Study of bathymetry in determining Nuclear Power Plant Site in Gosong Beach Waters, West Kalimantan

H Susiati*, T A Ryanto¹, H Suntoko¹, Risko², Muhardi³ and Z Zibar⁴

¹National Atomic Energy Agency, Indonesia
²Department of Marine Science, Faculty of Mathematics and Natural Sciences Tanjungpura University, Indonesia
³Department of Geophysics, Faculty of Mathematics and Natural Sciences Tanjungpura University, Indonesia
⁴Department of Marine Science, OSO University, Indonesia

*E-mail: heni_susiati@batan.go.id

Abstract. Gosong Beach waters are located in Bengkayang Regency West Kalimantan, where the water conditions are influenced by the South China Sea. This study aimed to determine the shape of the bottom morphology profile (bathymetry). The bottom morphology of the water was used as initial data to determine the location of nuclear sites in the study area. Bathymetry measurements were conducted using a single beam echosounder corrected by tidal data to determine the chart datum value, then used to correct sea depth for accuracy. The measurement of tidal data was conducted for 15 days in March 2021 with an interval of 1 hour. The results showed that the type of tidal obtained was mixed tide mixed with the double daily slope with Formzhal (F) value 0.77. The depth of the waters at the study site ranges from 0.9 to 8.45 meters. The average value of the coastal slope shows that spatially there are variations in the slope class with the percentage value ranging from 0.13 to 2.29% which is included in the classification of flat coastal slopes.

Keywords: bathymetry, Gosong Beach Water, morphology, tidal

1. Introduction
Gosong coastal waters Bengkayang Regency West Kalimantan is an area where the environmental conditions of the waters are influenced by the conditions of the South China Sea and include shallow sea waters. Mapping shallow marine water is important in studying the bottom morphology of the water, marine environment, and coastal resources management [1]. The use of space in coastal areas must be supported by oceanographic data and information, one of which is bathymetric surveys [2-3].

A bathymetric survey is a process of describing the bottom of the waters starting from field measurements, processing to visualizing the bottom of the waters to obtain information about the shape of the surface (topography) of the bottom of the waters [4]. One of the methods used in bathymetry measurements is using the acoustic method. This method has several systems, one of which is the single beam echosounder system, a water depth measuring instrument that uses a single beam system as a sender and receiver of sound wave signals [5]. This system measures the water depth directly from the survey vessel by considering the sound propagation process, sound characteristics, environmental or medium factors, and target conditions [6-7].
Several related studies that have been conducted on bathymetry and bottom morphology studies include Masrakhin et al. [8], researched bathymetry and seabed morphology studies in determining the path of laying subsea pipelines, which resulted in depth ranging from 1.09 to 13.78 meters with a very gentle slope. A similar study was also conducted by Satriadi [9] regarding bathymetry studies with the results obtained showing the depth of the waters in the study area between 0 - 9 meters with slope values ranging from 0.18% - 0.20%. Pangestu et al. [10] investigated those parameters for River Estuary. They revealed a depth of 0.5 to 4.2 meters and sloping coastal characteristics in which the cross-section in the river's direction is steep toward the sea. Many aspects of the ocean, spatial planning, marine environment, aquaculture require bathymetric data [11]. One of them is a feasibility study for the planned construction of a Nuclear Power Plant (PLTN).

The plan to build a nuclear power plant on the Gosong coast, Bengkayang Regency West Kalimantan, aims to meet national electricity needs, spur industrial growth, and improve community welfare. In connection with this nuclear power plant development plan, it is necessary to study the bathymetry and bottom morphology of the waters in the area to provide baseline data in preparation for the development of nuclear power plants in the Bengkayang Regency. The study aimed to determine the shape of the bottom water profile, which was used as an initial survey to determine the location of the nuclear footprint in the water in the study area.

