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Oil Spill Analysis on Ambon Bay, Moluccas, Indonesia: Its Influence on the SS *Aquila* Shipwreck Site

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Abstract

The Steam Ship (SS) Duke of Sparta or SS Aquila shipwreck site is one of the underwater cultural heritages (UCH) discovered in Ambon Bay, Moluccas waters, Indonesia. Currently, this 1940-s British-Italian shipwreck is threatened by an oil spill contamination on Ambon Bay. In Ambon Bay, there is Wayaime Port, which is a transit port for ships, and the port for oil tankers to loading and unloading their oil cargoes. One of the biggest oil spill incidents in Ambon Bay occurred in August 2005, when a fishing boat of MV Fu Yuan Fu F66 was exploded. This on-going oil spill occurrence can affect SS Aquila site sustainability due to corrosion issue, disrupt marine tourism activities, and harm marine biota in the surrounding area. One purpose of the study conducted by Research Institute for Coastal Resources and Vulnerability in 2016 is to determine the oil spill distribution inside the Ambon Bay which is threatening the SS Aquila shipwreck site. The method employed in this

research is a hydrodynamic modelling approach of oil spill module. The result of oil spill modeling is then analysed spatially. The study results show the period of diesel oil distribution is reached \pm 285 hours, with the spread direction is toward to Southwest (outer of the bay). The processes found in this oil spills event includes a process of dissolution, evaporation, and vertical dispersion. Based on the study, it can be concluded that the intake of the oil spill on Ambon Bay waters is undoubtedly threatening the preservation of the SS Aquila underwater cultural heritage along with its marine environment, and the development of marine heritage utilization.

Keywords: *SS Aquila, hydrodynamic modelling, oil spill analysis, underwater cultural heritage preservation*

Introduction

The waters of Indonesian Archipelago, both in east and west parts, are significant on the regional-interregional maritime trade routes, and is well-known as the center of the spice trade. The eastern part of Indonesian Archipelago became a vital area of global sea navigation due to abundant spices resources such as cloves, nutmegs, and cinnamon. While, the western part was important in the spice trade routes due to its position as the center of pepper trade (Harkantiningih, 2013). That condition is caused by the strategic geographical location and the existence of the transportation network which facilitated the distribution of these primary trade commodities since an ancient time (Fig. 1). One of the essential spice trading spots in Indonesia is the Moluccas, which is also popular as Spice Islands.

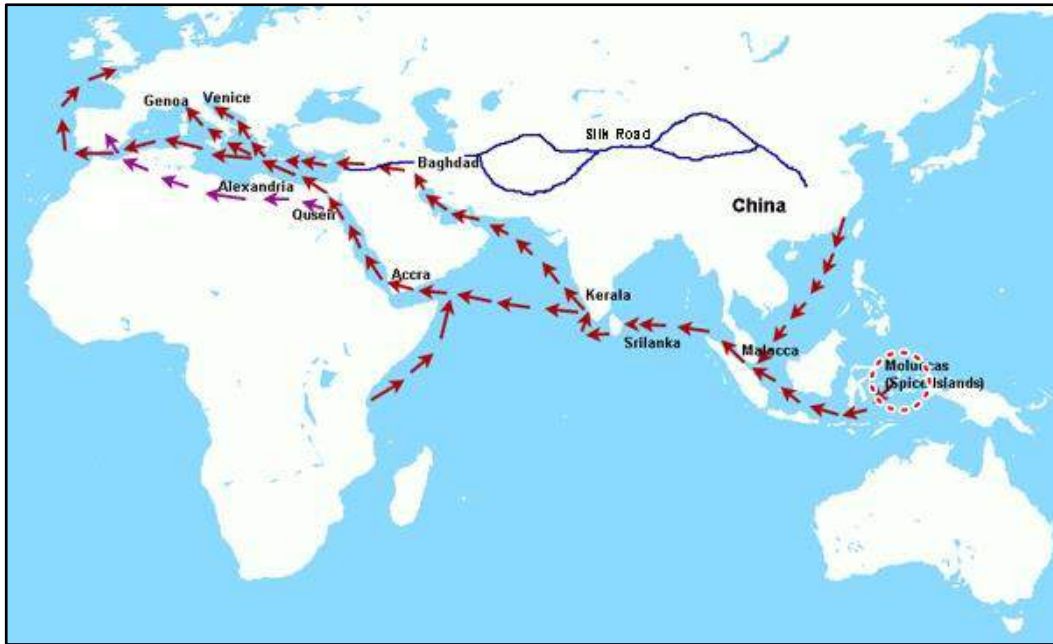


Fig. 1: Map of Maritime Trade Routes

(Source: <http://juliansoplanit.blogspot.co.id/2011/11> modified by authors)

