



INSTITUT PENYELIDIKAN AIR KEBANGSAAN MALAYSIA (NAHRIM)



Technical Report

Sonar Mapping Survey at Kemaman Port Areas

Prepared by,

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1.0 Introduction

Understanding the morphology of the seabed is crucial for ensuring the safety, efficiency, and sustainability of port operations, especially in high-traffic areas like Kemaman Port, Terengganu. The dynamic nature of coastal and port environments, influenced by tidal currents, sediment transport, and anthropogenic activities, necessitates regular monitoring and mapping of the seafloor. In this regard, side scan sonar (SSS) technology plays a vital role in producing high-resolution images that reveal the physical characteristics and composition of the seabed. These images are instrumental in identifying sedimentation patterns, bottom current effects, and potential underwater hazards, all of which are essential for informed decision-making in port maintenance and maritime navigation.

This study, conducted collaboratively by NAHRIM, Universiti Malaysia Terengganu (UMT), and CNH Advantech Sdn. Bhd., involved a comprehensive sonar survey using dual-frequency side scan sonar integrated with differential GPS (DGPS) positioning systems. The survey focused on two key areas: the internal port area within Kemaman Supply Base (KSB) and the external coastal and riverine waters extending approximately one nautical mile from the port. By processing the collected sonar data through advanced software platforms such as Sonar Wiz and ArcGIS, a detailed mosaic of the seabed was produced, offering insights into sediment dynamics, accumulation zones, and the presence of natural and man-made seabed features.

The primary objective of this survey is to support the ongoing study of sediment transport and its implications for port maintenance and coastal development. In doing so, it also contributes to the broader understanding of how hydrodynamic forces shape the seabed and affect port infrastructure. This introduction sets the stage for the subsequent analysis, which interprets sonar images to uncover the patterns and processes at play beneath the surface of Kemaman Port and its adjacent coastal waters.

2.0 Objectives

The objectives highlighted in the scope of work including on seafloor morphology in the Kemaman Port area and the surrounding area.

3.0 Method & Equipment

3.1 Personnel

No.	Name	Position	Agencies/company
1	Ts. Saiful Bahri Hamzah	Project Director	NAHRIM
2	Ir. Ts. Muhammad Rizal Razali	Project Manager	NAHRIM
3	Prof. Madya Dr. Effi Helmy Ariffin	Project Supervisor	INOS UMT
4	Ts. Dr. Azizi Ali	Senior Researcher	INOS UMT
5	Roslan Latif	Researcher	INOS UMT
6	Azri Muhammad	Researcher	INOS UMT
7	Siti Salihah Hj. Mohd Sendek	Assistant Researcher	NAHRIM
8	Hazamri Harith	Manager	CNH Advantech S/B

3.2 Survey Areas

The sonar mapping survey for the study of sediment transport was conducted within two distinct but interconnected zones in and around Kemaman Port, namely the internal port area and the external coastal and riverine waters. These zones were carefully selected to provide a comprehensive understanding of sediment dynamics across different marine environments that influence port operations and coastal management strategies. The first study area, illustrated in Figure 1, encompasses the internal port zone within the Kemaman Supply Base (KSB). This area spans approximately 1.74 square kilometres, covering berthing zones, navigation channels, and areas adjacent to port infrastructure. The port's enclosed nature makes it particularly susceptible to sediment accumulation, which can affect the draught of vessels and the operational safety of maritime activities. Sediment build-up in this zone is typically influenced by limited hydrodynamic flushing, regular vessel movement, and freshwater inputs from nearby river systems. Mapping this area is critical for planning dredging operations, maintaining navigable depths, and ensuring smooth port logistics.

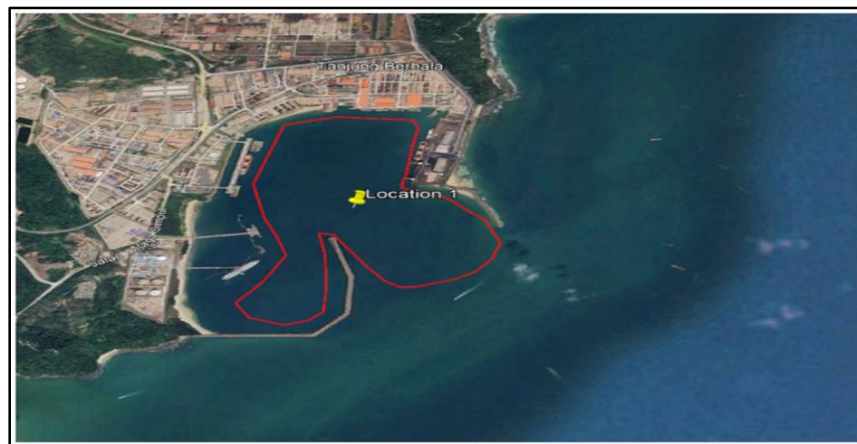


Figure 1. Location of survey at Kemaman Supply Based (KSB)

3.3 Side Scan Sonar System

The side scan sonar (SSS) system is a key component of this survey, utilized to produce high-resolution imagery of the seafloor in the Kemaman Port study area. This acoustic technology is particularly valuable in coastal and port environments where detailed understanding of the seabed morphology is essential for navigation safety, sediment transport studies, and infrastructure development. The principle behind side scan sonar involves the transmission of sound waves from a transducer, commonly referred to as a towfish, which is either towed behind a survey vessel or mounted to a submerged platform. These sound waves are emitted laterally in a fan-shaped pattern across the seabed, enabling wide coverage of the survey area in a single pass.

The SSS system used in this study operates at dual frequencies, typically ranging between 100 kHz and 500 kHz. Lower frequencies offer greater range but lower resolution, while higher frequencies provide finer detail over a shorter range. In the context of the Kemaman Port survey, the dual-frequency setup allowed for flexibility—balancing wide-area coverage with the ability to resolve smaller seabed features such as ripples, scours, debris, and submerged objects. The sonar pulses are reflected off the seafloor and any objects present, with the intensity of the return signals being recorded. Hard, compact materials like rock or man-made debris reflect strong signals and appear bright in the sonar imagery, whereas soft, silty or muddy sediments reflect weaker signals and are rendered as darker areas.

The image formation process involves measuring the time it takes for sound pulses to return to the receiver and converting the echo intensities into a grayscale image mosaic. These mosaics can reveal a wealth of information about seafloor composition, texture, and structural features. The data collected during the survey were processed using specialized sonar mapping software, which includes image enhancement, noise reduction, and geo-referencing functions to ensure accuracy and usability of the outputs. After initial processing, the data were exported to GIS platforms such as ArcGIS, where they were further analysed and integrated with positional data for interpretation and mapping purposes.

As illustrated in Figure 3, the basic operation of the side scan sonar involves the systematic scanning of the seabed on both sides of the survey vessel's track line, effectively producing a continuous ribbon of seabed imagery. This method is highly efficient for covering large survey areas and is non-intrusive, making it suitable for sensitive marine habitats and complex underwater environments. The sonar system used in this study was integrated with a Differential Global Positioning System (DGPS) to ensure precise spatial referencing of all collected imagery, enabling accurate correlation of sonar features with real-world coordinates.

Overall, the use of side scan sonar in this project allowed for a detailed and reliable characterization of the seafloor in both the confined port area and the more dynamic coastal and riverine environments outside the port. The technology proved effective in detecting sedimentary structures, assessing potential geo-hazards such as rocky outcrops, and identifying areas of sediment accumulation. These insights are fundamental for supporting ongoing port maintenance, sediment management, and coastal planning initiatives in the Kemaman Port region.

