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ANALYSIS OF BATHYMETRIC DATA UTILIZATION FOR UNDERWATER MORPHOLOGY VISUALIZATION IN JEMAJA ANAMBAS ISLANDS RIAU ISLANDS INDONESIA

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ABSTRACT

Administratively, Pulau Jemaja is located in the Kepulauan Anambas Regency, Riau Islands Province, which lies between 2°10'0" - 3°40'0" N and 105°15'0" - 106°45'0" E. This area is situated on the outermost border of the Unitary State of the Republic of Indonesia and possesses potential natural resources. The potential resources available in the Natuna Regency, especially on Pulau Jemaja, include coral reefs, mangroves, marine sediment/sand, petroleum, and fishery resources. The presence of these resources on Pulau Jemaja, coupled with its location on the national border, is crucial in determining the research location. This study utilizes two sets of secondary data: bathymetric data issued by Pushidrosal of the Indonesian Navy and BATNAS (National Bathymetric Mapping) data issued by BIG (Geospatial Information Agency). The aim of this research is to determine the morphology of the seabed in the Jemaja port area by comparing the bathymetric data from Pushidrosal and BATNAS (BIG) with a resolution of 6 arc-seconds. The method used in this research is GIS with the assistance of ArcGIS and Surfer software. Data analysis in this study employs descriptive analysis, utilizing comparison tables. Prior to analysis, data preprocessing was conducted to facilitate analysis. The results of this study indicate that the maximum depth in this area is -36 meters according to the data issued by Pushidrosal, while the data from BIG indicates a maximum depth of -40 meters. The seabed morphology around the waters of Jemaja falls within the Continental Shelf. The 3D modeling results show differences due to the varying spatial resolution between the two datasets.

Keywords: *Bathymetric;Morphology;BATNAS*

INTRODUCTION

Indonesia is an archipelagic country with thousands of islands, including small ones (Roesma, 2024). As the largest archipelagic state in the world, it has two-thirds of its territory consisting of oceans, covering an area of 6,320,000 km2, with the land area of the islands being 17,504 km2 (Soemarmi & Diamantina, 2019). Indonesia also boasts the second-longest coastline in the world after Canada, which is 99,093 km2, and the presence of Law No. 27 of 2007 concerning the management of coastal areas and small islands further solidifies Indonesia as a maritime nation (Arianto, 2020). As a maritime nation with the second-longest coastline, Indonesia has a vast coastal area with various potential resources that differ from one another.

Coastal areas are transitional zones between land and sea, with the marine part still influenced by land activities (Yonvitner, 2016). These areas serve as hubs for various activities such as settlements, aquaculture, and recreation, heavily impacted by human activities (Prasita, 2023) There are abundant natural resources in coastal areas that require serious attention in utilization efforts to maximize their benefits. The potential in coastal areas is not limited to the land-sea border but also extends underwater. To identify the potential underwater resources, bathymetric studies can be employed.

Bathymetry is the science that studies conditions beneath the water surface, specifically depths (Prananda, 2017). It is a method or technique used to determine the depth or seabed profile based on the analysis of depth data associated with integrated coastal management aspects (Tozer, 2019). Bathymetric measurements are conducted to understand underwater conditions and their relation to hydrographic phenomena (Hilton, 2020). The utilization of bathymetric maps in the marine sector includes determining shipping lanes, coastal or offshore structure planning, exploitation of fisheries resources, and underwater morphology (Iswara, 2022).

The study of seafloor morphology involves the depiction/visualization of the underwater surface, including features such as landmasses, mountains, and trenches (Sunamura, 2015). Understanding the conditions of the seabed, including its topography, structures, and textures, is crucial. This aids in providing geospatial information, marine exploration, fisheries, and the development of marine infrastructure. Therefore, detailed information provision necessitates a study of seafloor morphology, especially considering Indonesia's archipelagic nature with diverse underwater characteristics, such as those found around Jemaja Island.

Administratively, Jemaja Island is located in the Kepulauan Anambas Regency, Riau Islands Province, situated between 2°10'0" – 3°40'0" S and 105°15'0" – 106°45'0" E (BPS, 2023). This region is situated at the outermost border of the Unitary State of the Republic of Indonesia and harbors considerable resource potential. The available resources in the Natuna Regency, particularly on Jemaja Island, include coral reefs, mangroves, marine sedimentation/sand, petroleum, and fishery resources (Pratiwi & Elfidasari, 2020). Conducting underwater morphology analysis is crucial because exploring the resources beneath the sea requires an understanding of the underwater conditions.