The center city of Moluccas is Ambon city. This city has a long history of World War II (WWII) incident which involved the Japanese imperial troops and Allied Forces including Dutch *Het Koninklijke Nederlands(ch)-Indische Leger* (KNIL) and Australia. After WWII was over in 1945, Ambon city along with other cities in eastern part of Indonesia faced a rebel movement incident committed by *Perjuangan Rakjat Semesta* (PERMESTA) or *The Universal People Struggle Army* in 1957-1958. This rebellion to attack the Indonesian central government, and implicitly, to re-established the Dutch colonialism in Indonesia, was supported by Allied Forces, particularly Dutch and United States of America (USA). In this PERMESTA rebellion time, the trade ship of *SS Aquila* was bombed by a *Douglas B26 Invader* plane in 1958 in the northern of Ambon Bay. This bombing of *SS Aquila* was planned by the Central Intelligence Agency (CIA) of USA to clutter up the economic sector from trading activities in Indonesia (Amal, 2006).

Today, the location of SS *Aquila* is well-known as a dive site among the locals and international divers. It becomes one of the underwater cultural heritage sites discovered in Ambon Bay¹. This shipwreck is located on a slope on the seabed off Ambon, with its stern about 15 meters (8 fathoms) below the surface and its bow about 35 meters (19 fathoms) depth². Besides *Aquila*, there are some other shipwreck sites which have not been identified yet found in this bay. Recently, the existence of SS *Aquila* shipwreck is threatened by disposal waste, sedimentation, marine litters, and oil spill contamination which directly stream to SS *Aquila* and other UCH sites in the inner of Ambon Bay. A Wayaime Port in Ambon Bay is a transit port for many types of ships, and also the port for oil tankers to loading and unloading their oil cargoes. Therefore, oil spill incident becomes quite common in this bay. In August 2005, a fishing boat of MV *Fu Yuan Fu F66* was exploded³ and became one of the biggest oil spill incidents in Ambon Bay. This on-going oil spill occurrence may affect SS *Aquila* site sustainability due to corrosion issue, disrupt marine tourism activities, and harm marine biota in the surrounding area. In addition, the lack of heritage knowledge and awareness of the local community, local authorities, oil and shipping companies, and general public regarding the importance of UCH preservation in Ambon Bay require immediate attention.

Those conditions can endanger the wreck site and inhibit the site preservation, the development of maritime conservation area, and can decrease shipwreck diving tourism activities. Due to that reason, the research which deeply concerns in the oil spill impact to the shipwreck site is necessary to be conducted. Besides identifying the shipwreck site in Ambon Bay and researching its current physical condition, the underwater archaeological study carried out by the research team of Research Institute for Coastal Resources and Vulnerability in 2016 was also aimed

to determine the oil spill distribution inside the Ambon Bay which is threatening SS *Aquila* shipwreck.

The History of SS Aquila (SS Duke of Sparta)

SS *Aquila* was a cargo ship which initially named as SS *Duke of Sparta*. This *Duke of Sparta* was launched in 1940 from William Gray Shipyard, West Hartlepool, and later on, sold to a Napoli Italian company in 1951. Its name was changed and became SS *Aquila*. In Indonesian history, SS *Aquila* has been targetted to be destroyed by USA to support PERMESTA rebel movement interest in disrupting an economic sector of Indonesia. Besides SS *Aquila*, there are two other cargo ships in Ambon Bay, which were a Yunani ship, SS *Armania*, and Panama ship, SS *Flying Lark*. Those ships had been raided by Allen Lawrence Pope, a USA paramilitary aviator who flew CIA bombing missions in the PERMESTA rebellion. He joined USA Air Force officer, William H. Beale Jr, to operate a bomber aircraft *Douglas B-26 Invader* for PERMESTA rebels. In 27th April 1958, Allen Pope did his first mission at the same time of William Beale's 3rd bomb mission. The air raid of SS *Aquila* by Allen Pope was not resulting in any fatalities, and that ship was sunk one month after bombing incident on 27th May 1958.