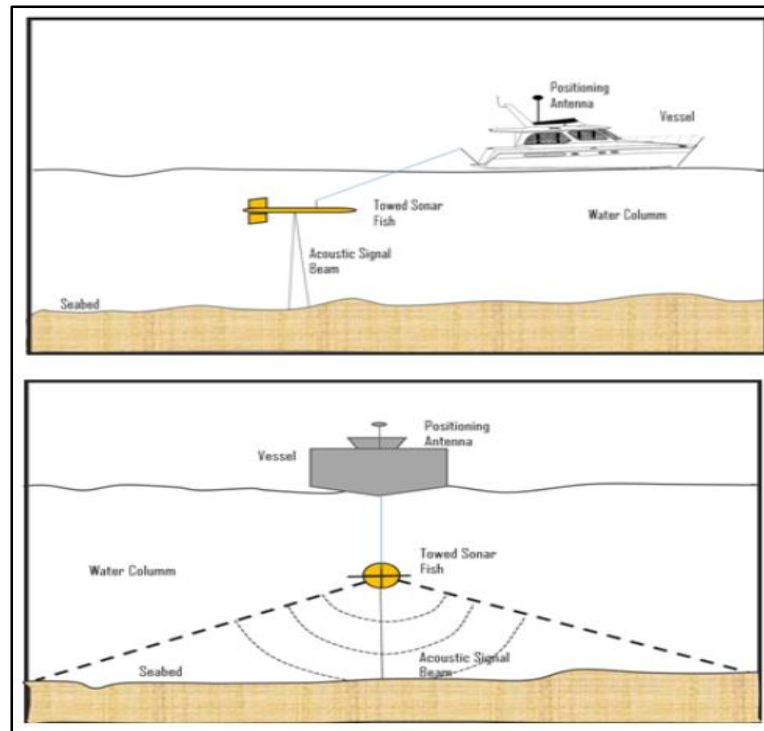


Figure 3. Basic Operation of Side Scan Sonar

3.4 Determination of Survey Sites using Differential Positioning System (DGPS) and HypacMax Survey Software

Accurate positioning is fundamental in hydrographic and seabed surveys to ensure that spatial data collected from sonar equipment can be precisely referenced to real-world coordinates. For this study at Kemaman Port, a high-precision Differential Global Positioning System (DGPS) was employed in conjunction with Hypack Max Survey Software to determine the location of all survey lines and control the navigation paths of the vessel during data acquisition. This integration enabled the research team to maintain consistent and repeatable track lines across both the internal and external study zones, thereby enhancing the spatial accuracy and reliability of the collected side scan sonar data.

The DGPS system used in this survey was the Hemisphere V200 GNSS Compass, a robust, all-in-one positioning and heading solution optimized for marine survey applications. This system utilizes multiple satellite constellations—including GPS, GLONASS, BeiDou, Galileo, and QZSS—allowing it to maintain uninterrupted signal lock and provide real-time position correction. The V200 is built around Hemisphere’s Crescent Vector H220 OEM board and incorporates two high-performance antennas spaced 20 cm apart, a multi-axis gyro, and tilt sensors within a compact and rugged enclosure. The combination of these elements allows the system to deliver highly accurate heading information with a precision of 1.5 degrees (and optionally up to 0.75 degrees), and positional

accuracy down to 30–60 cm using Atlas L-band corrections. This level of precision is well-suited for detailed nearshore mapping tasks, where even minor deviations in positioning can lead to significant discrepancies in spatial interpretation.

To complement the DGPS, the team utilized Hypack Max, a widely adopted hydrographic survey software platform that provides tools for survey planning, real-time data acquisition, and post-processing. Hypack Max was instrumental in designing the layout of the survey lines, ensuring optimal swath coverage and minimizing data overlap or gaps. During the survey, the software provided real-time feedback to the vessel operator, enabling adjustments to be made dynamically to maintain alignment with pre-defined track lines. The software also facilitated real-time monitoring of data quality and vessel position, which was especially important in the variable environmental conditions encountered during the survey.

As shown in Figure 4, the Trimble SPS351 system used alongside the V200 setup further reinforced the reliability of the spatial data captured. Together, these systems ensured that every sonar image and seafloor observation could be precisely georeferenced, allowing for the creation of accurate geospatial mosaics and maps in subsequent processing stages. This capability was essential for interpreting sonar imagery in relation to port infrastructure, sediment pathways, and potential hazard zones.

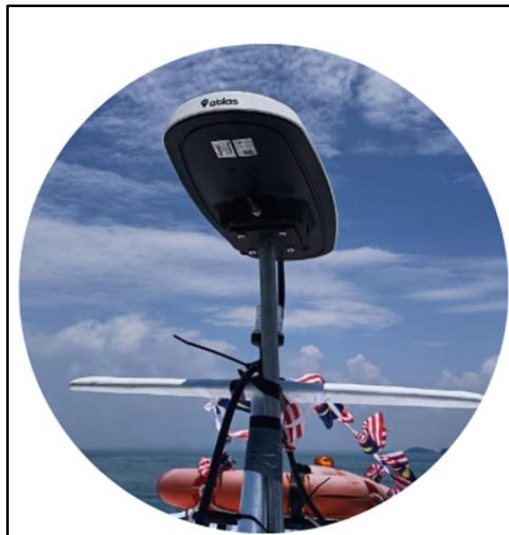


Figure 4. Trimble Sps351 (Differential Global Positioning System)

The integration of advanced GNSS technology and professional survey software ensured that the seabed mapping conducted at Kemaman Port met high standards of positional accuracy and operational efficiency. The use of DGPS not only enhanced the quality of the sonar data but also facilitated effective survey execution across complex marine environments, supporting the broader objectives of sediment transport analysis and coastal management in the region.

3.5 Survey Boat

The success of any marine geophysical survey, particularly those involving precise acoustic instruments such as side scan sonar, is highly dependent on the stability, suitability, and operational readiness of the survey platform. For this project, the survey was conducted using a registered vessel known as **Noor PL 2**, which is approved by **Jabatan Laut Malaysia** for marine operations. The selection of this vessel was based on its compliance with maritime safety standards, appropriate size for nearshore deployment, and its ability to support the necessary survey equipment and personnel.

Noor PL 2 was configured specifically for the survey task, with necessary modifications to accommodate the deployment of the **towfish sonar unit**, **Differential Global Positioning System (DGPS) antennas**, and **data acquisition systems** on board. The vessel's deck was organized to allow for the safe launch and retrieval of the side scan sonar towfish, ensuring smooth and uninterrupted operation during data collection. In addition, mounting points for DGPS antennas were carefully positioned to minimize multipath interference and ensure optimal signal reception throughout the survey. The operational characteristics of the vessel, including its manoeuvrability and stability, played a key role in maintaining consistent survey lines and ensuring data quality. Given that side scan sonar imagery is highly sensitive to vessel motion—especially yaw, pitch, and roll—it was essential that the survey boat be capable of maintaining steady headings and speed throughout each transect. Noor PL 2 provided the required performance in this regard, even under moderately challenging sea conditions caused by seasonal southeast winds during the time of the survey.

Furthermore, the vessel was manned by a qualified and experienced crew, including hydrographers and technical officers from Universiti Malaysia Terengganu (UMT), who were responsible for real-time data monitoring, navigation, and equipment handling. Their familiarity with local maritime conditions and expertise in sonar operations ensured efficient execution of the survey plan and rapid response to any technical or environmental challenges encountered in the field. As shown in **Figure 5**, Noor PL 2 served as a reliable survey platform, enabling the comprehensive acquisition of sonar data across both the sheltered port area and the more dynamic coastal and riverine environments. Its suitability for the scope of this study contributed significantly to the overall success of the survey, ensuring that the collected data were of high quality, accurately georeferenced, and suitable for post-processing and interpretation in support of the study's sediment transport and seabed mapping objectives.



Figure 5. Survey Boat

4.0 Result Sonar Survey

The side scan sonar (SSS) survey conducted across Kemaman Port and its surrounding coastal and riverine zones has provided essential data for evaluating sediment transport processes, seabed morphology, and the operational needs of the port. Utilizing dual-frequency side scan sonar technology integrated with differential GPS positioning, the survey successfully captured high-resolution imagery over two primary areas: the internal port zone and the external coastal domain, including river mouths and adjacent nearshore waters. The processed sonar mosaics provide detailed insight into the physical conditions of the seabed, which hold direct implications for navigational safety, port maintenance, and environmental management.