The presence of resource potential on Jemaja Island, coupled with its location at the national boundary, becomes a crucial point in determining the research location. Changes in seafloor morphology also affect national boundaries. This is because the determination of national boundaries uses exclusive zones based on coastal morphology, especially boundaries influenced by underwater morphology (Bergsma, 2021).

The study of seafloor morphology is a fundamental requirement for spatial information provision as a reference for further research. In a previous study conducted by Purnomo Raharjo in the Lampa Strait, Natuna, Riau Islands in 2017, the underwater morphology was mapped using geophysical data. The research conducted in Jemaja Island aims to visualize and interpret qualitatively the processed data, including depth points, depth contours, DEM (Digital Elevation Model), and compare the results from two bathymetric data sources: BATNAS from BIG (Indonesian Geospatial Information Agency) and bathymetric data from Pushidrosal TNI AL (Indonesian Navy's Hydrographic and Oceanographic Center). This research is important as the visualization results are needed for spatial information provision.

This research aims to understand the underwater conditions using secondary data in the form of bathymetric data. The obtained bathymetric data are processed using ArcGIS software employing methods such as delineation and interpolation. The interpolation method utilized is the Inverse Distance Weighting (IDW) method, which correlates and resembles the proportionality with distance (Almasi, 2014). The outcome of this study is a visualization of the underwater morphology around the Jemaja port.

MATERIALS AND METHODS

Jemaja Island is part of the Anambas Archipelago Regency. Astronomically, Jemaja Island is located between 2°10'0" and 3°40'0" LU and 105°15'0" and 106°45'0" BT, this is based on Law No. 33 of 2008 concerning the formation of the Anambas Archipelago Regency in the Riau Islands Province. Jemaja Island has a total area of 232.5 hectares. Its northern boundary is adjacent to Pulau Impul Besar, its southern boundary is with the Tambelan Regency, its western boundary is with the South China Sea or Malaysia, and eastern boundary is with Buton Island. In this research specifically, it is located around the Jemaja port area (see **Figure 1**).

This research utilizes two sets of secondary data, namely bathymetric data and BATNAS DEM. Bathymetric data contain information on depth points and contours in a water body, while DEM (Digital Elevation Model) is capable of modeling physical features such as elevated relief maps and rendering 3D visualizations. These secondary data sets are issued by various institutions. The bathymetric data is issued by the Hydro-Oceanographic Center of the Indonesian Navy (Pushidrosal) in 2016. BATNAS (National Bathymetry) is issued by the Meteorology Climatology and Geophysics Agency (BIG) with a spatial resolution of 6-arcsecond using Mean Sea Level (MSL) datum. Gridded National Bathymetry data ranges from 90 to 150 degrees East longitude and from 20 degrees South to 20 degrees North latitude. Accuracy assessment of the free air gravity anomaly data is conducted by comparing the model results against shipborne data. Accuracy testing results indicate that the developed marine gravity model has sufficient accuracy as a basis for bathymetry model estimation at 1m resolution before performing data smoothing iteration from 1m resolution to 6-arcsecond (Fahrianti, 2024).