2. Materials and Methods

2.1. Data Acquisition

This research was conducted in Gosong Beach, Bengkayang Regency, West Kalimantan (Figure 1). Depth data retrieval (sounding) was carried out using a single beam echosounder Garmin GPSMap 585, then corrected with tidal data to determine the chart datum value. The datum chart is used as the starting point of the water level, which is adjusted to the data from the sounding results. This tidal data measurement was carried out for 15 days in March 2021 with an interval of every 1 hour.

![Figure 1. Location of the sounding study area in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan.](image-url)
2.2. Data analysis

Tidal data correction processing begins with tide data analyzed using the Admiralty method for obtaining the value of the components of the tides. According to Rawi [13], method Admiralty is one of the methods used in determining the value of the constant harmonic and determining the type of tidal sites. This analysis is used to get the value of the component tides ($Q_1, K_1, K_2, M_2, S_2$). This tidal component is used to calculate the Formzahl number ($F$), which is used to determine the type of tide and the chart datum ($Z_0$) which will be used as correction of the sea depth data to obtain the actual sea depth. The equation used to determine the number Formzahl ($F$) [14-15] and the chart datum ($Z_0$) [16] is as follows:

$$F = \frac{Q_1 + K_1}{M_2 + S_2}$$  \hspace{1cm} (1)

$$Z_0 = S_0 - (1,2\times (M_2 + S_2 + K_2))$$  \hspace{1cm} (2)

Furthermore, the bathymetric measurement data must be corrected to the sea level position at the time of measurement, and corrections are made to the transducer sinking distance so that the actual depth is obtained. The correction for the tides is formulated as follows:

$$rt = TWL_t - (MSL + Z_0)$$  \hspace{1cm} (3)

Where $rt$ is the amount of reduction (correction) given to the results of depth measurements at time $t$, $TWL_t$ is the position of the actual sea level (true water level) at time $t$, $MSL$ is mean sea level, and $Z_0$ is the depth of the face of the tide below $MSL$.

After obtaining the reduction value between the depth during sounding and the tidal value, then determine the actual depth value:

$$D = dT - rt$$  \hspace{1cm} (4)

Where $D$ and $dT$ are the actual depth and the transducer corrected depth, respectively. The corrected sea depth data is interpolated using the kriging method to obtain depth contours. Furthermore, the slope of the coast can be calculated using equation [17]:

$$\tan \theta = \frac{d}{x}$$  \hspace{1cm} (5)

Where $\tan \theta$ is the beach slope ($^\circ$), $d$ is the water depth (m) and $x$ is the distance from the shoreline to a depth $d$ (m).

3. Results and Discussion

3.1. Tides in the coastal water of Gosong Beach Bengkayang

Based on the measurement results processed using the Admiralty method, the results of the tidal harmonic constants in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan, as shown in Table 1. The constant harmonic data are used to determine the Formzahl number, Mean Sea Level (MSL), and chart datum. The value of the Formzahl number obtained is used to determine the type of tide at that location.

| Tidal component | Amplitude (m) |
|-----------------|---------------|
| $Q_1$           | 0.25          |
| $K_1$           | 0.12          |
| $K_2$           | 0.04          |
| $M_2$           | 0.23          |
| $S_2$           | 0.15          |

Table 1. The value of the tidal harmonic constant.
From the value of the tidal harmonic constant above, the average sea level height obtained is 1.91 meters and the Formzhal (F) value 0.77. Based on the Formzhal (F) value that has been obtained, it is known that the tidal types in the waters of Gosong Beach, Bengkayang Regency is mixed tide prevailing semidiurnal tide. According to Wyrtki [13] that this type of tide occurs twice and two lows in one day, and sometimes there is one high tide and one low tide with different heights and times of occurrence. This tidal type is similar to the results of research conducted by Muhardi et al. [18] in the waters of Kura-Kura Beach, Bengkayang Regency, which is not far from the location of Gosong Beach. The pattern of the results of tidal measurements in the field that has been obtained is by the results of tidal predictions obtained from the Geospatial Information Agency (BIG) (Figure 2). According to Boggs [19], tides are one of the factors that affect sediment distribution patterns other than currents because at high tide and low tide, sediments carried by seawater can be carried away from or near the coast, so that these tides also affect changes in the morphology of the bottom of the waters. There is a study area.

