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MAPPING ESTIMATION OF SHALLOW WATER DEPTH USING BATHYMETRIC EMPIRICAL MODELING ECHOSOUNDER DATA AND SENTINEL-2 SATELLITE IMAGE DATA (CASE STUDY: SHALLOW WATERS OF BAYUR BAY, PADANG CITY)

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ABSTRACT: This study aims to see the depth of the shallow waters of Teluk Bayur, Padang City, West Sumatra Province using Sentinel 2 imagery through the processing of Geographic Information Systems and Remote Sensing. Satellite imagery is intended to obtain in-depth information at an affordable cost and to examine differences in the use of the algorithms used.
This study uses Sentinel 2 satellite data. The algorithm used in this research is Bathymetric Empirical Modeling which is applied to Sentinel-2 digital satellite imagery, it will go through several analytical processes, starting from the extraction of water bodies where this process separates between water bodies and non-water bodies. waters, after that the process of correcting the reflection of the water surface or Sunglint.
The results of this study are empirical maps of the shallow waters of Teluk Bayur which get a maximum depth of 125 m using band 1 and band 2, while the maximum depth that is more accurate is 128 m using band 2 and band 3 where the maximum depth of 128 m is also the depth of data acquisition results echosounder PT. PELINDO II Teluk Bayur Branch.

Keywords: Bathymetry, Sentinel 2 Imagery, Empirical Modeling of Bathymetry, Remote Sensing.

1. INTRODUCTION

Bathymetry or water depth is a measure of the depth from the surface of the water to the seabed. Bathymetry mapping in shallow waters has an important role in fisheries and marine activities both directly and indirectly. Bathymetric maps provide information about the condition of the seabed, its structure, shape, and appearance (Setiawan et al., 2014). Intertidal zone bathymetry is needed for the study of seafloor morphology, environment, coastal resource management, and oceanographic modeling. Information about underwater topographical structures can help identify the presence of coral reefs, shoals, and global (Siregar and Selamat, 2010).

The increasing importance of accurate data regarding the characteristics of the shallow water bottom on a temporal and spatial scale in an area causes survey models and their detection methods to require techniques or methods that must be studied on an ongoing basis. Various techniques and methods have been developed in the decades ranging from conventional data collection and sounding to the use of remote sensing technology (Siregar, 2010).

Bathymetric mapping technology has evolved. Early bathymetric techniques used weighted ropes or cables lowered from the side of the ship. However, the main limitation of this technique is that it can only take one measurement at a time, which is considered inefficient. The technique is also subject to ship movements and currents.

In the modern era, bathymetry measurements can be carried out by echo sounding (sonar), which is installed on the side of a ship and then waves are emitted for the process of measuring the depth of water by emitting pulses or sound waves regularly from the surface of the water and then reflecting echoes (echo) which comes from the seabed will be recaptured by the receiver. The distance and time resulting from the process of sending sound waves and returning sound waves will be translated as the depth of the sea (Firdaus, 2008). This method is considered more practical, fast, and accurate. However, this method has several drawbacks, namely that we cannot obtain information about temperature, rock types, and signs of life on the seabed.

The need for shallow water bathymetry mapping is indispensable for various kinds of shipping engineering and safety work (Wahyuningrum et al, 2008). Ships carrying various mapping equipment find it difficult to enter the waters freely due to the unique characteristics of these waters, such as shallow water conditions.

as well as the state of the base substrate being irregular. In addition, considering that shallow water ecosystems are very broad, mapping activities with this method will require a long time and very high costs.

Therefore, bathymetry measurement technology has now been developed using remote sensing technology which is considered more cost-effective and easier to apply as well as visible advantages. The results of this technology can be used in the preparation and revision of existing resource maps and are useful as an aid in resource planning and management (Lillesand, 1994). This technology can be used to obtain data directly and quickly and continuously because it has been programmed to traverse the same area at a certain time to observe phenomena that occur either on land or in the vast ocean with accuracy close to the original conditions in nature.