Within the internal port area, the seabed was found to exhibit distinct patterns of sand and mud ripples, indicating the presence of active bottom currents. These currents play a significant role in sediment redistribution within the port basin. The observed ripples reflect ongoing sedimentation processes, especially in the port's open channel zones, where sediment tends to accumulate. Such accumulation may pose operational risks, particularly for larger vessels navigating at lower tides, and highlights the continued need for maintenance dredging to preserve safe and efficient water depth throughout the port.

In the transition area between the river outflow and coastal waters, the seabed displays a higher level of complexity, with alternating sandy ripples and exposed rocky outcrops. These features suggest a dynamic interaction between fluvial sediment input and coastal hydrodynamic forces. Rippled sandy textures are indicative of sediment transport toward the open sea, while the rocky substrates—often partially buried or exposed—may represent potential hazards to navigation, particularly in shallow waters during low-tide conditions. The mixed composition of the seabed in this area reflects a highly variable environment, shaped by both natural sedimentary processes and underlying geological structures.

Further offshore, the survey revealed a patchwork of sandy and rocky seabed conditions across the wider coastal zone. These offshore areas exhibit both coarse and fine sediment deposits, alongside compact, reflective seabed features indicative of harder substrates. Such variations are important considerations for offshore engineering activities, including anchoring, marine infrastructure installation, and dredged material disposal. Notably, several zones of consistent, clean sandy seabed were identified, located farther from active sediment transport areas. These depositional zones, likely situated beyond the Depth of Closure (DoC), are considered potentially suitable for the placement of dredged materials from port maintenance activities due to their lower susceptibility to resuspension.

Overall, the findings from this survey reinforce the importance of regular seabed monitoring and integrated sediment management within the port and its surrounding waters. Areas exhibiting active sediment accumulation will require routine dredging, while the presence of rocky hazards demands ongoing updates to navigational charts and operational planning. Offshore sandy zones offer strategic value for sediment relocation efforts, provided they are evaluated for environmental suitability and long-term stability.

Despite the presence of adverse weather during the survey period, particularly from strong south-easterly winds that impacted sonar data stability, the quality of the data remained sufficient for reliable interpretation. The sonar survey has effectively captured the diverse and dynamic nature of the seabed across different environments, providing a robust foundation for future port planning, environmental assessments, and coastal development initiatives. These results play a key role in supporting sustainable and safe maritime operations within the Kemaman Port region.

4.1 Overview Entire Study Area

The overall study area surveyed during the side scan sonar operation encompasses a strategically planned coverage that includes both the internal port region within Kemaman Supply Base (KSB) and the external coastal and riverine environments. As shown in Figure 6, the mapped area extends across two main zones: an enclosed, high-activity port basin, and a broader external region consisting of transitional estuarine zones and nearshore coastal waters. This comprehensive spatial coverage was critical to capture the full range of sedimentary dynamics and seabed features influencing port operations and sediment transport processes.

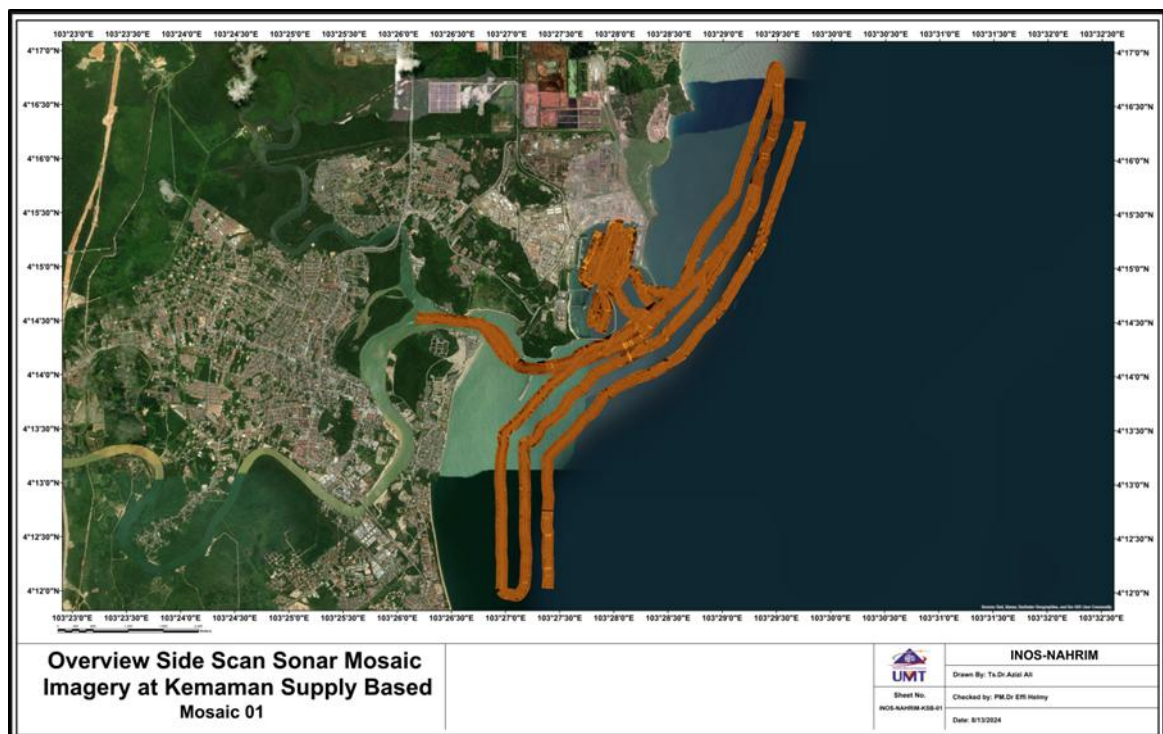


Figure 6. Overview entire study area

The layout of the survey lines, as visualized in the figure, demonstrates a systematic and dense grid pattern inside the port, ensuring high-resolution coverage of critical operational zones such as docking areas, turning basins, and main navigation channels. Outside the port, the survey lines are more elongated and aligned with the coastal and riverine morphology, capturing features from river

mouths to open coastal sediment pathways. This design ensures that both localized depositional patterns within the port and larger-scale sediment transport mechanisms in adjacent waters are effectively documented. The combination of these two settings provides a comprehensive seabed dataset that not only supports current port maintenance planning but also offers valuable insights into regional sediment supply, erosion potential, and morphological stability. By linking the high-resolution sonar data collected across these spatially distinct environments, the study offers a coherent overview of how fluvial, tidal, and wave-driven processes interact with man-made maritime infrastructure.

4.2 Interpretation image Overview in Kemaman Supply Based

The analysis of side scan sonar imagery collected within the Kemaman Supply Base (KSB) provides a detailed view of the seabed conditions and sedimentary features that characterize this enclosed port environment. The sonar mosaics presented in Figures 7 to 13 illustrate various seabed textures and formations, highlighting active sediment transport processes, depositional trends, and potential maintenance concerns. These observations are crucial in assessing sediment dynamics within the port, guiding future dredging operations, and ensuring navigational safety.

Figure 7 reveals the presence of clearly defined ripple marks on the seabed, which indicate active bottom currents influencing sediment movement within the port basin. The orientation and spacing of these ripples suggest that hydrodynamic forces, likely driven by tidal exchange and vessel-induced flow, are continually shaping the seabed. This dynamic setting promotes the redistribution of fine to medium-grained sediments, particularly in areas with regular vessel traffic.