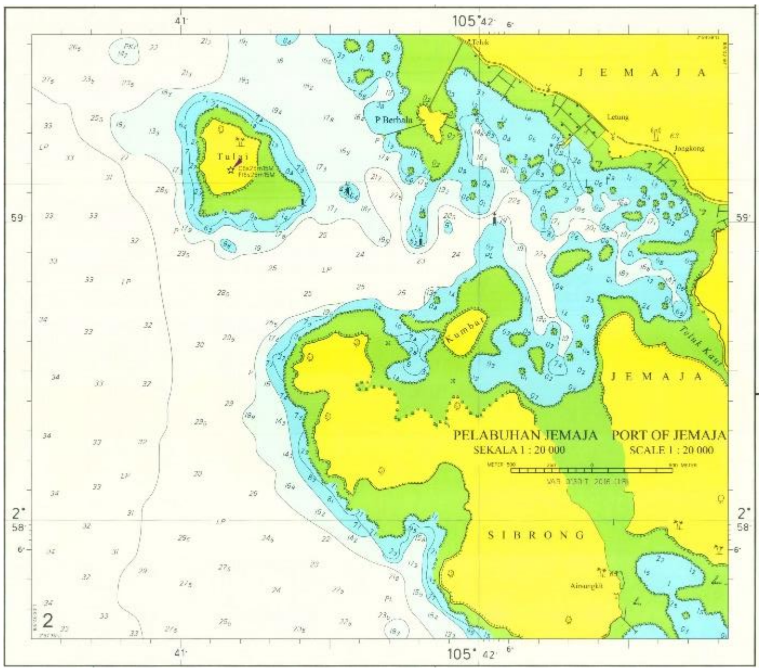

Figure 1. Bathymetric data of Jemaja port

Source: Pushidrosal TNI AL (2016)

This research employs GIS methods using ArcGIS and Surfer 19 software. The stages of this research include digitization, which begins with preparation processes involving map preparation and scanning. The subsequent stages involve processing, which includes map georeferencing, accuracy testing, raster transformation, followed by delineation of maps resulting in vector data comprising points, lines, and areas. Then, for comparison between the two datasets, depth samples are randomly taken using a Point Shapefile at respective locations in each dataset, followed by Extraction to determine the depth data differences. The final stage involves interpolating vector data to DEM (Digital Elevation Model).

Interpolation is a method used to estimate information in a specific area based on existing information in other areas (Sofia, 2018). It is a process of estimating values in unsampled or unmeasured areas for the purpose of map compilation or distribution of values across the entire mapped area (Syaeful Hadi, 2015). Interpolation encompasses several methods, one of which is Inverse Distance Weighting (IDW).

Inverse Distance Weighting (IDW) is one of the interpolation methods used to estimate a value at unsampled locations based on surrounding data (Purnomo, 2018). The IDW method directly implements the assumption that things closer together are more similar than those farther apart. In the IDW method, it is assumed that the level of correlation and similarity between the estimated point and the estimation data is proportional to the distance. To achieve more detailed visualization, the researcher employs 3D modeling using Surfer software.

The data analysis in this study employs descriptive analysis, utilizing comparison tables. Prior to analysis, data preprocessing was conducted to facilitate analysis. Subsequently, sample points were generated, and the results were used for comparing the two sets of data. The sampled data were then transferred into tables and analyzed by reading and interpreting the tables based on the depth sample results. Data Processing Flowchart shown in **Figure 2**.

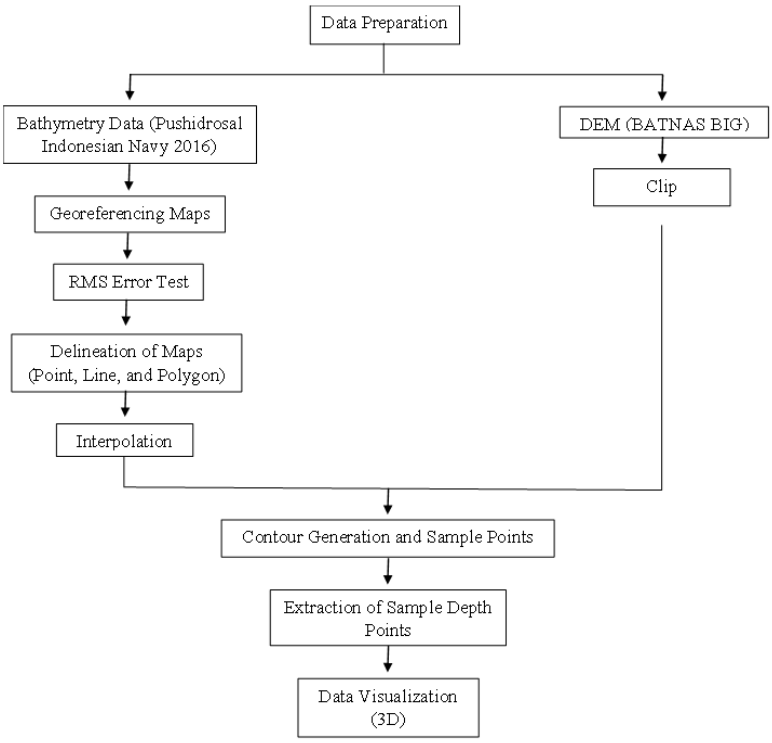

Figure 2. Data Processing Flowchart

RESULTS AND DISCUSSION

Based on the results of depth measurements in the waters of Jemaja, bathymetric data such as in figure 2 are obtained. This figure shows that the seabed depth reaches 33.9 meters. The coast around Jemaja Port in the Anambas Islands is a coastal plain that

