JRSSEM 2025, Vol. 05, No. 03,
E-ISSN: 2807 - 6311, P-ISSN: 2807 - 6494

JRSSEM
JOURNAL RESEARCH OF SOCIAL SCIENCE, ECONOMICS, AND MANAGEMENT

Hydrographic Data Fulfillment Strategy to Improve the Capabilities of Pushidrosal as a National Hydrographic Institution in order to Answer the Mandatory IMO Member States Audit Scheme (MIMSAS)

Khoirul Anwar*, Edi Iwan Bangun, Dany Wira Nugraha
Sekolah Staf dan Komando Angkatan Laut, Indonesia
Email: khoirulanwarmalta@gmail.com*

Abstract. Indonesia, as the largest archipelagic state, plays a critical role in global maritime navigation. Accurate and up-to-date hydrographic data are essential for ensuring navigational safety, marine resource management, and national maritime security. The Indonesia Hydro-Oceanographic Centre (Pushidrosal), as the National Hydrographic Office, is responsible for producing and maintaining nautical charts in accordance with international standards. This study aims to develop strategies to enhance Pushidrosal's capability in fulfilling hydrographic coverage and meeting the Mandatory IMO Member States Audit Scheme (MIMSAS). Using a qualitative descriptive approach supported by GIS-based scoring and SWOT analysis, this research identifies national hydrographic data coverage gaps and proposes prioritized survey strategies. The results show that systematic and data-driven prioritization of survey areas is critical to achieving compliance with international obligations under SOLAS and UNCLOS. The study provides practical recommendations for Pushidrosal's strategic planning to accelerate hydrographic data acquisition. The implications of this study extend to both policy and operational domains. From a policy perspective, the findings support the need to integrate hydrographic data acquisition into Indonesia's national maritime governance strategy and ensure long-term budget allocation for survey modernization.

Keywords: Hydrographic, Survey, Pushidrosal, IMO, MIMSAS, Nautical Chart.

INTRODUCTION

Indonesia, as the largest archipelagic country in the world, plays a strategic role in global maritime navigation (Listiyono et al., 2021; Pulungan, 2024). The existence of accurate and up-to-date hydrographic data is essential to support shipping safety, marine resource management, and national defense and security interests (Ponce, 2019). The Naval Hydro-Oceanography Center (Pushidrosal), as the National Hydrographic Institute, is responsible for providing hydrographic data and ocean mapping that meet international standards. (Pushidrosal, 2023)

One of the main challenges in fulfilling its obligations as a National Hydrographic Institute is the lack of optimal coverage of hydrographic surveys across all Indonesian waters under national jurisdiction (Suhartotok, 2020). Based on existing data, the sea area that has not yet been surveyed reaches approximately 4,040,903 km². With an average survey rate of 25,000 km² per year, it would take more than 160 years to complete the entire area if there are no changes in strategy or capability improvements.

This condition reflects a significant gap between the need for accurate, up-to-date, and comprehensive hydrographic data and current institutional capabilities (Addor et al., 2020). This is a serious concern, especially in the context of the Mandatory IMO Member States Audit Scheme (MIMSAS), which emphasizes the importance of providing adequate hydrographic information to ensure shipping safety, protect the marine environment, and support the development of the national maritime sector. (IMO SOLAS, 2020)

The state's obligation to ensure navigation safety is also expressly regulated in the United Nations Convention on the Law of the Sea (UNCLOS) 1982, particularly in Articles 21 and 94. The convention states that coastal states are responsible for establishing navigation rules, including the provision of hydrographic information and the production of nautical

charts, to ensure safe navigation within their jurisdictions (Contarinis et al., 2023). (UNCLOS, 1982) This obligation strengthens the strategic role of the National Hydrographic Institute within the framework of international maritime law.

Furthermore, the implementation of these obligations falls under the supervision of the International Maritime Organization (IMO), a United Nations body responsible for setting global standards for shipping safety (Basaran, 2016; Christodoulou & Echebarria Fernández, 2021). Through the MIMSAS program—an international audit scheme—the IMO ensures that member countries, including Indonesia, comply with international standards and provisions related to maritime safety and environmental protection, including the availability of hydrographic data (Miettinen, 2024; Suwonnawong, 2024). This audit evaluates how well countries have implemented international provisions such as the Safety of Life at Sea (SOLAS) Convention, Chapter V, which mandates the regular updating of marine chart data. (IMO SOLAS, 1982)

In this regard, the role of the International Hydrographic Organization (IHO) is also crucial, as it is the body responsible for establishing technical standards and coordinating global hydrographic activities (Sinapi, 2021; Standard, 2017). The IHO encourages each member state to maintain a National Hydrographic Institute capable of conducting ocean surveys and mapping effectively (Sinapi, 2021). As an active IHO member, Indonesia must demonstrate its commitment through a credible technical institution supported by a well-structured and targeted survey strategy.