Figure 7. Overview entire study area at Kemaman Supply Based

Moving to Figure 8, the imagery shows a dense concentration of sand ripples in a likely vessel transit corridor. The repetitive ripple patterns further reinforce the presence of strong near-bottom currents, potentially intensified by the propulsion systems of docking or manoeuvring ships. This area appears to be subject to repeated disturbance, resulting in a well-sorted and mobile seabed surface. The presence of active sediment movement in this zone suggests that periodic monitoring is necessary to mitigate risks associated with shoaling and reduced water depth.



Figure 8. Enlarge image of KSB Port

Figure 9 presents a contrasting image, with the sonar return indicating a softer, more homogeneous seabed texture, likely composed of unconsolidated mud or fine silt. These darker acoustic returns suggest a low-energy depositional environment, where suspended sediments tend to settle. Such areas are often located in corners or sheltered regions of the port, where water movement is restricted. These zones can act as sediment traps and may become hotspots for gradual sediment accumulation, posing challenges for long-term port maintenance if not regularly dredged.

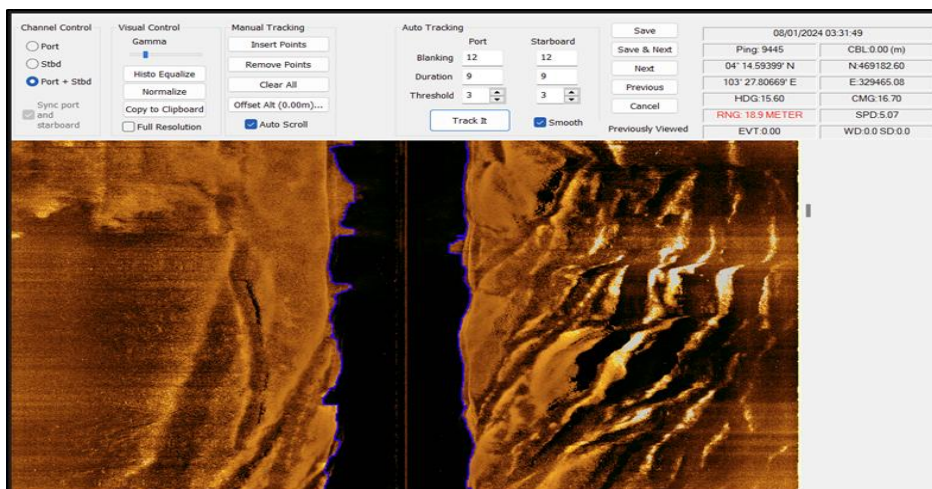


Figure 9. Interpretation image at Point 1, KSB Port – sand/mud ripper

In Figure 10, the sonar image reveals a more irregular and heterogeneous seabed, suggesting the presence of mixed sediment types or possibly scattered objects on the port floor. The variation in acoustic reflectivity could indicate coarser materials, debris, or submerged infrastructure, such as mooring blocks or remnants of construction materials. These features may pose navigational or operational hazards, particularly during berthing operations, and should be investigated further through visual inspection or ground-truthing surveys.

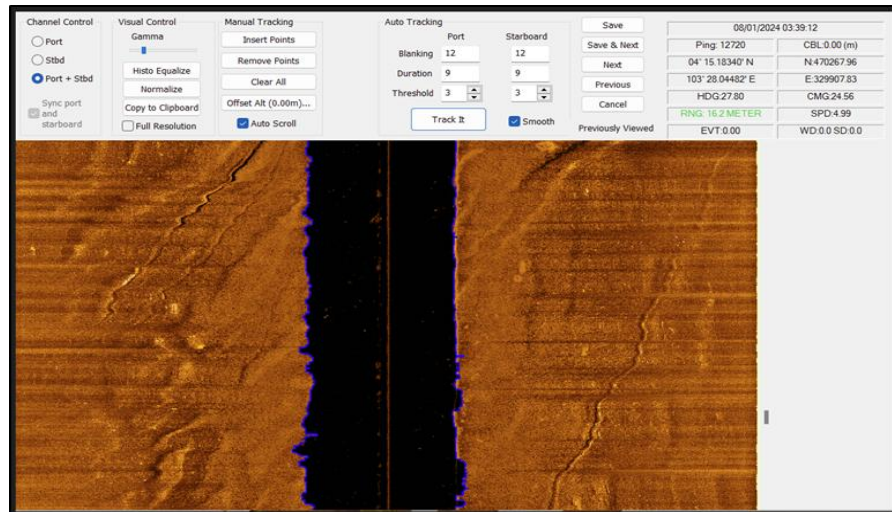


Figure 10. Interpretation image kat point 2 at KSB Port – sand/mud ripper

Figure 11 shows a comparatively uniform and stable seabed, with consistent sonar reflectivity across the image. This suggests a well-settled and possibly compacted sediment layer, potentially within a zone that has been subject to recent maintenance dredging. The absence of pronounced ripples or obstructions indicates a relatively inactive sedimentary environment. Maintaining such areas is important for ensuring predictable depth conditions and safe navigation.

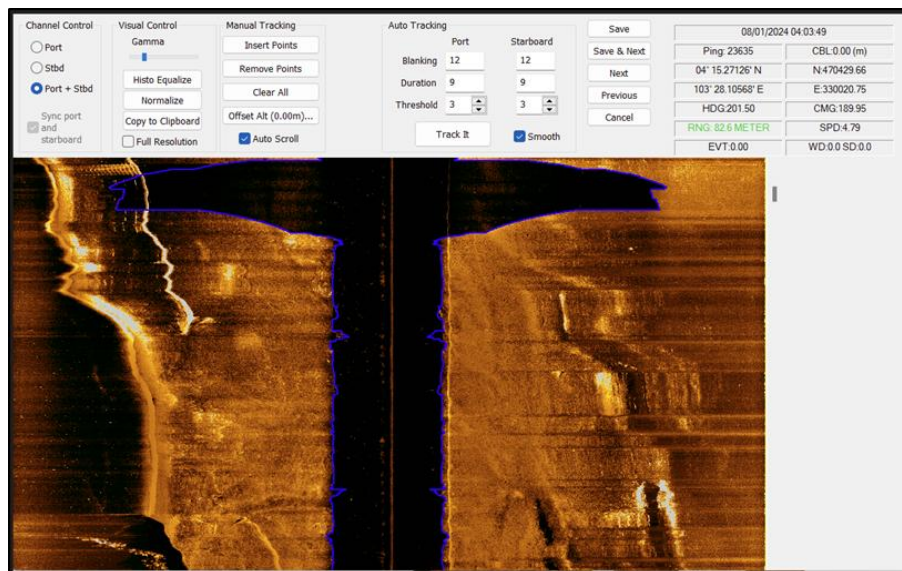


Figure 11. Interpretation image kat point 3 at KSB Port – sand/mud ripper

A distinct feature appears in Figure 12, where a large sand wave or dune-like bed form is visible. This formation may be the result of stronger cross-flow sediment transport, possibly linked to hydrodynamic forcing from open port entrances or storm-driven currents. These larger-scale bed forms represent areas of more significant sediment mobility and, depending on their location relative to navigation channels, may influence depth variability and sediment migration over time.