The use of Sentinel-2 satellite technology will facilitate the process of measuring water depth data (bathymetry) which will be combined with field data in the shallow waters of Teluk Bayur. Judging from its location, Teluk Bayur is a very strategic coastal area, as can be seen from the existence of port areas, industries, settlements, and the traffic of fishing boats, local shops, and local ships. foreign. Because the waters of Teluk Bayur are located on the west coast of Sumatra which is water with a mud substrate, it is very possible for the process of changing bathymetry in its waters in the form of shallowing of the waters or even deepening of the waters. Given this, it is highly recommended to research bathymetry in the shallow waters of Bayur Bay on a regular and sustainable basis, so that the process of boat traffic and fishing activities is not disturbed by the process of change in the area.

Based on the explanation above, the authors will conduct research related to bathymetry mapping with the title "Mapping Estimation of Shallow Waters Depth Using Empirical Bathymetric Modeling Utilizing Echosounder Data and Sentinel-2 Satellite Image Data (Case Study: Teluk Bayur Shallow Waters, Padang City)".

2. THE METHOD

2.1 Research Form

Teluk Bayur is included in Teluk Bayur Village, South Padang District, Padang Municipality, West Sumatra Province. Geographically Bayur Bay is located at 0° 59' 30" South Latitude and 100° 22'11" East Longitude. The area of Teluk Bayur Village is 2.83 Km² with a population of 2,919 people.

The boundaries of the Teluk Bayur Village area are determined based on regulatory provisionsarea or the provisions of the existing government apparatus in this region as the regions in Indonesia. What has been determined based on the provisions of regional regulations regarding the boundaries of the Teluk Bayur Village area are as follows:

a. To the north it is bordered by West Padang District and East Padang District.
b. To the east it is bordered by Lubuk Begalung District.
c. To the south it is bordered by the Indonesian Ocean
d. To the west it is bordered by the Indonesian Ocean

2.2 Research methods

This research uses quantitative methods. The stages of this research are as follows:

2.2.1. Pre-Processing Stage (Pre-Processing Image Data.

a. Normalized Difference Water Index(NDWI)
In the first stage identify the depth of the bayur shallow waters based on sentinel-2 satellite imagery data, namely masking. Masking is the stage to separate the waters and land areas by blocking the land digital number (DN) value with a zero value. This stage is done so that the mainland does not affect waters at the time of the entry of the algorithm shallow water bathymetry. In this masking process, the NDWI (Normalized Difference Water Index) method is used to separate land and water.

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Vol 2 No 2 | Dec 2021

NDWI:(GREEN-SWIR1)+(GREEN+SWIR 1)

where: GREEN: Band 3

SWIR 1: Band 11

b. Sun Glint

In the next stage, the image cropping process is carried out which aims to adjust the location of the image to the research area. After that, sun glint correction or sunglint effect removal is carried out to remove the sparkle on the surface of the water due to the reflection of sparkling sunlight. The sun's condition on the water's surface can cause errors when mapping the depth of water bodies. An algorithm for removing the sunglint effect was developed by Hochberg et al (2003)), which was refined by Hedley, et al., (2005) as in the following equation.

R'i = Ri – bi (Rnir – Minnir)

Where:

R'I = The value of channel i after reduction

R = of Initial i channel value
Bi = The magnitude of the slope of the regression
Rnir = NIR channel value
Minnir = Minimum value of NIR channel

2.2.2. *Image Data Processing Stage*

a. Ratio Transform Algorithm (RTA)\

In the next stage, estimate depth was developed by (Stumpf et.al. 2003). The principle of this method is to use a ratio of two bands where if the ratio increases, the results of the estimated depth will also increase, if the depth continues to increase, bands with high absorption rates will continue to decrease (Irwanto, 2018). The equation of the Stumpf method is as follows:

$$Z = m1\frac{ln(nRw(\lambda i))}{ln(nRw(\lambda j))} - m0$$

Where:

Z: Searched depth m1: Calibration coefficient
ln: Constant

m0: Depth Correction

RW: water reflectance in band ʎi or ʎj ʎ: spectral band
n: the constant area value of the positive logarithmic value of each case and the ratio which will refer to the linear regression response to the water depth response

b. Empirical Modeling

In the next stage, bathymetric empirical modeling is carried out by looking for the relationship between the pixel values recorded by the sensor and the survey data field with the use of an echosounder. This bathymetric empirical modeling was carried out on the SNAP application tool.