Pushidrosal, as the National Hydrographic Institute, plays a strategic role in addressing these challenges (Nasution, 2018). However, limited resources, the vast coverage of Indonesia's marine territory, and the dynamic nature of maritime information demands call for a more systematic, targeted, and priority-based survey strategy.

Recent studies have advanced hydrographic survey prioritization, yet gaps remain for Indonesia's National Hydrographic Office (Pushidrosal) (Nasution, 2018). Bongiovanni (2021) proposes an uncertainty-based, quantitative approach that estimates "chart health" to target resurveys in U.S. waters; however, the method is calibrated for Chesapeake Bay/Delmarva and does not address compliance pressures under IMO audits or resource constraints faced by large archipelagic nations. Niyazi et al. (2025) assess the global status of seafloor mapping and identify significant coverage deficits—especially across Asian EEZs—while projecting timelines at current mapping rates. Nonetheless, their work stops short of translating macro-level deficits into an operational, GIS-driven prioritization model for national programs such as Pushidrosal. Building on these insights, this study fills the gap by integrating GIS-based scoring (traffic density, hazards, socio-economic corridors, legacy survey quality/CATZOC, and environmental sensitivity) with SWOT analysis tailored to Indonesia's SOLAS V/9 and MIMSAS obligations, thereby producing a transparent, auditable set of survey priorities that align national risk management with international compliance requirements.

Based on the discussion above, the purpose of this study is to analyze the current conditions and identify the challenges faced by Pushidrosal in fulfilling hydrographic data coverage; to develop effective strategies for implementing surveys and mapping to accelerate coverage; and to formulate appropriate policies, strategies, and efforts to improve Pushidrosal's capabilities as a national hydrographic institution. In addition, this study aims to meet the requirements established under the Mandatory IMO Member States Audit Scheme (MIMSAS). Therefore, an approach that can establish hydrographic survey priorities objectively, efficiently, and measurably is required. A Geographic Information System (GIS)-based approach, combined with the SWOT method, is believed to provide an effective solution.

The study's benefits are twofold: theoretical, by adapting uncertainty- and risk-based prioritization to an archipelagic, compliance-constrained context; and practical, by delivering

an implementable roadmap for Pushidrosal's strategic planning that aligns survey execution with SOLAS and UNCLOS duties and ensures MIMSAS audit readiness.

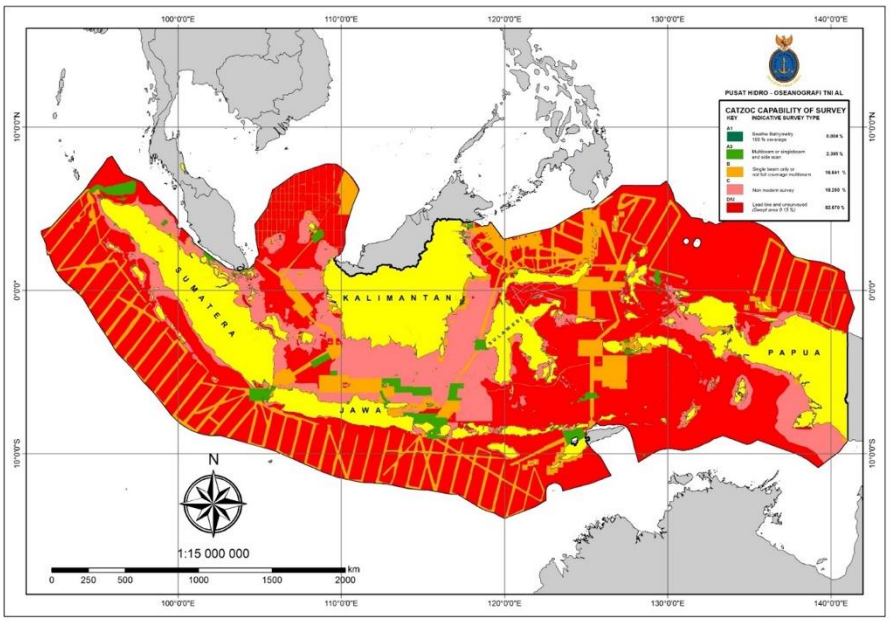

Figure 1. Survey Coverage and Quality in Indonesian Waters
Source: Dispeta Pushidrosal, 2025