The Potential of Maritime Archaeological Resources of SS *Aquila*

The top position of SS *Aquila* shipwreck was found in the depth of 15-35 meters with the bow position facing to southwest. The shipwreck body was still intact and several parts has collapsed, such as the crane, chimney, and the crane wall. Some parts of the shipwreck were damaged due to human pillaging. The ship engines, which were still intact and covered by cables and stairs, were found in the depth of \pm 40 meters. While, the profiler cannot be seen anymore. Coral covered the shipboard name.

According to the information obtained from local people, there were massive lootings of SS *Aquila* shipwreck committed by irresponsible people using makeshift tools. It is assumed that the looters salvaged the ship profiler which has high economic value. The dimension of SS *Aquila* can be seen in Table 1. At the time of diving SS *Aquila*, the team still could penetrate some parts of the shipwreck to take a video and photo documentation. Figure 2 shows the underwater documentation of SS *Aquila*, and the location of *Aquila* shipwreck site is shown in Fig. 3.

*Table 1. The Specification of SS Aquila
(Source: Tony, 2013)*

Name	SS. Aquila (1951-1958) SS. Duke of Sparta (1940-1951)
Type	Cargo ship
The sunken date	27 th May 1958 in Wayame, Ambon Bay
Weight	5397 Ton
Length	441.1 ft. (134.4 m)
Width	57.8 ft. (17.6 m)
Height	25.4 ft. (7.7 m)
Propulsion	3-cylinder triple-expansion steam engine
Power	492 NHP

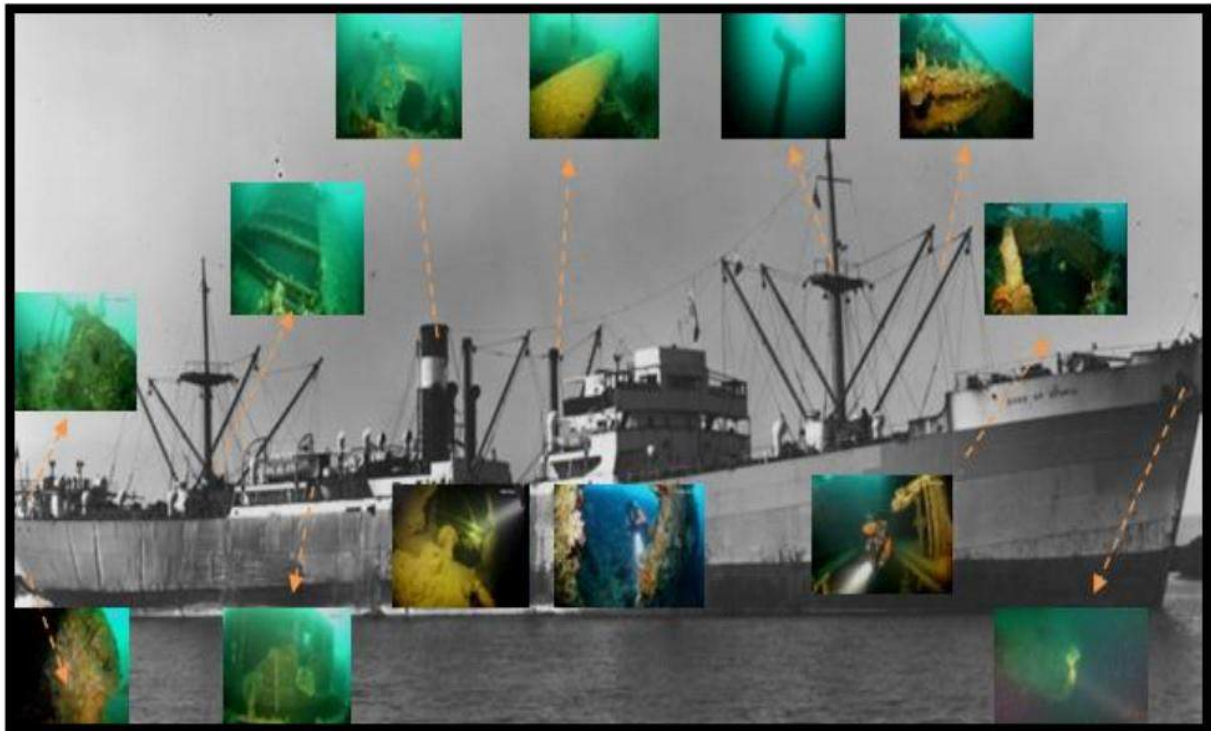


Fig. 2: SS Aquila and its current condition.