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gradually rises inland, as seen in the depth observation gradation data issued by the Navy (Pushidrosal). To see the comparison of bathymetric shapes, bathymetric images from Pushidrosal (**Figure 3**) and BATNAS (**Figure 4**) are shown.Top of Form

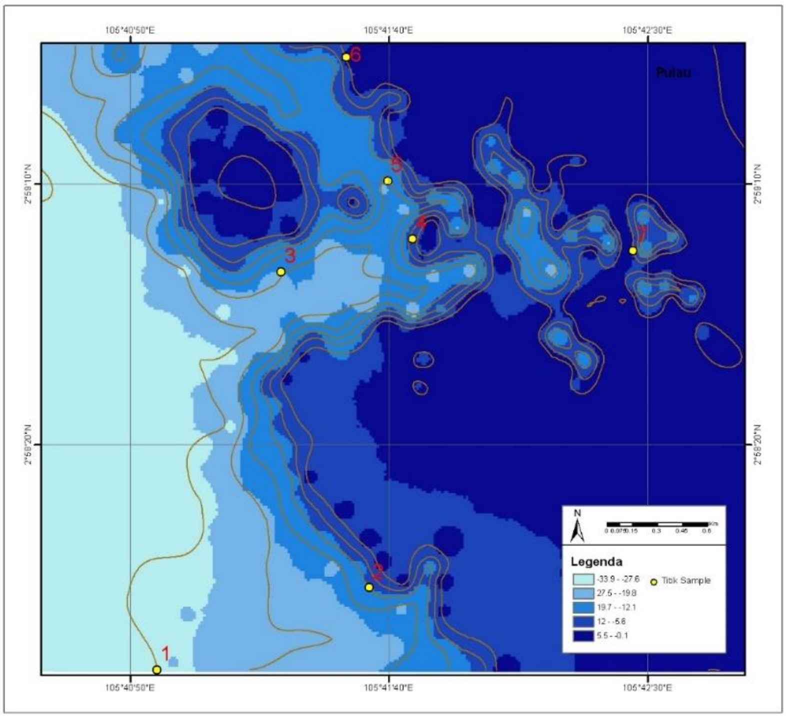

Figure 3. The bathymetric image from Pushidrosal data

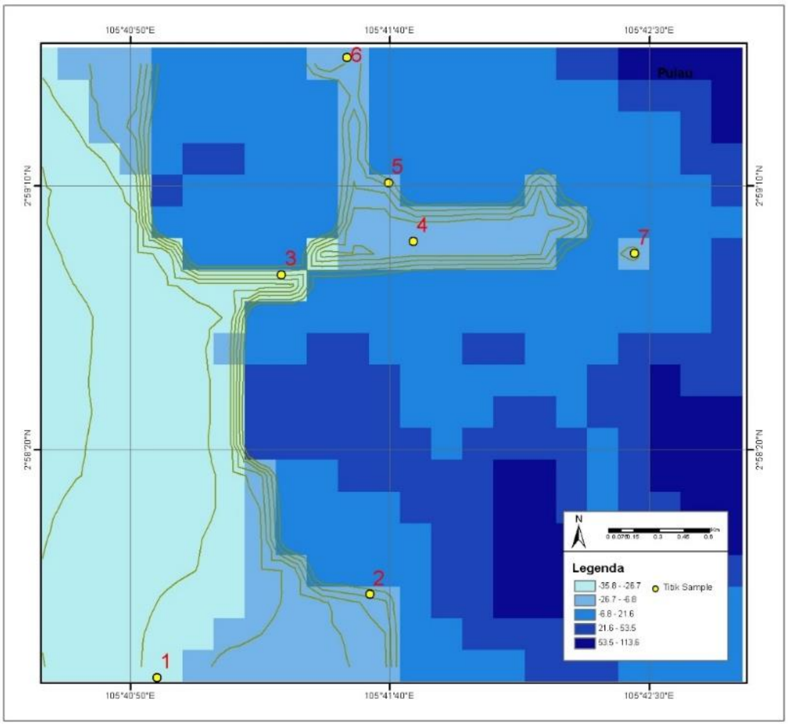

Figure 4. The bathymetric image from BATNAS data

Data processing from Pushidrosal can be compared with the contour results of BATNAS with the same interval of 5 meters. The contour lines from BATNAS data show that the bathymetric contours tend to be steeper compared to the data from Pushidrosal. Additionally, it is also noted that the maximum seabed depth from Pushidrosal data is only 33.9 meters, while the maximum water depth when using bathymetric data from BATNAS reaches 35.8 meters. The depiction of bathymetry from BATNAS data appears irregular compared to the bathymetry obtained from Pushidrosal. This can be understood because the spatial resolution of bathymetric data affects the quality of contours and depth information as well as the accuracy of the data obtained (Lubis, 2021).