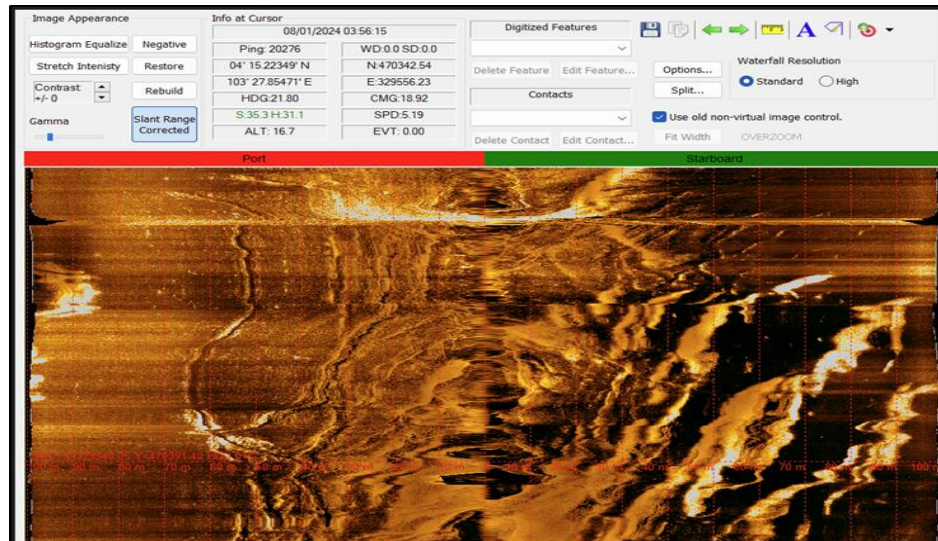


Figure 12. Interpretation image kat point 4 at KSB Port – sand/mud ripper

Lastly, Figure 13 illustrates a transitional seabed zone, where ripple formations gradually fade into smoother, finer sediment surfaces. This gradual shift in texture reflects the spatial variation in hydrodynamic energy across the port area—from high-energy zones that actively rework sediments to calmer zones where deposition dominates. Understanding these transitions is essential in identifying sediment retention areas and anticipating changes in seabed elevation that could impact operational efficiency.

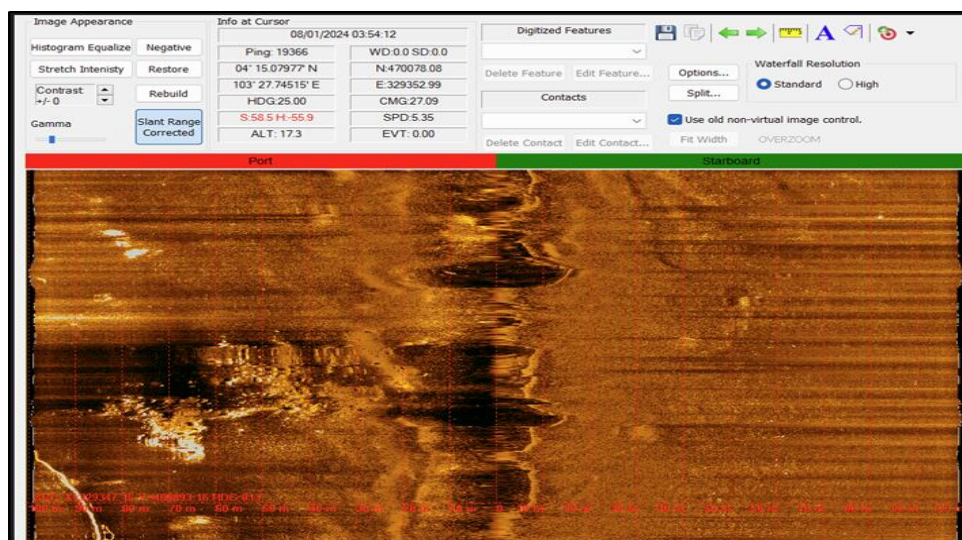


Figure 13. Interpretation image kat at point 5 at KSB Port – sand/mud ripper

In summary, the side scan sonar imagery from Figures 7 through 13 provides valuable insights into the spatial variability and dynamics of the seabed within Kemaman Supply Base. The coexistence of active ripple zones, fine sediment deposits, and irregular bed forms reflects a complex interplay between natural hydrodynamic processes and anthropogenic influences. These findings support the need for a strategic sediment management plan, involving targeted dredging, hazard monitoring, and periodic reassessment of sediment transport behaviour to ensure the port remains safe, navigable, and operationally efficient.

4.3 Interpretation image in Coastal and River Water Line No 1

The side scan sonar imagery presented in Figures 14 to 17 captures the seabed characteristics along the river and coastal transition zone outside the Kemaman Port boundary. This area, being the interface between fluvial and marine systems, is influenced by both river discharge and nearshore hydrodynamic forces, making it a critical region for understanding sediment transport, depositional patterns, and potential navigational risks.

In Figure 14, the sonar image depicts an area dominated by fine sand and rippled seabed textures. The presence of well-defined sand ripples indicates the influence of moderate to strong bottom currents, likely driven by tidal flushing and seasonal freshwater flow. These ripples are oriented in a manner consistent with seaward sediment transport, suggesting that the river is actively exporting sediment into the coastal system. This finding aligns with expected patterns in estuarine zones, where sediments delivered from upstream are redistributed by tidal and wave action.

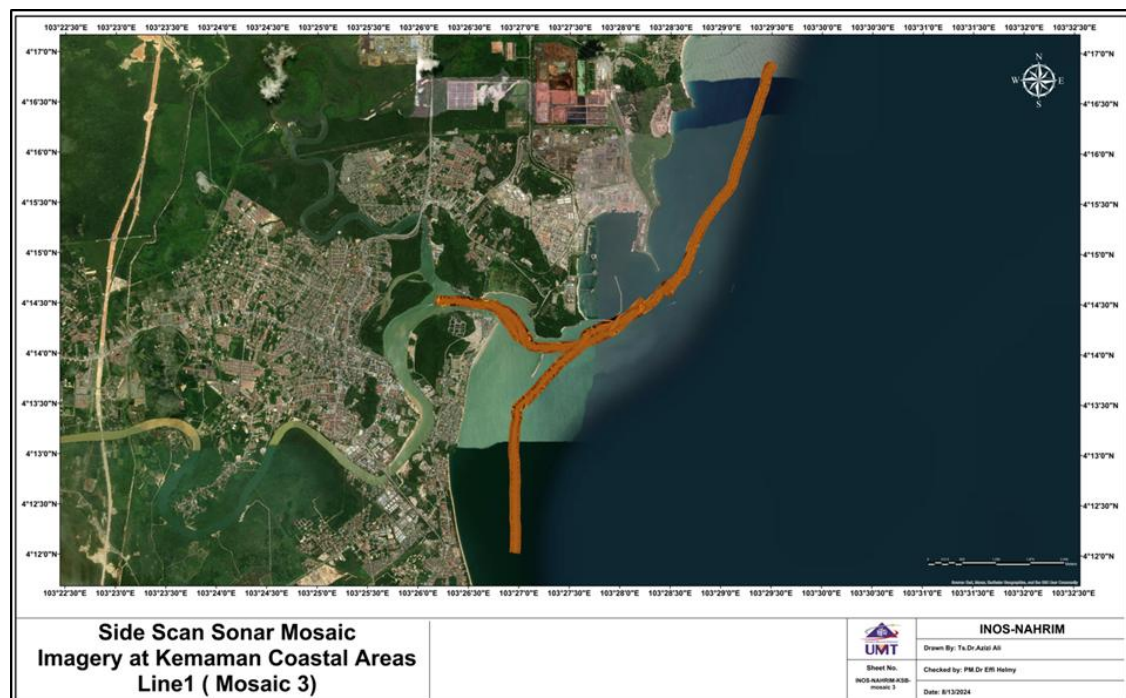


Figure 14. Mosaic image of side scan sonar at line 1 outside KSB Port

Figure 15 also highlights a sandy seabed with noticeable ripple features, reinforcing the interpretation of an active hydrodynamic environment near the river mouth. Such features are typically formed by bottom currents that have sufficient energy to mobilize loose sediments. This condition implies that sediment is not static but rather undergoing continuous transport and redistribution, which has implications for the long-term morphology of the river entrance and surrounding shallow waters. These zones are likely prone to sedimentation and may require periodic hydrographic monitoring to prevent navigational hazards caused by shoaling.