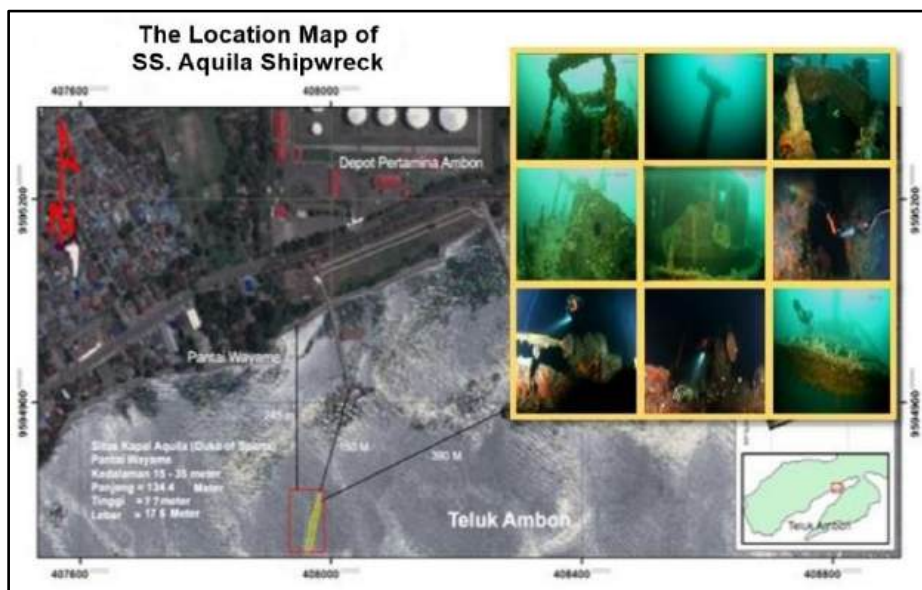


Fig. 3: The location of the SS Aquila.

There were a lot of biota living in the shipwreck site including 42 types of reefs which are covering the ship's body. Additionally, some types of fish can also be seen around the site. Local communities and foreigners

have known the presence of *Aquila* shipwreck. However, even though today it has been utilized for diving tourism, this *Aquila* site has not been managed properly by government, both local and central.

The underwater cultural heritage potential in Indonesia is tremendously huge (Ridwan, 2011) in the form of shipwreck sites. This includes some shipwreck sites discovered across the Moluccas waters which related to the significance of sea trading activities in the maritime history of Moluccas waters. According to Amal (2006), the trading strategy implemented was expropriated the spice production area to facilitate monitoring. While, they also developed the collecting area of spices, such as Ambon waters, where the spices later on will be sent to Europe. Therefore, it is clear that the Moluccas is one of the most important regions of spice sea trading at that time with large number of sailing ships from many countries and regions. This situation added by many incidents from WWII until the PERMESTA rebellion caused the richness of UCH found in this area.

The Oil Spill Problem in the Inner of Ambon Bay

The presence of oil spill in the inner of Ambon Bay was severe alarming. The ships daily activities in Waiyame Port in Ambon Bay affect and increase the oil concentration in this sea waters area. This condition which is also supported by the weak water mass dynamics can result in the deposition of the oil spilled. According to Huang (1983), nine processes (including the physical, chemical, and biological processes) can cause the providence and behavior of spilled oil such as advection, spreading, evaporation, dissolution, emulsification, dispersion, auto-oxidation, biodegradation, and sinking/sedimentation. The spilled oil does not only inhibit the environmental condition but also affects negatively the biota. Moreover, all of part of sea water in the area will be polluted, and

consequently will also affect SS *Aquila* site sustainability and cause a corrosion issue on the shipwreck.

The explosion incident of MV *Fu Yuan Fu 66* resulted in the water pollution in Ambon Bay (Research Center of Biotechnology, 2009), which widespread along the coastline around the exploded ship. The source of explosion was an engine room and caused the ship's engine leaking, therefore, the oil spilled into the sea water (Helut, 2015). The prevention action was done by the local people using an *oil boom net*. However, the effort did not really work in reducing the impact of this oil spilled incident.