Table 1 and **Figure 5.** show the results of extracting depth values from samples. The depth values from BATNAS bathymetric data are significantly different when compared to the bathymetric data from Pushidrosal. From the depth sample creation results: in sample 1, the depth value from BATNAS data is -29.8 meters, while from Pushidrosal it is 28.1 meters. In sample 2, it's -12.5 (BATNAS) and -11.2 (Pushidrosal). Sample 5 shows -16.8 (BATNAS) and -14.3 (Pushidrosal). Sample 6 is -3.9 (BATNAS) and -8.1 (Pushidrosal). Sample 7 is -7.1 (BATNAS) and -8.1 (Pushidrosal). The depth value difference in samples 1, 2, 5, 6, and 7 is only about 1-2 meters. However, different results are shown in samples 3 and 4. In Pushidrosal data, sample 3 has a depth value of -26.9 meters, while in BATNAS data it is -19.4 meters. For sample 4, Pushidrosal shows -21.4 meters and BATNAS shows -9.4 meters. The difference in depth values between the two datasets is caused not only by different spatial resolution but also by the data collection and formation methods used (Yuniastuti, 2018).

Table 1. Result of sample depth

No	Point Sample	X	Y	Depth (m)	
				Pushidrosal	BATNAS
1	Sample 1	575.787194	327.220205	-28.1	-29.8
2	Sample 2	577.051593	327.70461	-11.2	-12.5
3	Sample 3	576.525422	329.563488	-26.9	-19.4
4	Sample 4	577.308488	329.759083	-21.4	-9.4
5	Sample 5	577.162932	330.097978	-14.3	-16.8
6	Sample 6	576.916278	330.825859	-8.1	-3.9
7	Sample 7	578.626587	329.68777	-8.1	-7.1