METHOD

This study uses a qualitative approach with an analytical descriptive strategy. The qualitative approach was chosen because it is appropriate to understand complex and dynamic phenomena related to policies, strategies, and the fulfillment of international obligations by national hydrographic institutions. This method emphasizes deepening the context, process, and meaning of a phenomenon, rather than purely numerical measurements. In this context, the researcher seeks to explore in-depth information related to the strategy of fulfilling hydrographic data coverage by Pushidrosal in order to answer the mandate of the IMO Member State Audit Scheme (MIMSAS).

To support a comprehensive analysis, this study integrates three analysis approaches, namely Geographic Information System (GIS), scoring methods, and SWOT analysis.

Utilization of Geographic Information Systems (GIS) and Scoring Methods for Survey Prioritization

GIS is used to manage and analyze spatial data related to Indonesia's marine areas, especially in the context of hydrographic data coverage. Using GIS software, mapping and visualization of locations that have been and have not been covered by hydrographic surveys are carried out. GIS helps in identifying spatial information gaps as well as prioritizing survey areas based on specific criteria. This analysis is exploratory and descriptive, showing a map of actual coverage and potential areas that are still white spots or blind spots.

The scoring method is used to score a number of criteria that affect the urgency of hydrographic surveys in an area. These criteria include: ship traffic density, the existence of strategic ports, the availability of previous data, the status of waters in the ALKI/EEZ zoning, and potential navigation risks. Each criterion is given a certain weight based on expert judgment or strategic needs. The final score of each region is calculated and mapped using GIS to visually display the survey priority areas. This scoring method allows the transformation of qualitative data (such as national strategic interests) and quantitative data (such as vessel traffic intensity) into a more objective value matrix for comparison.

SWOT Analysis for Strategy Formulation

To develop the right strategy in improving the capabilities of Pushidrosal, the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis method is used. This analysis aims to identify internal and external conditions that affect the implementation of Pushidrosal's duties in fulfilling national hydrographic obligations according to IMO standards. The SWOT results will be the basis for formulating alternative strategies, such as the SO strategy (using strength to take opportunities), WO (overcoming weaknesses by taking advantage of opportunities), ST (using strength to deal with threats), or WT (minimizing weaknesses and avoiding threats). By combining the results of spatial analysis (GIS), priority analysis (scoring), and strategy analysis (SWOT), realistic, contextual, and supportive strategic recommendations were obtained that supported the fulfillment of MIMSAS standards by Pushidrosal.

RESULTS AND DISCUSSION

Results of Geographic Information System (GIS) Analysis

The use of Geographic Information System (GIS) in this study aims to map the waters of Indonesia based on the level of urgency of hydrographic surveys. Six parameters were used as the basis for spatial assessment, namely depth, port presence, shipping flow, *Category of Zone of Confidence (CATZOC)* data quality, ship accident/shallowness history, and Band 3 area (heavy traffic zone). Each parameter was analyzed spatially and scored based on its importance to navigational safety and international standards (IMO/IHO).

Priority of Depth (Bathymetry)

Areas with low depths (0–50 meters), especially in coastal areas and shallow waters, have a high urgency to be surveyed because they are prone to running aground and risk shipping safety. The scoring results show that the Natuna waters, including most of southern Papua and the Java Sea, have a depth of 0 to 50 meters. A high score is given for this area because shallow depth is a significant indicator of navigation risk.