![Tidal chart in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan.](image)

**Figure 2.** Tidal chart in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan.

3.2. **Bathymetry in the coastal waters of Gosong Beach Bengkayang Regency**

Based on the results of measurements in the field, the depth value varies from 0.9 to 8.45 meters. The map display as shown in Figure 3, shows that colour gradations and contour lines representing levels of detectable depth with depths less than 3.6 meters are visible along the coastline. According to Triadmodjo [20], the coastal area is an area of land that is affected by tidal movements, and the starting point of the zone starts from the lowest mean low tide level to the highest average tide level.
Figure 3. Depth profile of the sounding results in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan.

Changes in depth conditions occur from the mouth of the river mouth towards the sea. The colour gradation appears to have changed to dark blue which indicates that the depth from the estuary to the sea has increased in depth. This happens because the sedimentation process that occurs in the estuary area causes a buildup of sediment at the mouth of the river mouth. The distance of adjacent contours shows the rate of addition of depth or steep topography [21] as at several points in the West and Southwest (3-8 meters).

3.3. Cross-section seabed morphology

The cross-section profile is a vertical view that describes the configuration of the earth's surface along a selected line on a topographic or bathymetric map [22]. The cross-sectional profile of the waters at this location is divided into four cross-sections (A-D) as shown in Figure 4.

Figure 4. Cross-section plot for morphological studies in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan.
The average value of the coastal slope shows that spatially there is a variation of the slope class with the percentage value ranging from 0.13 to 2.29% (Figure 5). Based on the value of the slope of the coastal slope, the coastal waters of Gosong are included in the classification of flat coastal slopes. According to Van Zuidam [23], the classification of flat slopes has a value range of 0 – 3%. The flat coastal slope is thought to be related to the condition of the coastal area with wide intertidal areas as a result of abrasion along the coastal area and the supply of sediment that enters the sea through rivers [25].

![Figure 5. Cross-sections shapes A, B, C, and D in the waters of Gosong Beach, Bengkayang Regency, West Kalimantan.](image-url)
4. Conclusion
The depth of the coastal water waters of Gosong Beach, Bengkayang Regency ranges from 0.9 to 8.45 meters. The type of tidal obtained is mixed tide mixed with the double daily slope with an average sea level of 1.91 meters and Formzhal number (F) of 0.77. The percentage value of the coastal slope ranges from 0.13 to 2.29%, where the water is included in the classification of flat coastal slopes.

Acknowledgments
This research was funded by Indonesian Government Research in 2021. It is managed by Center for Nuclear Energy System Assessment, National Nuclear Energy Agency of Indonesia (BATAN). Also partially supported by RISTEK/BRIN-LPDP project (14/E1/III/PRN/2021).