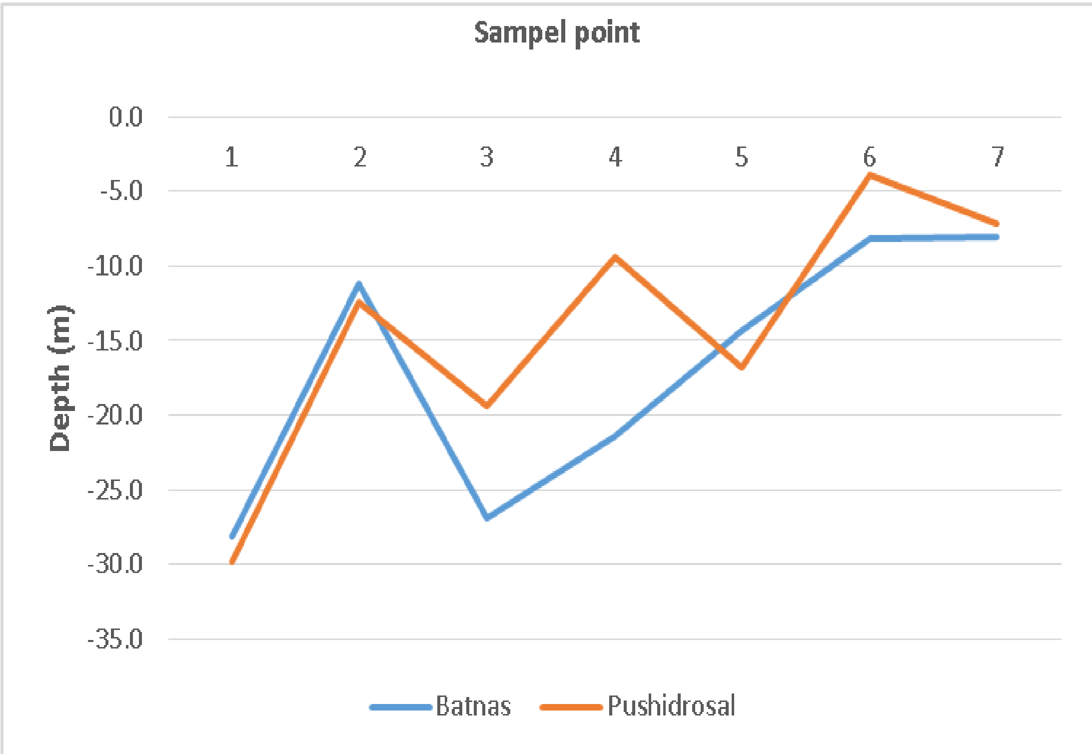

Figure 5. Graph of depth samples

The results of underwater morphology visualization using Surfer show differences between the data from BATNAS and the data from Pushidrosal. BATNAS data (**Figure 5**) includes elevation data, so when visualized in 3D, the island part has elevation contours, whereas Pushidrosal data (Figure 5) does not, as it is primarily focused on mapping the seabed. The maximum depth in BATNAS data reaches 40 meters, while the maximum depth using Pushidrosal data reaches 36 meters.

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The results of the 3D model based on contour processing data indicate the presence of shapes and distances between contours. The contour map shows that the coastal areas are initially flat, and as the distance increases towards the sea, the depth becomes steeper. In each dataset, the western region shows steep underwater morphology. Both datasets indicate the presence of trenches but not excessively deep ones. Based on the bathymetric contour results of the waters around Jemaja, it falls within the continental shelf morphology, with a depth value of around -30 meters. This aligns with Kennett's statement (1982) that the Continental Shelf is a shallow seabed with gentle slopes and steep inclines, with an average depth of around -30 meters (Yuniastuti, 2018).