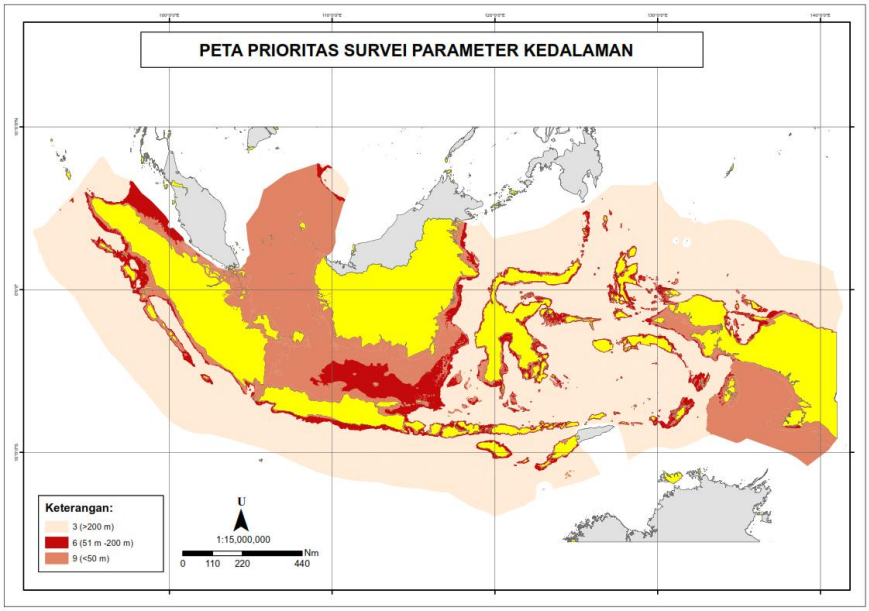

Figure 2. Depth Parameter Survey Priority Map
Source: Processing, 2025

Priority Port Existence

The existence of ports is one of the main indicators in determining the priority of hydrographic survey areas because ports are vital nodes in national and international logistics networks. The port has a strategic role as a trade gateway, a center for the distribution of goods, and a fulcrum for the economic growth of the coastal area.

Major ports such as Tanjung Priok (Jakarta), Belawan (Medan), Tanjung Perak (Surabaya), and Makassar are centers of maritime activities with heavy ship traffic, including large container ships, passenger ships, and tankers. The high volume of ship movements in this region demands the availability of accurate, up-to-date hydrographic data, and meets shipping safety standards. The maneuvering of large ships in the shipping channel in and out of the port is highly dependent on depth information, seabed structure, and the presence of *navigational hazards*.

In this context, the water area around the port is categorized as a high-priority zone for the implementation of modern hydrographic surveys. The accuracy of data in shipping channels, turning basins, anchorage areas, and terminals is critical to support port operational efficiency and avoid marine accidents such as shipwrecks or ship collisions.

As part of the spatial analysis using the Scoring approach in the Geographic Information System (GIS), ports in Indonesia are divided into four types based on the classification of the Ministry of Transportation and the Central Statistics Agency, namely:

Each port category is given a different score weight in the survey priority scoring system. Major ports gain the highest weight due to greater shipping safety risks and extremely high economic value. Meanwhile, regional and local ports get low weight.

