Identification of a wharf wall condition using an Oblique Side Scan Sonar approach

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Abstract. Port of Tanjung Perak has several terminals, one of which is Nilam Terminal. Nilam Terminal itself is a Multipurpose Terminal and one of the terminals with the highest loading and unloading activities at Port of Tanjung Perak. With the high level of activities occurring at the Nilam Terminal, monitoring and maintenance of the wharf wall conditions are needed, so that the ongoing activities can run smoothly. Therefore, the purpose of this study is to identify the condition of the wharf walls with acoustic imaging using the Oblique Side Scan Sonar approach and provide an overview of the condition of the Nilam Terminal. To produce a picture of the wharf wall with an acoustic image requires Side Scan Sonar data, where during installation, the tool is turned 90° so that it faces the wharf wall. In this study, three types of corrections were made, which are Altitude Correction, Slant Range Correction, and Time-Varying Gain. In order to validate the Side Scan Sonar results, use digital cameras to increase the credibility of interpretation results. The length of the wharf wall surveyed is 268.62 meters with a total area of 3223.44 m². In that area there are three locations that are interpreted as holes in the wharf wall. The position of the first hole at the UTM (Universal Transverse Mercator) coordinates 49S A Zone is at (690268.97 m; 9203336.09 m) with an area of 2.07 m², the position of the second hole is at (690224.71 m; 9203404.98 m) with an area of 1.91 m², and for the position of the third hole is (690208.15 m; 9203438.66 m) with an area of 1.21 m².

Keywords: Oblique Side Scan Sonar, Wharf, Acoustic Image

1. Introduction

Indonesia is the biggest archipelago country in the world. Therefore, Indonesia needs a good and efficiently managed port sector [1]. According to Government Regulation of the Republic of Indonesia Number 61 Year 2009 Article 1 Paragraph 1, a port is a place consisting of land and waters around it with certain limits as a place of government activity and economic activities used as a place for ships to the wharf, anchored, lean on and off passengers and / or loading and unloading of goods equipped with shipping safety facilities and port support activities as well as intra and inter modes of transportation.

PT Pelabuhan Indonesia III (Persero) is a company engaged in port services [2]. PT Pelindo III manages many large ports, one of which is the largest port in East Java, namely the Port of Tanjung Perak. Tanjung Perak Port is one of the gateway ports in Indonesia, which is the center of collectors and
distributors of goods to Eastern Indonesia, especially in East Java Province [3]. Tanjung Perak Harbor has several terminals, one of which is Nilam Terminal. Nilam Terminal is a Multipurpose Terminal and one of the terminals with the highest level of loading and unloading activities at the Port of Tanjung Perak [4]. This terminal was previously a conventional terminal equipped with several warehouses, until finally PT. Pelindo III (Persero) optimizes it by revitalizing it into a modern terminal. One of the revitalization activities carried out is to carry out the stages of improving the wharf building.

The wharf is a harbour building used to dock ships and tether them at the time of loading and unloading of goods, so it can be explained that the wharf is where the ship is moored at the port [5]. The existence of various activities that occur around the wharf requires monitoring the condition of the wharf. The condition of the wharf is not only influenced by human activities, but also by natural activities such as waves and ocean currents. Likewise, Nilam Terminal, located in the Port of Tanjung Perak, requires monitoring the condition of the wharf for monitoring and maintenance needs.

In identifying the condition of the wharf requires acoustic observation of the seabed. Acoustic methods are currently widely used to detect the presence of underwater objects. The acoustic system is very effective for exploring the underwater environment. One of the seabed instruments that can be used for identification purposes is the Side Scan Sonar (SSS). This technology uses acoustic wave emission to determine the type of sediment and objects that are on the seabed. SSS records the backscattering value reflected by the seafloor in the form of electrical energy. This instrument is able to distinguish the large and small particles making up the surface of the sea floor such as rocks, mud, sand, gravel, or other types of the aquatic bottom[6].

In general, the use of Side Scan Sonar (SSS) for acoustic observation of the seabed position of the wave beam facing downward / seabed but to get an overview of the conditions of the wharf then its use needs to be rotated 90 ° on the horizontal axis or in a side-facing condition (Oblique Side Scan Sonar). Using this method, it can be identified the condition of the wharf based on the backscattering parameters of the wharf structure, which will be interpreted qualitatively later. The purpose of this study is to identify the condition of Surabaya East Nilam Wharf based on the backscattering value of objects on the wharf with the Oblique Side Scan Sonar method so that a description of the wharf condition can not be seen from above the water surface. The results of this study are expected to be the basis for the needs of supervision and maintenance of the East Nilam wharf in the Port of Tanjung Perak.