In the bathymetry empirical modeling with the first SNAP application by selecting a sunlight-corrected image, then the processing parameters are required to select two bands, the band used in Empirical bathymetric modeling generally uses blue bands (sensitive to substrates) and green bands (sensitive to water turbidity), but in empirical bathymetric modeling, you can use a combination of coastal aerosol bands (sensitive to aerosols) and blue bands (sensitive to substrates). Next, determine the bathymetry data points, the bathymetry data points are the depth samples measured directly in the field.

In the bathymetry empirical modeling tools belonging to the SNAP application, it is required to store depth data from field measurements in the format of latitude or latitude, longitude or longitude, and depth data denoted by positive numbers. This data is typed in notepad format which is then saved in the .csv file format

IRSAJ
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Vol 2 No 2 | Dec 2021

3. DISCUSSION RESULT

1) Results

By conducting bathymetric empirical modeling research in the shallow waters of Bayur Bay, Padang City using Sentinel 2A satellite imagery to create a bathymetric map, the results of the bathymetric mapping research with empirical bathymetry modeling were obtained as follows:
In the bathymetric mapping process with bathymetric empirical modeling, there will be three main data processing stages, in which sentinel 2 imagery is used in the band used in the modeling.

This empirical bathymetry uses the blue band (sensitive to the substrate) and the green band (sensitive to water turbidity) and the coastal aerosol band (sensitive to aerosols). Mapping the depth of the shallow waters of Bayur Bay uses empirical bathymetry modeling using echosounder data and sentinel-2 satellite imagery (Band 1 and Band 2) (Band 2 and Band 3).

a. Processing

i. Normalized Difference Water Index(NDWI)
In the first stage identify the depth of the bayur shallow waters based on sentinel-2 satellite imagery data, namely masking. Masking is a step to separate water and land areas by blocking digital number values(DN) land with a value of zero. This stage is carried out so that the land area does not affect the waters when entering the shallow water bathymetry algorithm. In this masking process, the NDWI (Normalized Difference Water Index) method is used to separate land and water.
In this stage, the researchers succeeded in implementing the NDWI algorithm to highlight aquatic objects and discriminate against non-aquatic objects to facilitate the next bathymetric analysis stage. The results of the NDWI image transformation can be seen in Figure 5 below:

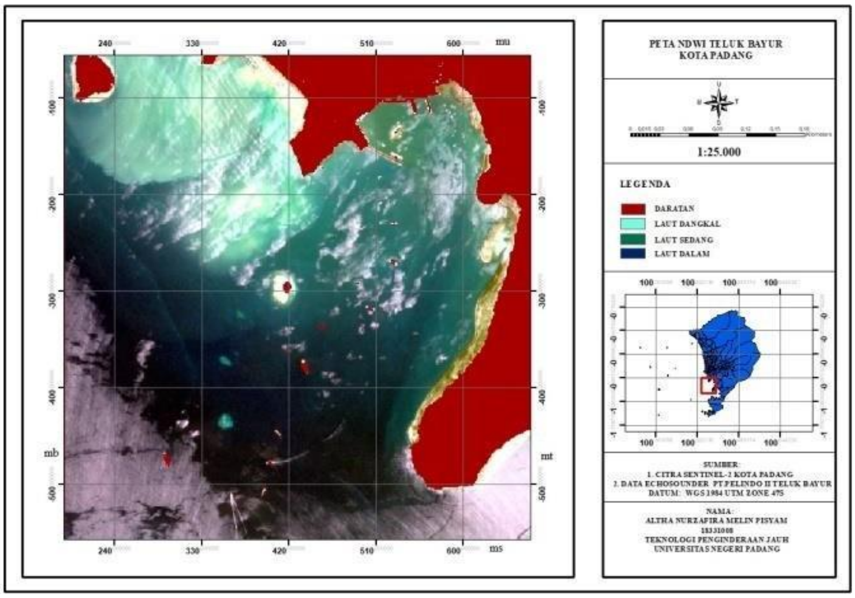

Figure 5. Map of the NDWI Bayur Shallow Waters

Figure 5 it shows that the red color indicates land, the Tosca green color indicates shallow sea, the dark Tosca green color indicates medium sea and the dark blue color indicates deep sea. Masking results using Sentinel-2 looks more detailed because Sentinel-2 imagery produces better details. After all, it can record the smallest object sizes up to 10m.