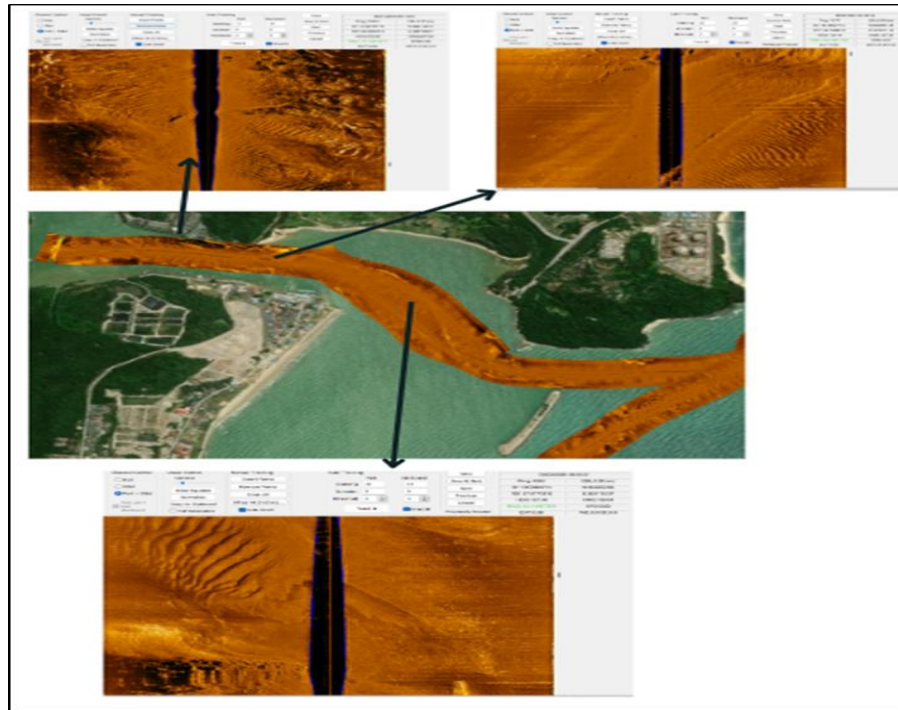


Figure 15. The area is sandy and there is ripper sand in the survey area

In Figure 16, a more heterogeneous seabed is evident, with sonar returns indicating the presence of rocky patches interspersed with sandy areas. The bright, high-reflectivity zones correspond to harder substrates, possibly submerged rock or compacted sediment, while the darker areas suggest softer sandy coverage. The coexistence of rocky and sandy features in close proximity signals a complex and potentially hazardous area for vessel navigation, especially during low tide when water depths are minimal. These rocky substrates could also serve as structural controls on sediment deposition, potentially influencing the direction and efficiency of sediment flow from the river mouth to the nearshore zone.

Figure 17 shows a continuation of the sandy rippled seabed, further confirming that this section of the river-coast interface is subject to active sediment reworking. The consistent acoustic texture and absence of significant obstructions suggest that this area functions as a transitional sediment transport corridor, moving materials from the river into the coastal zone. The dynamics in this area are essential to the sediment budget of the region and could influence nearby beach stability or coastal erosion if sediment supply is altered.

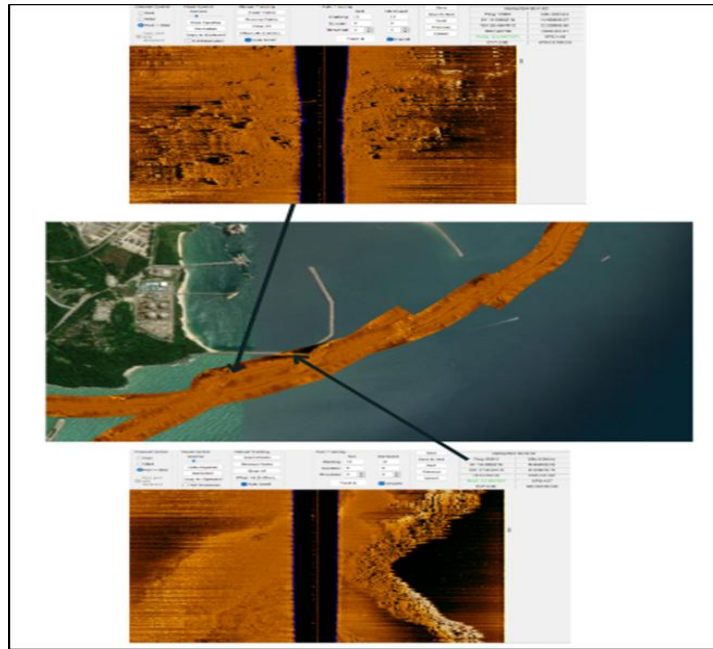


Figure 16. There are rocky areas and sandy seabeds.

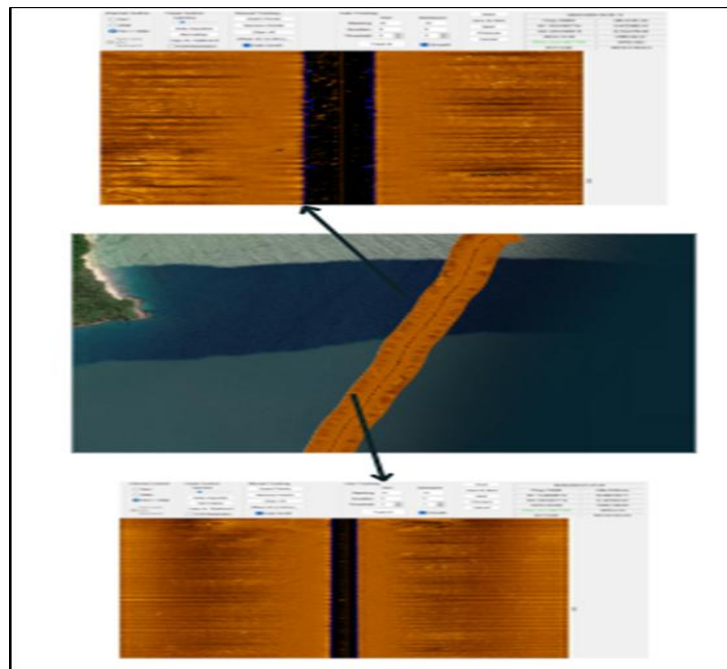


Figure 17. There is sand seabed

Collectively, the sonar imagery from Figures 14 through 17 demonstrates a dynamic and geologically variable seabed across the river-to-coast transition zone. The prevalence of sand ripples indicates strong bottom current activity and ongoing sediment transport, while the identification of rocky outcrops points to localized hazards and structural complexity. These insights are important for navigation safety, coastal sediment management, and environmental planning in areas where port activities interface with natural riverine systems. Continued monitoring and integration with

bathymetric and current data would enhance the understanding of sediment pathways and support sustainable coastal zone management near Kemaman Port.

4.4 Interpretation image in outside Kemaman Port Line 2.

The side scan sonar imagery collected along Survey Line 2, located outside the Kemaman Port boundary, presents a contrasting seafloor character compared to the enclosed port environment. As the survey transitions into more open coastal waters, the sonar data reveal a seabed influenced by natural coastal processes, including wave action, tidal currents, and sediment exchange at the river-sea interface. The analysis of this area is supported by Figures 18 to 20, each highlighting different sedimentary conditions and seabed features within this transitional nearshore zone.

Figure 18 provides a mosaic overview of the side scan sonar data acquired along Line 2. The image reveals a varied seabed texture, with alternating bands of higher and lower reflectivity. This pattern suggests the presence of both sandy and possibly silty substrates, interspersed with scattered harder features, likely to be natural rocky outcrops or compacted sediment layers. The overall texture of this area indicates a moderately dynamic sedimentary environment, where sediment is being both transported and deposited, influenced by the mixing of fluvial and marine energy systems. This transitional environment plays an important role in the sediment budget of the region, acting as a conduit for material exchange between the river mouth and offshore areas.

