for diving tourism.

CONCLUSION

Acoustic signals for estimating the depth of seawater are essential for identifying the presence of underwater archaeological sites. Using SWATH Bathymetry method, underwater and seafloor conditions are modelled to obtain an image of the dive site and the position of the shipwreck site that

is useful for site preservation, and the development and determination of underwater cultural heritage objects. Different waters and topographic conditions in each study area affect the diving provisions for the safety of divers in shipwreck diving tourism and can assist the policy making in terms of shipwreck site protection, preservation, and future development.

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Biographies

Guntur Adhi Rahmawan is Geomatics Research Scientist working in Indonesian Ministry of Marine Affairs and Fisheries since 2015. He was graduated from Department of Geomatics Engineering, Diponegoro University. His research interest is a coastal resources and vulnerability, particularly in Hydrography area. Guntur has involved in some underwater archaeological research in RICRV and has led the project of surveying SS *Aquila* shipwreck in Ambon Bay to provide data for establishing Maritime Conservation Area of Ambon Bay. He also frequently contributed to other archaeological researches and having role in bathymetry survey of underwater sites and making the shipwreck sketches in complementary analysis of coastal resources.

Nia Naelul Hasanah Ridwan is Maritime Archaeology Research Scientist working since 2005 in the Indonesian Ministry of Marine Affairs and Fisheries, and a Head of the Research Institute for Coastal Resources and Vulnerability. She studied Archaeology in Gadjah Mada University, and Environment and Heritage in James Cook University. Nia's interests include the relationship between Underwater Cultural Heritage (UCH) and the environment, UCH community engagement: threats to UCH; maritime museum affairs; illicit trafficking of underwater remains; and sustainable marine-heritage tourism. She has led a number of marine archaeological research projects throughout Indonesian Waters. Nia had attended some UNESCO Courses on UCH, ICCROM - SEAMEO SPAFA – Getty Foundation training courses, The Netherlands Cultural Heritage Agency Course on Sustainable Conservation of Cultural Heritage, ICCROM Forum, UNESCO-University College London Expert Meeting on the Serial Nomination of UNESCO World Heritage of the Maritime Silk Routes, and UNESCO-French Government International Meeting on Underwater Cultural Heritage. For her dedication, The President of Republic Indonesia awarded her the *Satya Lancana Wira Karya* Award in 2015. Nia has published her research in 69 publications including books, journal papers, proceedings, and articles in magazines and newspapers, and also published her research results in numerous national, regional, and international conferences.