ii. Sun Glint

Furthermore, the bathymetry mapping process goes through the sun glint correction stage. In principle, sun glint correction aims to eliminate the refractive bias of sunlight reflected by the water surface into the atmosphere so that the original image will show the sparkle of the water surface light which will cause errors in the analysis. Then the application of sunglint correction of the glare of the light on the surface of the water can be muted so that it can display the appearance of the depth of the water

corresponding to a normal reflection. The following is a picture of the sun glint correction result

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Vol 2 No 2 | Dec 2021

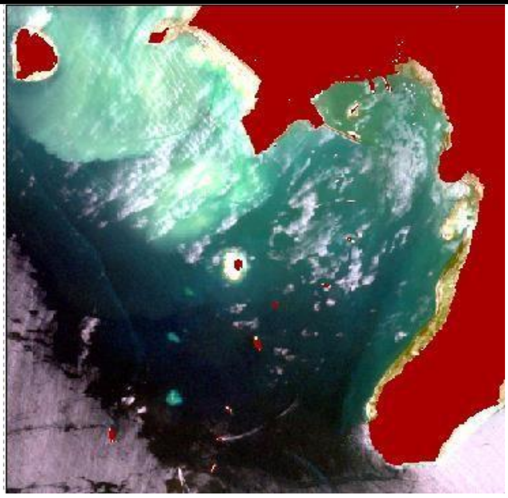

Figure 6. Image before sunglint correction

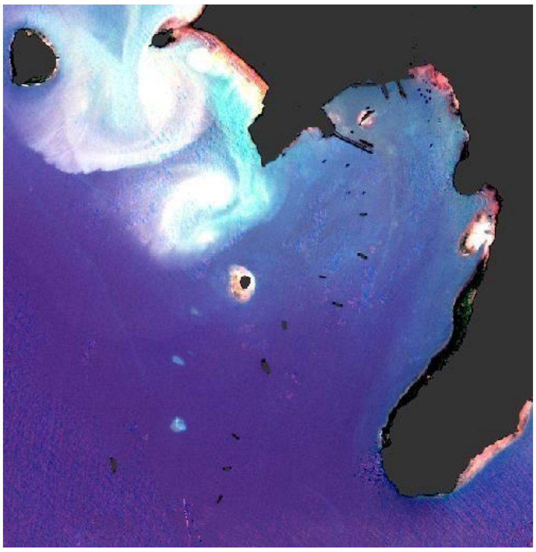

Figure 7. Image after sunglint correction From the image above it can be seen

the appearance of the sunglint corrected image, the sun's glare bias is no longer visible. At coordinates lon 100.33667, lat-1.00694 before sunglint correction has a value of DN 63 (sunshine), while the image after sunglint correction has a value of DN 127 (purplish blue). From the DN it can be concluded that the greater the DN value in the image, the better shows the brightness of the image. We can see a comparison of the appearance of the image before sun glint correction and after correction, the results show a very clear difference in the appearance of the water surface.

b. Processing
i. Bathymetry Empirical Modeling

In the next stage, bathymetric empirical modeling is carried out by looking for the relationship between the pixel values recorded by the sensor and the survey data field with the use of an echosounder. This bathymetric empirical modeling was carried out on the SNAP application tool.

In the bathymetric empirical modeling with the SNAP application first selecting a sunglint corrected image, then in the processing parameters, it is required to choose two bands, the band used in this empirical bathymetric modeling generally uses the blue band (substrate sensitive) with a wavelength of 490 nm and the band green (sensitive to water turbidity) with a wavelength of 560 nm, but in empirical modeling, this bathymetry can use a combination of the coastal aerosol band (sensitive to aerosols) with a wavelength of 443 nm and the blue band

IRSAJ
International Remote Sensing Applied Journal
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Vol 2 No 2 | Dec 2021

(sensitive to substrates) with a wavelength of 490 nm. Next, determine the bathymetry of the data points, the bathymetry of the data points is the sample depth measured directly infield.