2. Data dan methods

2.1. Data
The data used in this study consisted of:

a. Raw Side Scan Sonar Data
Side scan of raw sonar data obtained from the Garmin 72 SV instrument. This instrument produces images with high frequency (high frequency) with a large frequency of 455 kHz, by using high frequencies the SSS image will have a good image resolution with tight variations.

b. Wharf photo data using the camera
Wharf photo data were taken using a digital camera. the data is used as validation of the image interpretation process

2.2. Research Methodology
2.2.1 Data Selection Data selection is done to select Raw SSS data which will then be processed, this selection is done by selecting raw SSS data that covers the survey area or the entire vertical structure of the wharf.
2.2.2 Data Correction

a. Altitude Correction

Altitude Correction is done to correct the height of the sensor from the seabed by detecting the depth in accordance with the SSS record so that the first echo return is obtained, for this study the sensor detects the distance between the wharf wall and the transducer.

b. Slant Range Correction

Slant Range Correction is done to calculate the actual distance of the object in the SSS record from nadir (the point below the sensor).

c. Time-Varying Gain

Time-Varying Gain is done to get the image with the same brightness even though the object is far from nadir.

2.2.3 Coverage Validation

Check the corrected SSS image results so that the acoustic image meets the survey coverage area.

2.2.4 Side Scan Sonar Image Mosaics

After the survey area is covered, a mosaic will be formed to form an SSS acoustic image.

2.2.5 Interpretation of Objects

Interpretation of objects is made using acoustic SSS imagery and wharf photo data. The interpretation is made qualitatively, that is based on the shape (shape), size (size), shadow (shadow), the degree of black (hue saturation), texture, and pattern (pattern).

2.2.6 Interpretation of Validation

The validation of the interpretation uses the results of the SSS acoustic image with the photo wharf using a digital camera. If the appearance of the SSS acoustic image matches the wharf photos, the condition of the wharf can be analyzed, but if it is not appropriate, then data collection is performed again.

3. Results and Discussion

3.1. Correction results

Acoustic image data correction is done to eliminate errors that occur in the data acquisition process. SSS data correction is performed during data processing using SonarTRX software.

3.1.1 Altitude Correction

Altitude Correction is a correction made to obtain the value of the first echo return, which is the distance between the transducer and the surface of the object of observation. Therefore, there is a small object which is right in Nadir can not be represented so it produces noise in the middle of Nadir. From the noise, correction is done to produce an image that does not have noise in its nadir.
Figure 1. Altitude Correction (a) before correction; (b) after correction

In Figure 1a shows the Side Scan Sonar image data that has not been done Altitude Correction so that there is still noise in the middle of the image, after correction is made the noise in the nadir will disappear as shown in Figure 1b.

3.1.2 Slant Range Correction

Range Correction (SRC) is a correction used to calculate the actual distance of a seabed object from nadir. SRC also removes water column contained in SSS acoustic images.

Figure 2. Slant range Correction (a) before correction; (b) after correction

In Figure 2a shows the Side Scan Sonar image data that has not been done Slant Range Correction so that there is still a water column in the area around nadir, after being corrected the water column will disappear so that both sides (port side and starboard) of the image will become one as in Figure 2b.

3.1.3 Time-Varying Gain

Time-Varying Gain (TVG) is a correction that is useful for correcting the backscatter value of an object that is weakening along with the distance of an object with nadir. TVG correction is done by providing the appropriate gain parameters along with changes in the distance of the object from nadir.
Figure 3. Time-varying gain (a) before correction (b) after correction

In Figure 3a shows the Side Scan Sonar image data that has not been done Time Varying Gain correction so that the backscattering value of an object is still affected by the distance of the object to the nadir, after being corrected as in Figure 3b, the backscattering value of an object corresponds to each pixel in imagery.

3.2. SSS Raster Mosaic Results

The corrected acoustic SSS image data will have coordinates as shown below:

The corrected SSS acoustic image is exported into the .tiff format, and then a mosaic process is performed. The mosaic process is carried out using Global Mapper software.