Oil Spill Simulation Result

The oil spill simulation was supported by a hydrodynamic flow model implementation which simulated to determine the oil spill distribution. The simulation applied for 15 days to represent the oil distribution period until the oil degraded and deposited in the bottom of the water. Flow model was employed to build a hydrodynamics simulation which is shown in the form of two-dimensional form (Warren and Bach, 1992; Mehdiabadi *et al.*, 2015). The input of the model is using winds, bathymetry, and coastline data digitized using Google Earth image 2016. The surface elevation is obtained from NAOtide tide forecasting in the form of time series data.

Acoustic Doppler Current Profiler (ADCP) was deployed in shipwreck site area for 2x24 hours. ADCP records several physical data such as tide, temperature, and current data. The tides data are used for the verification of the results of the hydrodynamic modeling which employed *Root Mean Square Error* (RMSE) formula.

The simulation applied only used one scenario which employed the diesel oil with the oil viscosity of 6.9 %v/v. The distribution velocity of oil that spilled in the surface is based on the viscosity of that oil. Oil with low

viscosity will be easier to flow and vice versa (Mukhtasor, 2007). The source of diesel oil spill was implemented as well as the sunken point of MV *Fu Yuan* and Wayame Port. The model simulated the oil contamination from the source which is modeled based on the release of the particles.

The model result must be validated. The model validated by comparing the model data and field measurement data obtained. The graph of model validation is shown in Figure 4, which shows that the fluctuation of surface elevation has the same phase between two data. The RMSE value obtained of 4.57 %. The current speed obtained by retrieving the ADCP measurement result, which ranged from 0.1-0.3 m/s. According to Wang *et al.* (2008), the amount of oil released at sea is distributed among a large number of particles which are tracked separately. These particles are driven by a combination of induced currents, waves, and wind velocities.

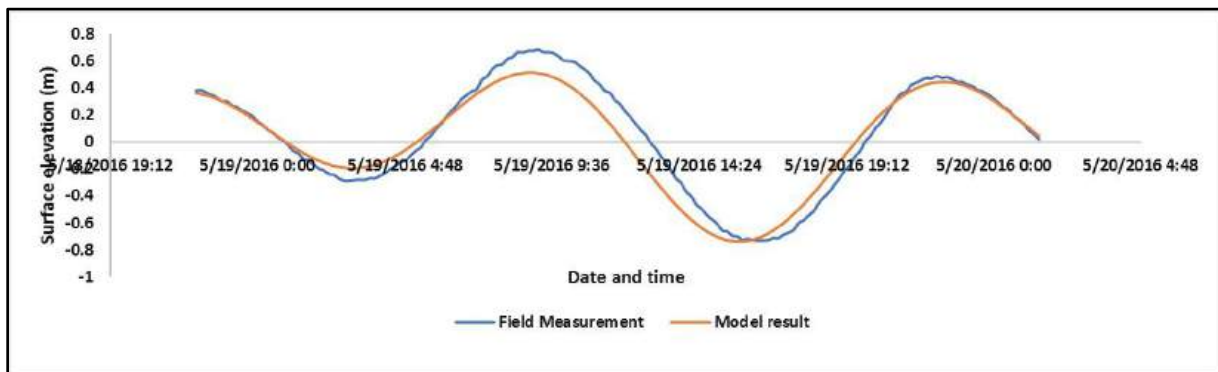


Fig. 4: Model validation using Surface Elevation.

Exposure time is the time needed by the oil spilled to move from one grid to another grid (DHI, 2007). Based on the 15 days simulation resulted the distribution pattern of spilled oil, it shows that the diesel oil has the exposure time of ± 285 hours. According to Simonato *et al.* (2010), the diesel oil is easier to be exposed due to the unsupported of residual fraction. Fig. 5 shows the spilled diesel oil which well distributed around

the border of inner and outer Ambon Bay. The oil flows gradually following the current direction. For 15 days simulation, the oil exposed to the area of UCH preservation in Ambon Bay. The processes found in this oil spills event includes a process of dissolution, evaporation, and vertical dispersion. McCay and Paine (2001) stated that the dissolution rate of hydrocarbons in water is useful in predicting both weathering pathways and possible biological harm. The oil evaporation effects on the formation of emulsification which the different types of emulsification are formed under different condition (Xie *et al.*, 2007). Li *et al.* (2008) pointed out that the effectiveness of dispersion can be found in the water column oil concentration and size distribution of dispersed oil droplets. It dispersed and diluted under the regular wave and breaking wave condition.