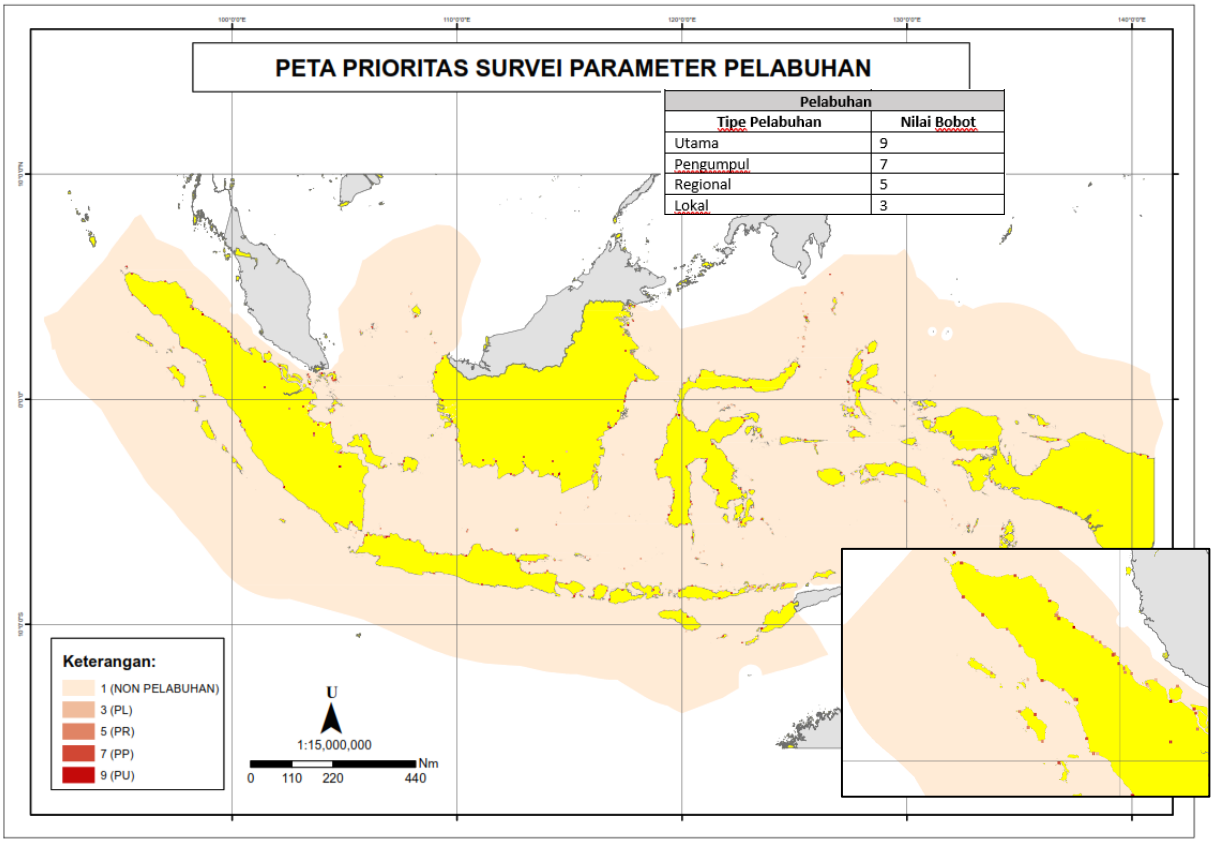

Figure 3. Port Parameter Survey Priority Map
Source: Processing, 2025

Priority of Shipping Flow

Shipping lanes are vital for ship mobility in Indonesian waters, which not only supports domestic connectivity but also facilitates international trade. In the context of hydrographic mapping, the presence and density of shipping channels are strategic indicators to determine survey priority areas. The higher the frequency of ship traffic, the greater the need for accurate and up-to-date hydrographic data to ensure navigation safety.

Indonesia as an archipelagic country with a geostrategic position has three main international shipping lanes that have been officially established within the framework of international maritime law, known as the Indonesian Archipelago Sea Lane (ALKI). This ALKI is regulated based on the provisions of the United Nations Convention on the Law of the Sea (UNCLOS) 1982, which allows foreign ships to sail peacefully (transit passage) through predetermined routes.

In addition to ALKI, there is a national shipping channel set by the Directorate of Navigation of the Ministry of Transportation. This channel includes hundreds of shipping lanes in coastal and inter-island areas, both for cargo ships, passenger ships, and fishing vessels. The determination of this flow is based on hydrographic studies, traffic density, and regional development needs.

In the context of spatial analysis using the Scoring approach in Geographic Information Systems (GIS), each shipping flow is given a priority score.