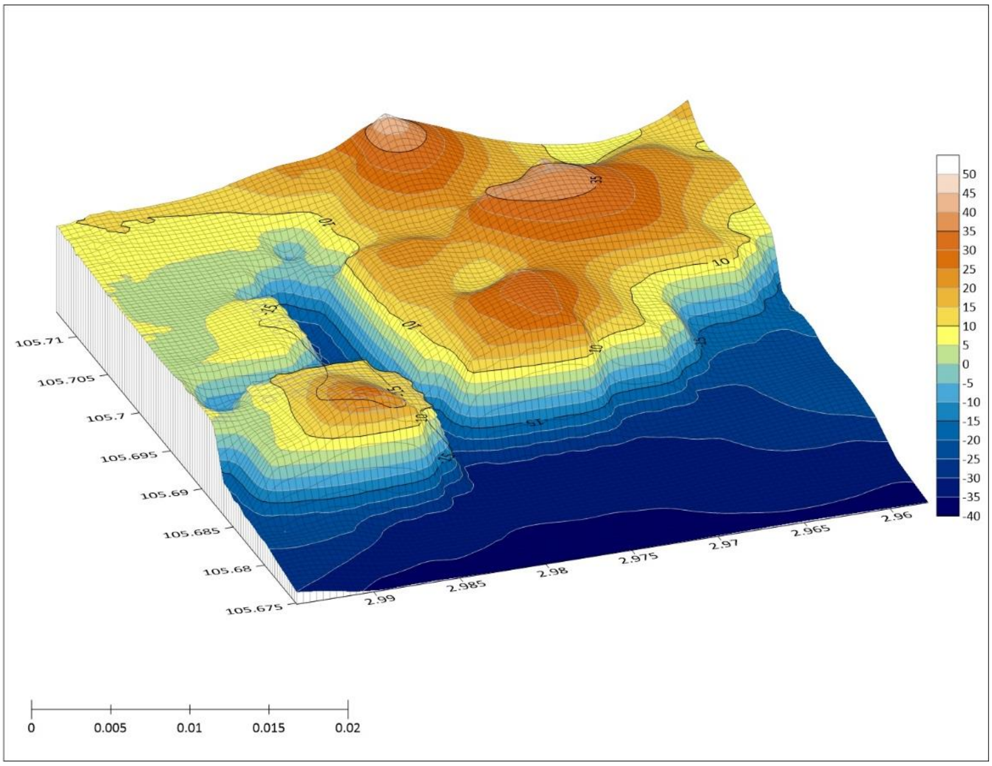

Figure 6 The result of 3D visualization of BATNAS data

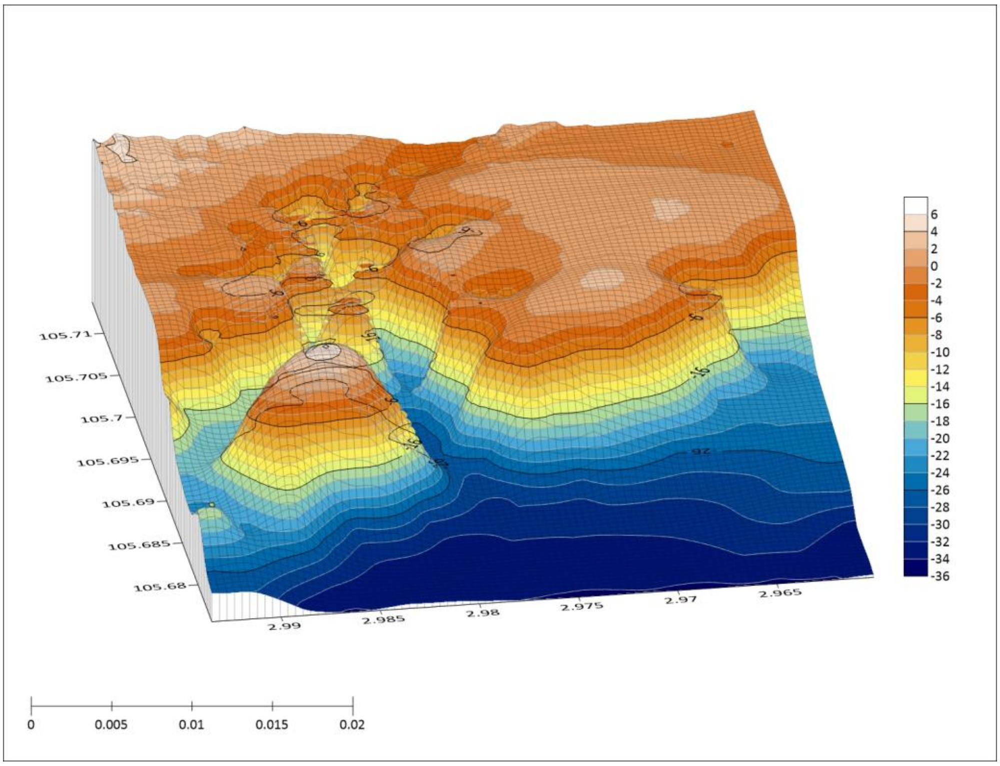

Figure 7. The result of 3D visualization of Pushidrosal data

Based on the analysis of two bathymetric datasets in the waters around Jemaja using GIS methods (**Figure 6** and **Figure 7),** it can be concluded that the maximum depth in this area is -36 meters according to the data issued by Pushidrosal TNI AL, while the data from BIG indicates a maximum depth of -40 meters. The underwater morphology around the waters of Jemaja falls within the Continental Shelf. The 3D modeling results differ due to the different spatial resolutions between the two datasets. Furthermore, considering that underwater morphology can be influenced by waves and currents, further research is needed in the future to observe oceanographic data and assess the dynamics of changes in underwater morphology in this area. For more detailed use of bathymetric data, it is preferable to use the data issued by Pushidrosal TNI AL because it provides depth contours on a map format, making it easier to interpret. However, Pushidrosal data also has its limitations as it may not be readily available and easily accessible. On the other hand, bathymetric data from BIG offers the advantage of easier access, despite still being in the form of DEM data.

CONCLUSIONS

Due to limitations of the researchers, the results of the data comparison in this study are biased as only secondary data were used. The researchers hope that this study can be used as an evaluation material and reference for underwater morphology visualization data analysis. For future researchers concerned with underwater morphology visualization, it is necessary to develop and use field data as a comparison to the research findings.

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