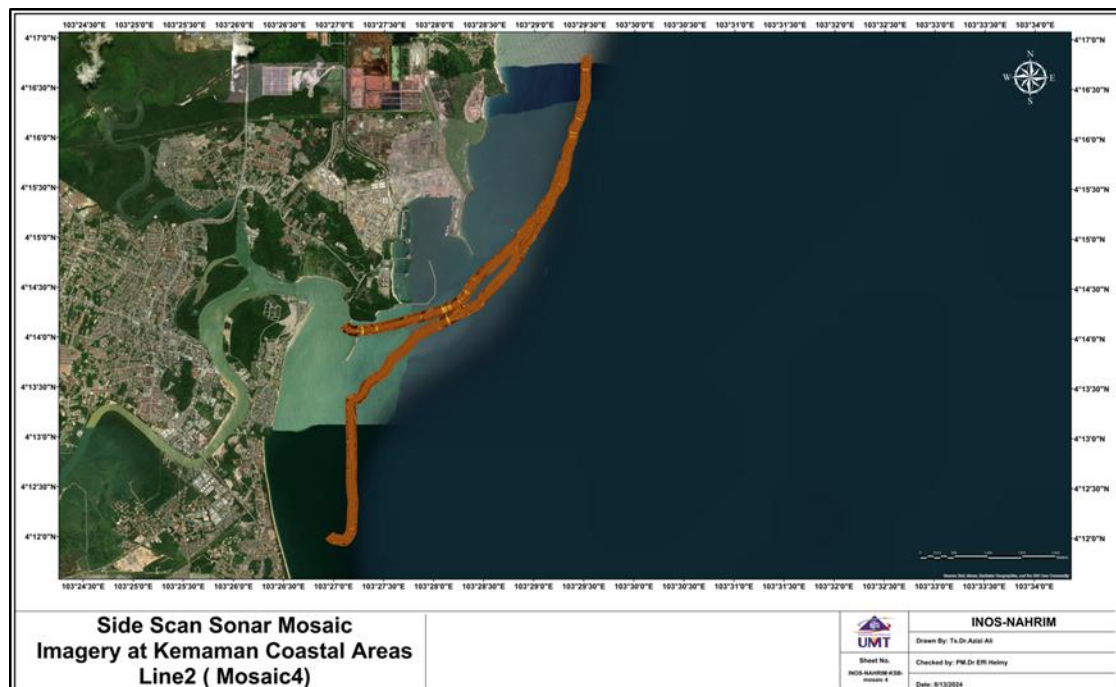


Figure 18. Mosaic image of side scan sonar at line 2 outside KSB port

Figure 19 provides a more focused view of a mixed seabed, clearly showing the coexistence of rocky patches and sandy substrates. The rocky areas appear as bright, irregular features with strong sonar returns, indicating high acoustic reflectivity due to their hardness. These may represent bedrock

exposures, coral remnants, or coastal rubble, and they pose potential navigational hazards for vessels operating in shallow coastal areas. In contrast, the surrounding sandy seabed, which appears darker, represents areas of active sediment transport. The juxtaposition of these features highlights a heterogeneous seabed, which is typical in coastal zones where geological formations intersect with mobile sediment layers.

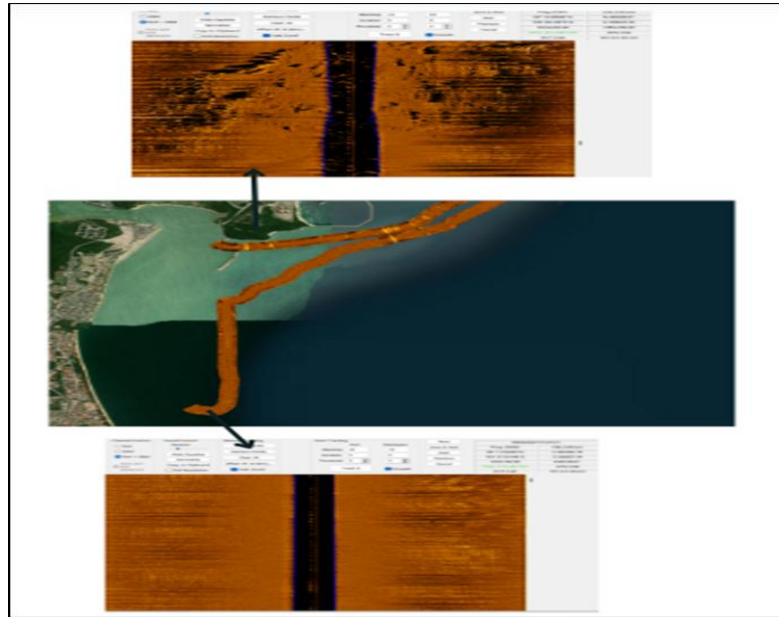


Figure 19. There are rocky areas and sandy seabed

Figure 20 reinforces this observation, again showing a combination of sandy and rocky seabed types. The repetition of this pattern across multiple sonar transects suggests that these features are widespread and significant from both a geological and operational perspective. These rocky areas can limit access for dredging activities or marine construction, while also offering potential habitat for marine organisms. Their presence also suggests limited sediment cover in some zones, which could be the result of strong wave action or tidal scouring, exposing harder substrate beneath.

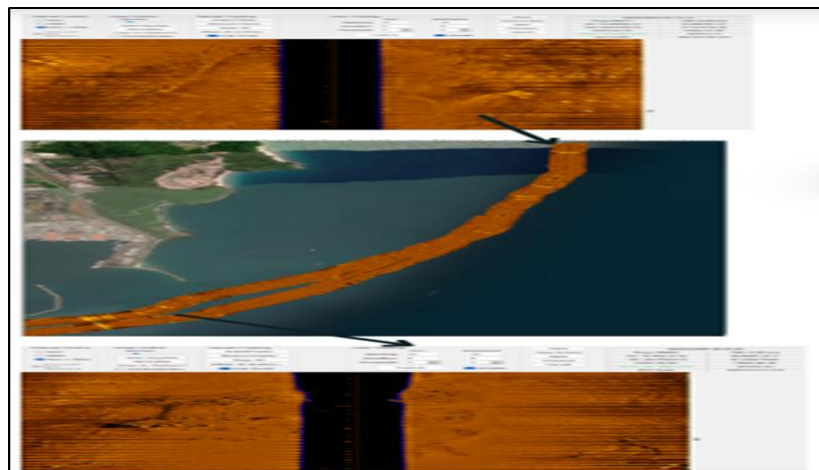


Figure 20. There are rocky areas and sandy seabed

The findings along Survey Line 2 emphasize the importance of seabed classification and hazard identification in coastal engineering and navigation planning. The natural complexity of the seabed outside Kemaman Port, as documented in Figures 18 to 20, highlights the challenges posed by non-uniform sediment distribution, exposed rock, and variable hydrodynamic conditions. These factors must be taken into account when planning any offshore infrastructure development, such as pipeline routes, anchoring zones, or sediment disposal sites.

In conclusion, the sonar imagery along Line 2 demonstrates a transitional coastal seabed, shaped by a combination of fluvial sediment input and marine erosional forces. The presence of rocky features interspersed with sandy stretches indicates that this zone is not only critical for sediment transfer but also requires careful management to ensure safe marine navigation and environmentally sound development. Continued monitoring of this area will aid in refining sediment transport models and in identifying zones of erosion or deposition that may impact future coastal projects.

4.5 Interpretation image in outside Kemaman Port Line 3.

The seabed interpretation along Survey Line 3, located further offshore from the Kemaman Port boundary, provides valuable insight into sediment distribution and coastal sediment dynamics beyond the immediate port influence. The sonar imagery from this section, as presented in Figures 21 and 22, reveals a predominantly sandy seabed, characteristic of a depositional environment in the nearshore coastal zone. This area lies closer to the Depth of Closure (DoC), where sediment movement caused by wave energy tends to diminish, making it a potential sink for sediments transported from the river mouth and adjacent coastlines.