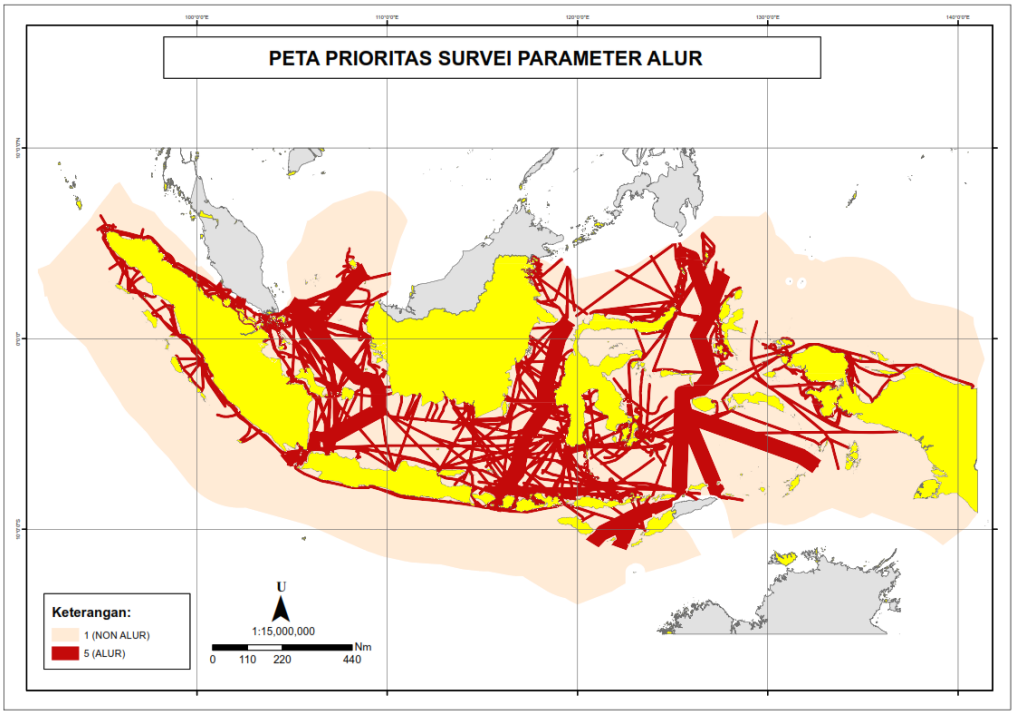

Figure 4. Pipeline Parameter Survey Priority Map
Source: Processing, 2025

CATZOC (Category of Zone of Confidence) Priority Map

CATZOC is an indicator of the quality of hydrographic data in nautical charts, ranging from A1 (highest) to U (unknown). Spatial analysis shows that most of Indonesia's waters are still in categories C, D, and U. Data from Pushidrosal shows that only about 19% of the area has CATZOC A1, A2, and B. Areas with low CATZOC are given high weights for immediate re-survey to meet IHO S-44 standards and MIMSAS requirements.

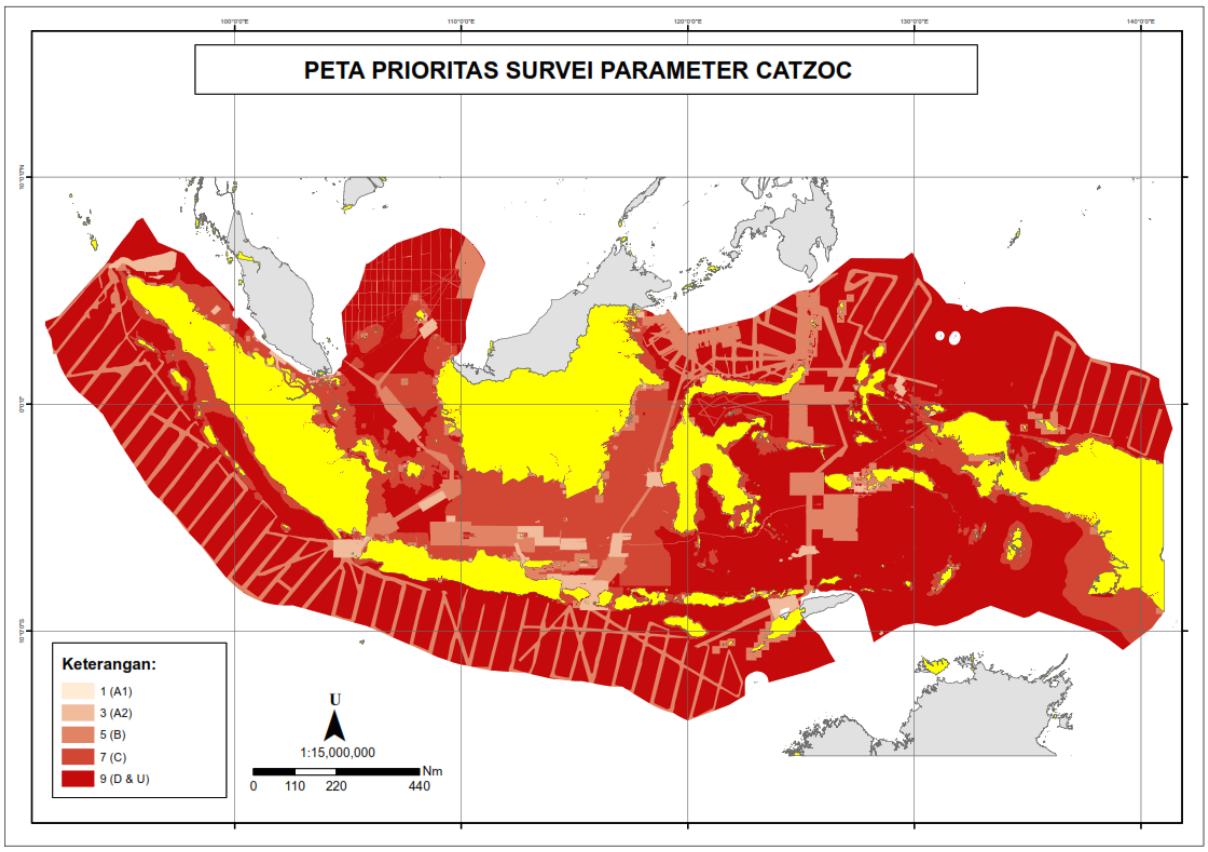

Figure 5. CATZOC Parameter Survey Priority Map
Source: Processing, 2025

Accident/Superficial Priority

Priority analysis of hydrographic survey areas based on marine accident incidents, particularly ship grounds, is an important risk-based approach to improve shipping safety and the effectiveness of national marine mapping. Spatial data on the occurrence of shipwrecks and marine accidents was obtained from the Pushidrosal report and data from the Directorate General of Sea Transportation of the Ministry of Transportation of the Republic of Indonesia over the past five years. This data includes chronological information of the incident, geographical location, type of vessel, and the main cause of the incident.