References
[1] Deng Z Ji M and Zhang Z 2008 Mapping Bathymetry From Multi-Source Remote Sensing Images: A Case Study In The Beilun Estuary, Guangxi, China The Inter Archives of the Photogrammetry, Remote Sensing and Spatial Inform Sci. 37 1321-1326.
[2] Umam S K, Yuwono and Subarsyah 2011 Studi Penggunaan Magnetometer dalam Pembuatan Peta Sebaran Logam untuk Mendukung Pemasangan Pipa Bawah Laut J. of Geodesy and Geomatics. 7 28-34.
[3] Lahay A, Djamaluddin R, Manengkey H W K and Djabar B 2020 Pemetaan Batimetri Pantai Malalayang Dua, Kota Manado Jurnal Pesisir dan Laut Tropis. 8 1-6.
[4] Poerbandono and Djunarsjah E 2005 Survei Hidrografi (Bandung: Refika Aditama) 166 p
[5] Standar Nasional Indonesia (SNI) 7646 2010 Survei Hidrografi Menggunakan Singlebeam Echosounder (Jakarta: Badan Standarisasi Nasional)
[6] Prananda A R A, Merici A C W B, Huda A N, Amalia A, Nastiti A, Wijayanto G N, Alfi H N, Yuda L D P, Kartika M R S B and Wibowo T W 2017 Pembuatan peta batimetri dengan menggunakan metode hidroakustik studi kasus sebagian Sungai Cijulang Kabupaten Pangandaran, Jawa Barat Proc. of 5th Geoinformation Science Symposium pp 138–143
[7] Brouwer P A I 2008 Seafloor classification using a single beam echosounder Magister Thesis Department of Earth Observation and Space System chair of Acoustic Remote Sensing. Delf, Netherlands.
[8] Masrukhin M A A, Sugianto D N and Satriadi A 2014 Studi Batimetri dan Morfologi Dasar Laut Dalam Penentuan Jalur Peletakan Pipa Bawah Laut (Perairan Larangan-Maribaya, Kabupaten Tegal) Jurnal Oceanografi 3 94-104
[9] Satriadi A 2012. Studi Batimteeri dan Jenis Sedimen Dasar Laut di Perairan Marina, Semarang, Jawa Tengah Bulletin Oceanografi Marina 1(5) 3-62.
[10] Pangestu N J, Kushadwijayanto and Nurrahman Y A 2020 Studi batimteeri dan morfologi Muara Sungai Mempawah Kabupaten Mempawah Kalimantan Barat Jurnal Laut Khatulistiwa 3 69-76.
[11] Hell B, Broman B, Jakobsson L, Jakobsson M, Magnusson A and Wiberg P 2012 The use of bathymetric data in society and science: a review from the Baltic Sea. J. AMBIO. 41138–150.
[12] Rawi H S 2010 Pasang Surut (Jakarta: Pusat Pendidikan Hidro-Oceanografi TNI-AL)
[13] Wyrtki K 1961 Physical Oceanography of the Southeast Asian Waters (California: Institution of Oceanography, The University of California)
[14] Pariwono J I 1989 Kondisi Pasang Surut di Indonesia in : Ongkosongo A, Otto S R., and Suyarso, ASEAN-Australia cooperative programs on marine science. Project 1: tides and tidal phenomena (Jakarta: Pusat Penelitian dan Pengembangan Oceanologi) pp 135-147.
[15] Soeprapto 1999 Pasut Laut dan Chard Datum (Yogyakarta: Gadjah Mada University Press) 196 p
[16] Masrukhin M A A, Sugianto D N and Satriadi A 2014 Studi batimetri dan morfologi dasar laut dalam penentuan jalur peletakan pipa bawah laut (Perairan Larangan-Maribaya, Kabupaten Tegal) J. Oseano 3 94-104
[17] United States Army Corps of Engineers (USACE) 2003 *Coastal Hydrodynamics Part II, Coastal Sediment Processes Part III* (Washington DC: Department of the Army. US Army Corps of Engineers)

[18] Muhardi, Risko and Susiati H 2021 Characteristics of hydro-oceanography in the coastal waters of Kura-Kura Beach, Bengkayang Regency *J. Pend Fis.* 6 45-52

[19] Boggs S 2006 *Principles of Sedimentology and Stratigraphy 4th Edition* ed P Lynch (London: Merrill Publishing Company)

[20] Triatmodjo B 2011 *Perencanaan Bangunan Pantai* (Yogyakarta: Beta Offset) 370 p

[21] Pipkin B W, Gorsline D S, Casey R E and Hammond D E 1987 *Laboratory Exercises in Oceanography* Second Edition (New York: W.H. Freeman and Company) 257 p

[22] Setiyono H 1996 *Kamus Oseanografi* (Yogyakarta: Gadjah Mada University Press) 210 p

[23] Van Zuidam, R A 1985 Aerial Photo-Interpretation in Terrain Analysis and Geomorphologic Mappin (The Hague: Smits Publishers)

[24] Kalay D E, Lopulissa V F, Noya Y A 2018 Analisis kemiringan lereng pantai dan distribusi sedimen pantai perairan Negeri Waai Kecamatan Salahutu Provinsi Maluku. *J. TRITON*. 14 10-18