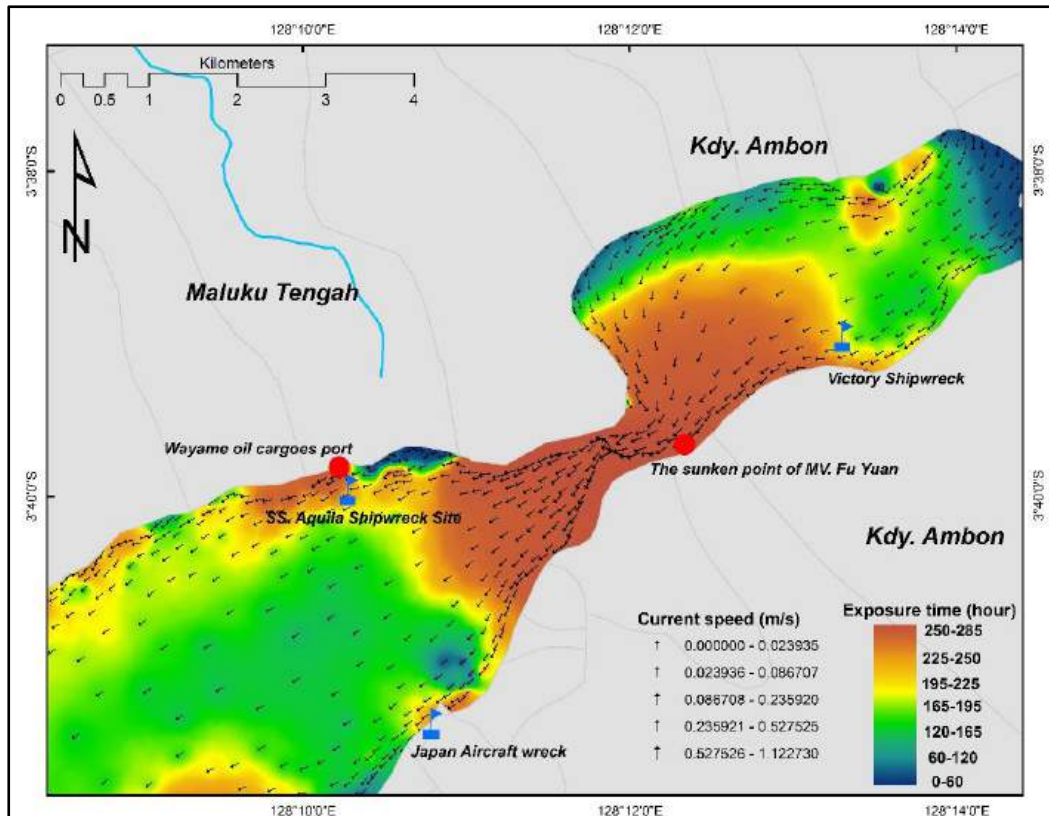


Fig. 5: Simulation for exposure time to diesel oil for 15 days.

The thickness of the diesel oil surface layer ranged from 105-185mm. It shows that the surface layer of diesel oil is 60% wider in the surface water, and the diesel oil is more readily exposed by hydrodynamic factors. The influence of spilled oil is threatening the existence of *SS Aquila* including the biota around it. This on-going vertically dispersed oil might be evoking the corrosion issue of the shipwreck impacted.

The impression of *SS Aquila* is dominated by the remains of the boiler, engine, and frames which are formed from steel and iron. In the tropical seawater which is warm, the corrosion of steel and iron are faster due to the support of encrusting organism's encapsulation such as bryozoan, corals and coralline algae (MacLeod, 2002). The occurrence of oil spilled aggravated the corrosion issue. The oxidation processes occurred beneath the marine growth and oil compound separation is the major

factor in the seabed corrosion. Supporting by the high rate of sedimentation will destroying the UCH of *SS Aquila*.