After overlaying the national hydrographic data quality map, a strong correlation was found between the frequency of landslides and areas with low data quality (CATZOC C–U) and depths that have not been modernly verified. Some high-incidence areas show limited depth data that still come from old surveys (pre-GPS era) or measurement results that do not meet the S-44 standard of the International Hydrographic Organization (IHO).

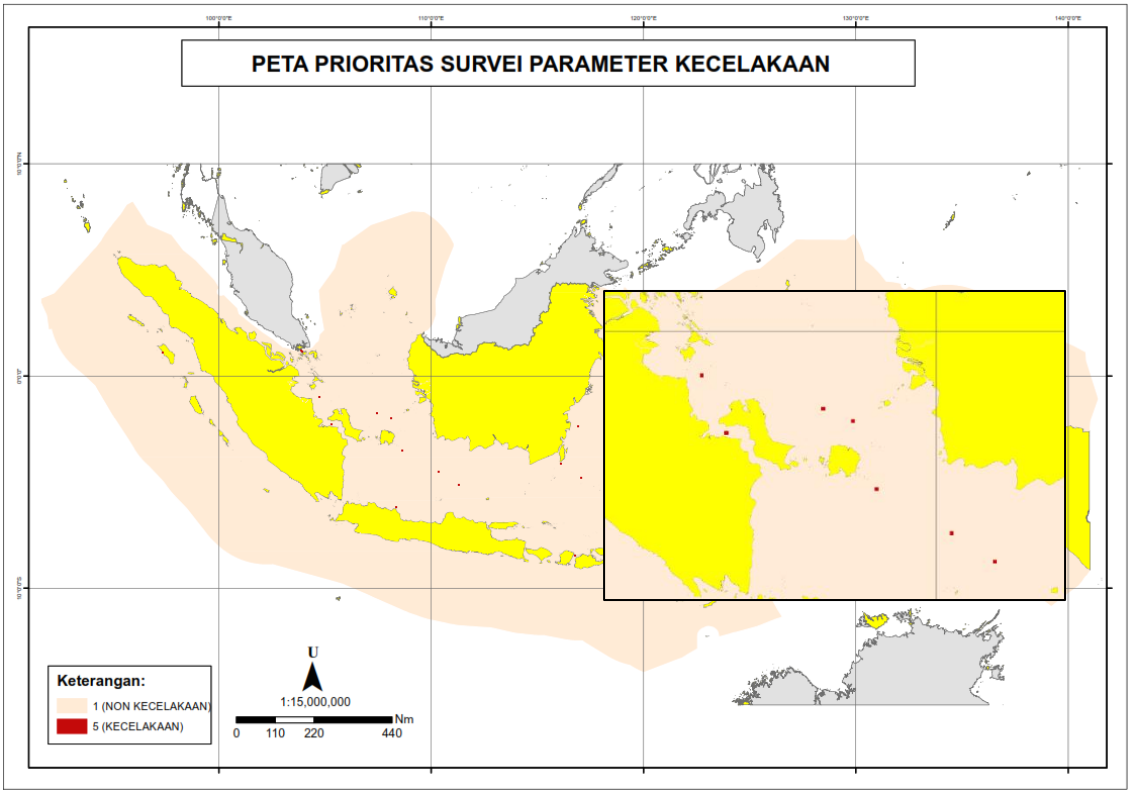

Figure 6. Accident Parameter Survey Priority Map
Source: Processing, 2025

Band 3 Priority (Coastal Scale)

In the national nautical chart classification system that refers to the standards of the International Hydrographic Organization (IHO), nautical charts are divided by scale and operational functions, one of which is Band 3, which includes medium-scale nautical charts (about 1:200,000) and is known as coastal maps. It serves as a bridge between large-scale maps (harbor charts and approach charts) and small-scale maps (overview charts), and is essential for cruises approaching beaches, harbors, and inter-island lanes. However, until now there are still a number of Indonesian waters that have not been adequately covered by the coastal scale map (Band 3).