Figure 21, which shows a mosaic image of the side scan sonar data along Line 3, indicates a relatively uniform acoustic texture with minimal contrast variations, suggesting the dominance of fine to medium-grained sand. The absence of hard targets or highly reflective features supports the interpretation of a stable, sediment-rich seabed with low occurrence of natural or artificial obstructions. This type of seabed condition is typically found in areas where sediment settles out of suspension as hydrodynamic energy decreases offshore. The smooth and consistent texture also implies minimal disturbance or scouring in this section, which may be attributed to the deeper location and weaker bottom currents compared to the inner port and river mouth areas.

Figure 22, which is also associated with the Line 3 transect, reinforces this observation by showing a clear and uninterrupted sandy bottom. The dark-toned sonar returns are consistent with soft, unconsolidated seabed material, and there is no indication of exposed rocky substrate or coarse debris. The characteristics of this area suggest its suitability as a potential sediment disposal zone, particularly for dredged materials from port maintenance activities. Because this area is located near the outer boundary of active sediment transport (i.e., beyond the DoC), deposited material here is less likely to be re-mobilized and returned to the port or navigational channels.

The interpretation of the sonar data along Line 3 underscores the significance of this area in the broader sediment budget of Kemaman's coastal system. It likely serves as a terminal point for

sediment transport, receiving material exported from the river and port basin through tidal and wave-driven processes. From a management perspective, this offshore sandy zone represents an ideal candidate for planned sediment placement or beach nourishment programs, provided that ecological and environmental assessments confirm its suitability.

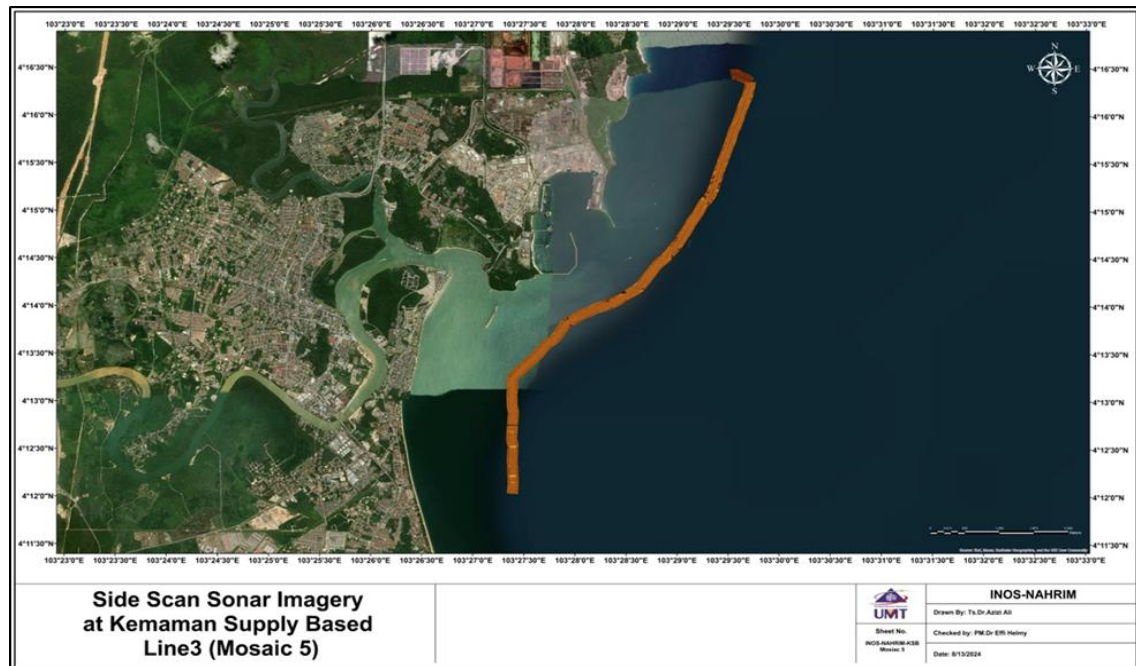


Figure 21. Mosaic image of side scan sonar at line 3 outside KSB port

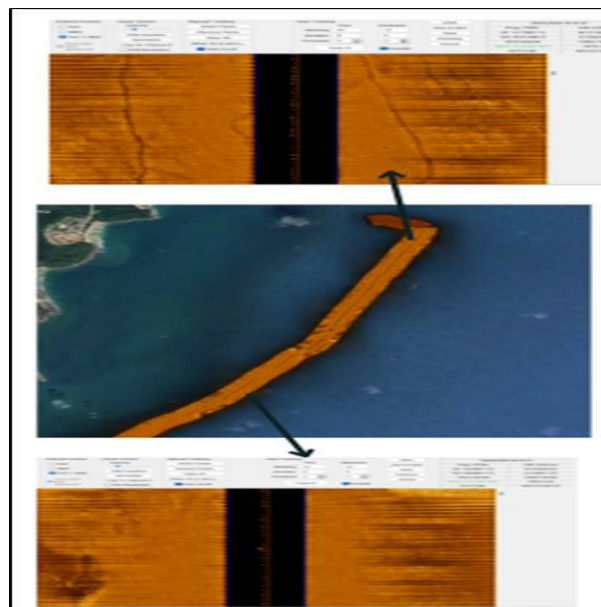


Figure 22. Sandy seabed

In summary, the sonar imagery from Line 3—documented in Figures 21 and 22—shows a homogeneous sandy seabed consistent with a low-energy depositional environment. This finding supports the conclusion that the outer offshore zone functions as a sediment accumulation area, with

potential use in dredged material management and coastal engineering planning. Continued monitoring and periodic seabed mapping in this region will help assess long-term sediment stability and support sustainable sediment management strategies for Kemaman Port and its surrounding coastal waters.

5.0 Conclusion

This technical report presents the findings from a comprehensive side scan sonar survey conducted within Kemaman Port and its surrounding coastal and riverine areas. The primary objective of the study was to investigate seabed morphology and sediment dynamics in support of sediment transport analysis, port maintenance planning, and safe navigation. The survey was executed using dual-frequency side scan sonar integrated with Differential Global Positioning System (DGPS) technology, ensuring precise spatial referencing and high-resolution seabed imaging across multiple zones.

The survey area was divided into two main regions: the internal port zone within Kemaman Supply Base (KSB) and external survey lines extending into riverine and coastal waters up to one nautical mile offshore. Within the port (as shown in Figures 7 to 13), sonar imagery revealed active sediment transport features such as sand and mud ripples, indicating strong bottom currents and areas of potential sediment accumulation. The presence of softer sediments in sheltered areas and irregular features in more trafficked zones suggests varying degrees of hydrodynamic influence and localized deposition. These findings emphasize the importance of ongoing maintenance dredging and sediment monitoring within the port basin to maintain operational depth and navigational safety.

Outside the port, along Line 2 (Figures 18 to 20), the seabed showed a combination of sandy substrates and rocky patches. These mixed textures indicate a transitional zone shaped by the interaction of riverine sediment input and coastal wave energy. Rocky outcrops identified in this area represent potential navigational hazards and should be clearly marked and monitored. The sediment dynamics here suggest active transport and redistribution processes, especially near the river mouth.

Further offshore, Line 3 (Figures 21 and 22) revealed a more stable and uniform sandy seabed. The sonar imagery indicated a depositional environment likely situated near the Depth of Closure, where wave-induced sediment movement becomes minimal. This area appears suitable for sediment disposal or dredged material placement due to its low-energy characteristics and relative isolation from active sediment transport pathways.

Overall, the side scan sonar survey provided valuable insights into the spatial variability of seabed features across Kemaman Port and its surrounding waters. The results highlight critical zones of sediment movement, potential hazards, and stable seabed areas suitable for future management interventions. These findings will aid in the development of sustainable sediment management strategies, improve port operational planning, and support long-term coastal monitoring and protection initiatives in the Kemaman region.

SURVEY WORK GALLERY