Conclusion

Based on the study of oil spill incident in the area of *SS Aquila* shipwreck site in Ambon Bay, it can be concluded that the distribution of diesel oil dominantly caused by hydrodynamic factors which evoke the process of dissolution, evaporation, and vertical dispersion. The water column dispersed oil triggers corrosion of the iron material such as a sunken ship in Ambon Bay. The intake of the oil spill on Ambon Bay is undoubtedly threatening the preservation of the *SS Aquila* underwater cultural heritage along with its marine environment, and disrupting the development of marine heritage utilization.

This study can be useful as a basis for the preservation of *SS Aquila* and other UCH sites in Moluccas waters. This research can also raise awareness of the local government to give more attention to oil spill incident, sea water pollution, and plundering activities of shipwreck sites committed by local communities in Ambon Bay. The rich history and potential of UCH sites in Ambon Bay can be utilized for the sustainable tourism development that gives opportunities to prosper the society in the vicinity.

A lot of method to resolve oil spill problems has been developed by researchers around the world such as by using oil booms, organic solvents, and superhydrophobic and superoleophilic sponges. It is recommended that the local government in particular the environmental agency to periodically control the condition of the waters and the symptoms of oil spills in Ambon Bay. Preventive action to safe the marine environment is urgently necessary to overcome the corrosion effects

which occur in SS *Aquila*. The corrosion and site destruction on shipwreck site are unavoidable. However, it can be reduced through monitoring effort of ships movement on shipwreck site, decrease oil spill incidents and other pollutants, and use cathodic protection method .

Endnotes

¹Information related to SS *Aquila* shipwreck diving can be found in some blogs of local divers. <http://www.divingmaluku.com/2017/03/ambon-wreck-diving-ss-aquila-duke-sparta/>. The integrated scientific research regarding SS *Aquila* shipwreck has never been done before the research conducted by Research Institute of Coastal Resources and Vulnerability in 2016.

²The specification of SS *Aquila* can be found in the Lloyd's Register, Steamers & Motorships. London: Lloyd's Register 1941.

³This information was retrieved from <http://www.m.liputan6.com>. (Tumpahan minyak di perairan Ambon meluas/11 July 2017)

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Biography

Ulung Jantama Wisna is Oceanography Research Scientist who has been working in the Ministry of Marine Affairs and Fisheries since 2015. He was graduated from Oceanography Department of Diponegoro University in 2014. Until present, he has contributed in several research projects on underwater cultural heritage (UCH) sites in Indonesia which conducted by Research Institute of Coastal Resources and Vulnerability. In 2015, he attended an underwater archaeology summer school organized by Institute of Archaeology-ICOMOS-ICUCH-SEAMEO SPAFA-UNESCO in Vietnam. His research interest is an applied oceanography area, including maritime archaeology, ocean modeling, environmental aspects, as well as ocean climate issues. He has published 17 writings until today.

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. Last year, he and his team have conducted research maritime archaeological resources for conservation

area in Ambon Bay which eventually provided the basis data of this paper. He also frequently contributed to other archaeological researches in RICRV and assisted in the making of shipwreck sketches in complementary analyzes of coastal resources.

Nia Naelul Hasanah Ridwan is Maritime Archaeology Researcher working in Ministry of Marine Affairs since 2005. She hold a Master of Social Science in Environment and Heritage from James Cook University. Until present, she has led some research projects on underwater cultural heritage (UCH) sites throughout Indonesian Water. For her dedication, The President of Indonesia awarded *Satya Lancana Wira Karya* Award in 2015. Nia's interests include the relationship between UCH and its environment; threats to UCH; UCH long term protection; maritime museum affairs, community engagement; marine-heritage tourism; and illicit trafficking. Nia had attended some trainings held by UNESCO, ICCROM-SEAMEO SPAFA-The Getty Foundation, and The Netherlands Cultural Heritage Agency. She has published 51 her research results.

Gunardi Kusumah has been working in the Ministry of Marine Affairs and Fisheries. In 2010, he was assigned as a Head of Research Institute for Coastal Resources and Vulnerability (RICRV) until present. His research interest is an Environmental Geology area. In recent years, he has focused his research on hydrogeology and groundwater resources, especially their characteristics and potency, as well as the interaction with coastal environment. He was also involved in all maritime archaeological researches conducted by RICRV from 2012-2017, and dedicates his expertise on sedimentation process and marine geological aspects to examine the vulnerability of shipwreck sites.