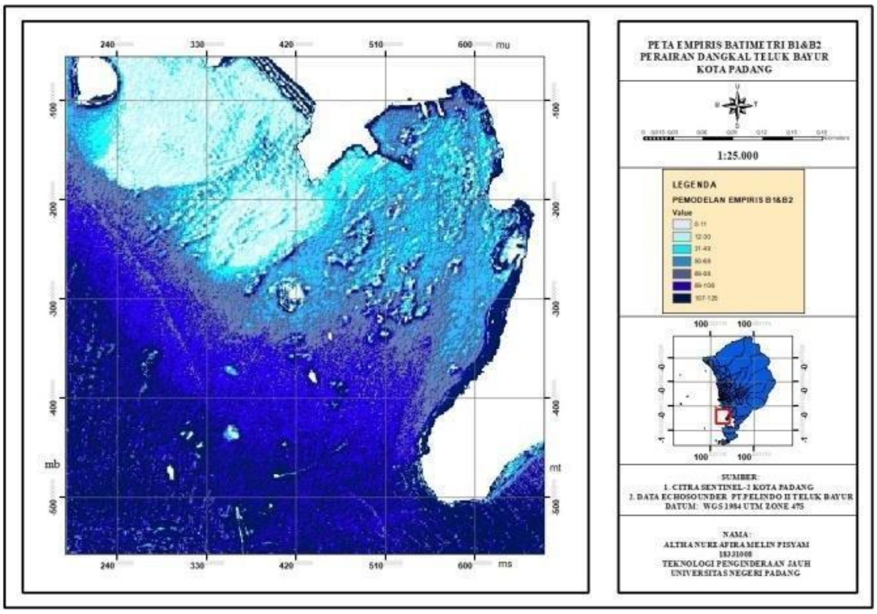

Figure 8. Empirical Bathymetry Map of the Shallow Waters of Teluk Bayur B1 and B2

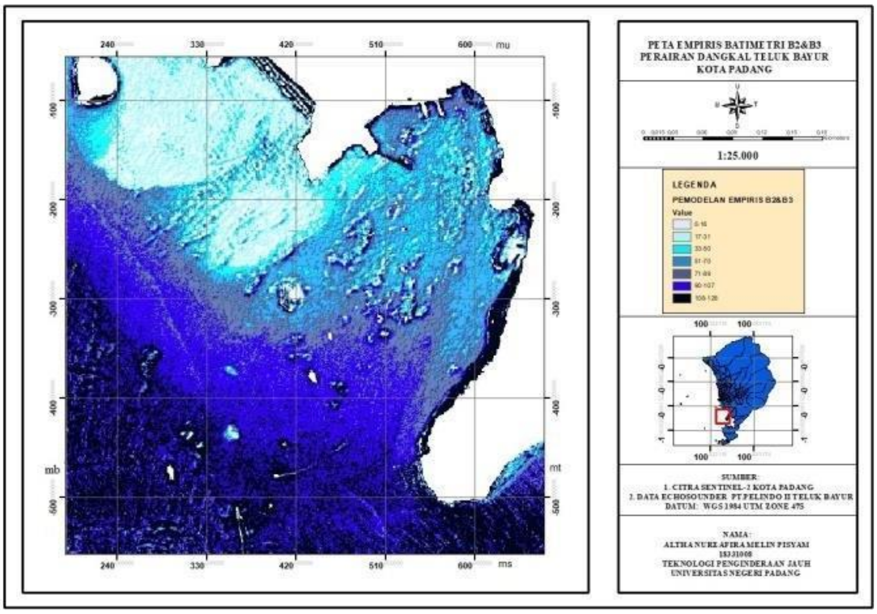

Figure 9. Empirical Bathymetry Map of the Bayur Shallow Waters

The figure above is the result of empirical modeling of the shallow water bathymetry of Bayur Bay, Padang City. The image represents the depth of the waters. From the map above, the researcher gives the color symbol from ultramarine to bright blue, where the ultramarine color informs that the location is deep waters in Teluk Bayur waters, while bright blue is shallow waters in Teluk Bayur waters.