Figure 4. SSS Raster Mosaic Results
3.3. **Interpretation of SSS Acoustic Imagery**

After all the processing results have been combined or have been mosaiced, then the SSS acoustic image is interpreted on the objects that appear on the acoustic image. In this research, there are four interpretations that are used in SSS image interpretation, including shape, size, tone/colour, texture. In the key interpretation of the shape of an object, can be categorized into:

1. Regular
   a. Rectangular
   b. Circle
2. Irregular

For the key interpretation of an object's size, it can be seen from its dimensions (length and width). The length and width of an object can be categorized into 3 based on comparison with the dimensions of the wharf, as in Table 1.

| Category   | Dimensions (length x width) (meters) |
|------------|--------------------------------------|
| Very small | 0 – 2                                 |
| Small      | 3 – 5                                 |
| Medium     | 6 – 8                                 |
| Large      | 9 – 11                                |
| Very large | ≥ 12                                  |

An object can be categorized if the length or width is included in the dimension criteria above. The key interpretation of the hue of an object can be categorized as:

1. Dark
2. Light

As for the key interpretation of the texture of an object can be categorized into:

1. Smooth
2. Rough

After all the processing results have been combined or have been mosaiced, then the SSS acoustic image can be interpreted on the objects that appear on the acoustic image. From the results of these interpretations are then validated with photos from digital cameras. Following are the results of the analysis of each appearance that appears on the SSS acoustic image:

- Object A

  This feature can be interpreted as a hole, with the following characteristics:

| Key to interpretation | Information          |
|-----------------------|----------------------|
| Shape                 | Square               |
| Size                  | Small                |
| Degree of blackness   | Dark                 |
| Pattern and texture   | Smooth and orderly   |

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| Table 2. Interpretation of Objects A |
This feature has the appearance of an SSS acoustic image as follows:

![Figure 5. The Appearance of A objects in SSS imagery](image)

The hole feature on the wharf wall is then validated with photos from a digital camera with UTM Zone 49S coordinates (690268.97 m; 9203336.09 m) or located between kilometers point 680-690 of the Nilam Timur Terminal with a feature area of 2.07 m².

![Figure 6. The Appearance of B objects in digital camera photos](image)

- **Object B**

  This feature can be interpreted as a hole, with the following characteristics:

  | Key to interpretation | Information          |
  |------------------------|----------------------|
  | Shape                  | Oval, irregular      |
  | Size                   | Medium               |
  | Degree of blackness    | Dark                 |
  | Pattern and texture    | Rude and irregular   |

  **Table 2. Interpretation of Object B**
This feature has the appearance of an SSS acoustic image as follows:

Figure 7. The Appearance of B objects in SSS imagery

The hole feature on the wharf wall is then validated with photos from a digital camera with UTM Zone 49S coordinates (690224.71 m; 9203404.98 m) or located between kilometers point 760-770 of the Nilam Timur Terminal with a feature area of 1.91 m².

Figure 8. The Appearance of B objects in digital camera photos

- Object C

This feature can be interpreted as a hole, with the following characteristics:

| Key to interpretation | Information             |
|-----------------------|-------------------------|
| Shape                 | Square                  |
| Size                  | Small                   |
| Degree of blackness   | Dark                    |
| Pattern and texture   | Smooth and organized    |
This feature has the appearance of an SSS acoustic image as follows:

![Figure 9](image_url)

**Figure 9.** The Appearance of C objects in SSS imagery

The hole feature on the wharf wall is then validated with photos from a digital camera with UTM Zone 49S coordinates (690208.15 m; 9203438.66 m) or located between kilometers point 800-810 of the Nilam Timur Terminal with a feature area of 1.21 m².

![Figure 10](image_url)

**Figure 10.** The Appearance of C objects in digital camera photos

From the results of the interpretation that has been validated with data from a digital camera the SSS Acoustic Image Map is produced as shown below.
Figure 11. SSS acoustic image map

Based on the survey results and validation of the position of the object at the wharf wall in the field it was found that the position of Object A is located at Kilometer Point (KP) 680-690, for Object B is located at Kilometer Point (KP) 760-770, and for Object C it is located at Kilometer Point (KP) 800-810.

4. Conclusions

The research activity of identifying the condition of the wharf using the oblique Side Scan Sonar method at the East Nilam Wharf, Tanjung Perak Harbor using the Garmin Echomap 72sv produced the following conclusions:

- Based on the Side Scan Sonar Acoustic Image Map, the length of the survey area or wharf wall is 272.26 meters with a total area of 4599.16 m², where there are 3 feature spots specified as holes in the wharf wall based on qualitative interpretation.
- From the results of the interpretation generated analysis of the condition of the wharf with the object hole there are 3 points. The position of the hole in the UTM (Universal Transverse Mercator) coordinates Zone 49S for object A is at (690268.97 m; 9203336.09 m) with an area of 2.07 m², for object B is at (690224.71 m; 9203404.98 m) with an area of 1.91 m², and for object C is at (690208.15 m; 9203438.66 m) with an area of 1.21 m². The damage is classified as small damage when compared to the dimensions of the wharf wall so it does not have much effect on the loading and unloading activities that take place at the wharf, and for the causes of damage caused by abrasion that occurs due to seawater.
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