From the empirical bathymetry map above, it can be Look at the depth distribution of the shallow waters of Bayur Bay, Padang City, where we can observe an empirical map of the bathymetry of the shallow waters of the Bayur Bay using bands 1 and band 2 to produce seven depth classes, namely in the first class the water depth is 0-11m, in the second class the water depth is 12-30m, in the third class the water depth is 31-49m, in the fourth class is the water depth is 50-68m, in the fifth class is the water depth is 69-87m, in the sixth class is the water depth is 88-106m and in the seventh class is the water depth 107-125m. Empirical bathymetry map of Bayur shallow waters

IRSAJ
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p_ISSN =_____- ____
Vol 2 No 2 | Dec 2021

using bands 2 and 3 produces seven depth classes, namely,y in the first class the water depth is 0-16m, in the second class the water depth is 17-32m,

4. Discussion

Based on the research results, researchers have found the depth of the shallow waters of Bayur Bay by going through several stages of data analysis. Utilizing the NDWI transformation

proves to be very efficient for delineating water areas because this transformation is very sensitive to indiscriminating non-water motorcycle taxis. This stage shows that the red color indicates land, the Tosca green color indicates shallow sea, the dark Tosca green color indicates moderate sea and the dark blue color indicates deep sea.

Furthermore, the results of this study also describe differences in image information and object appearance resulting from image recording beforesunglinth correction and images aftersunglinth correction. Where it was found that the lon coordinates 100.33667, lat -1.00694 before sunglasses correction have a DN 63 value (sunshine), while the image after sunglint correction has a DN 127 value (purplish blue). From the DN it can be concluded that the greater the DN value in the image the more it shows the brightness of the image.

The depth of the waters was successfully mapped in this case where the maximum depth was obtained at 125m using band 1 (443 nm) and band 2 (490 nm), while a more accurate maximum depth was obtained at 128 m using band 2 (490 nm) and band 3 (560 nm) where the maximum depth of 128m is also the depth of the PT. PELINDO II Teluk Bayur Branch which has an accuracy rate of 95%.

Table 1. Regresi dan Standar error peta empiris batimetri b1 dan b2

Regression Statistics	
Multiple R	0.996489915
R Square	0.992992151
Adjusted R Square	0.992849133
Standard Error	3.778986152

Tabel 2. Regresi dan Standar error peta empiris batimetri b2 dan b3

Regression Statistics	
Multiple R	0.999815518
R Square	0.999 63107
Adjusted R Square	0.999623541
Standard Error	0.86707102

From the table above we can understand that the relationship between these two data researchers managed to find the value of the regression coefficient with a value of 0.992992151 and has a standard error of 3.778986152 using band 1 (443 nm) and band 2(490 nm), while using band 2

(490 nm) and band 3 (560 nm) produces a regression coefficient value of 0.999815518 and has a standard error of 0.86707102. The standard error in band 1 and band 2 is larger than using band 2 and band 3, this is because band 1 has a spatial resolution of 60 m and band 2 has a spatial resolution of 10 m which must be resampled from 60 m to 10 m resolution, while in band 2 and band,3 both have a spatial resolution of 10m without having to resample the image. Therefore it is highly recommended to use band 2 and band 3 to carry out bathymetric empirical modeling because band 2 and band 3 have a smaller standard error than using band 1 and band 2.

It can be seen that b1 and b2 have an R^2 value of 0.993. The scatter plots b2 and b3 have an R^2 value of 0.9996. The closer R Square (R^2) is to number one, the more the model produced by the regression shows high accuracy. It can be seen that using b2 and b3 is better than b1 and b2 to carry out the bathymetric empirical modeling process

5. CONCLUSIONS

The results of this study resulted in conclusions based on the formulation of the problems that have been described previously. The conclusions that can be drawn in shallow water depth estimation mapping using empirical bathymetry modeling by utilizing echosounder data and Sentinel-2 satellite imagery data (case study: shallow waters of Teluk Bayur, Padang City) are as follows:

In the process of mapping bathymetry with empirical modeling of bathymetry through three main data processing stages, in which sentinel imagery 2a in bands 1 and 2 and 2 and 3 is used. It passes the separation stage between aquatic and non-water features and sunglint correction, RTA (Ratio Transform Algorithm,) and Bathymetric empirical modeling process. In this case,e using data from field surveys using echosounder data obtained from PT. PELINDO II Teluk Bayur City Branch Padang. So that the maximum depth results are obtained at 125m using band 1 and band 2, while a more accurate maximum depth is obtained at 128 m using band 2 and band 3 where the maximum depth of 128m is also the depth of the PT echosounder data acquisition. PELINDO II Teluk Bayur Branch.

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