Within the framework of the strategy to fulfill national hirographic data coverage, Band 3 is an element that must be prioritized because it is an important link between offshore navigation systems and coastal waters and ports. Through GIS scoring analysis, areas that have not been covered by the Band 3 map will be given high weight in the mapping of survey priorities. Therefore, the preparation of coastal scale sea maps is an important part of the Pushidrosal survey and mapping priority work plan, which is in line with the national strategy in strengthening maritime infrastructure and governance of Indonesia's marine areas.

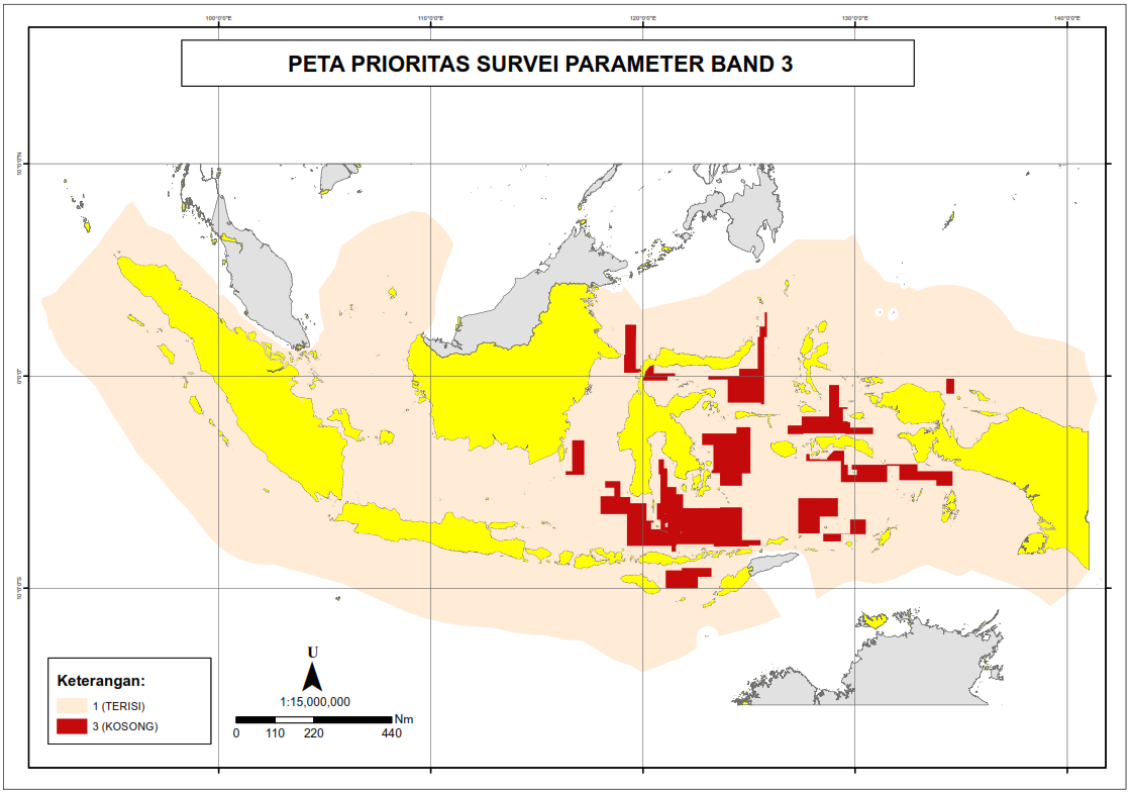

Figure 7. Accident Parameter Survey Priority Map
Source: Processing, 2025

In the classification of national marine map products, Band 3 refers to coastal scale sea maps, which are medium-scale maps (1:200,000). This scale is crucial for merchant ships, pioneer ships, and cruise ships in approaching coastal waters and ports. There are still several areas of Indonesian waters that have not been covered by coastal maps.

Results of Survey Priority Overlay Analysis with GIS

Spatial analysis using GIS combined with the scoring method has resulted in an objective and measurable mapping of the priorities of the national hydrographic survey area. Each parameter of depth, port, channel, CATZOC, accident/shallowness, and Band 3 coverage (coastal scale map) is given a value weight based on its level of urgency to shipping safety and national strategic interests so that the Survey priority is obtained.

The overlay of the six main parameters results in a priority map of the national hydrographic survey area with three classifications:

1 Very Priority Zone (total score 26 to 34)
2 Priority Zone (score 21 to 25)
3 Short-Term Zone (score 16 to 20)
4 Medium Term Zone (score 10 to 15)
5 Long-Term Zone (score 3 to 9)

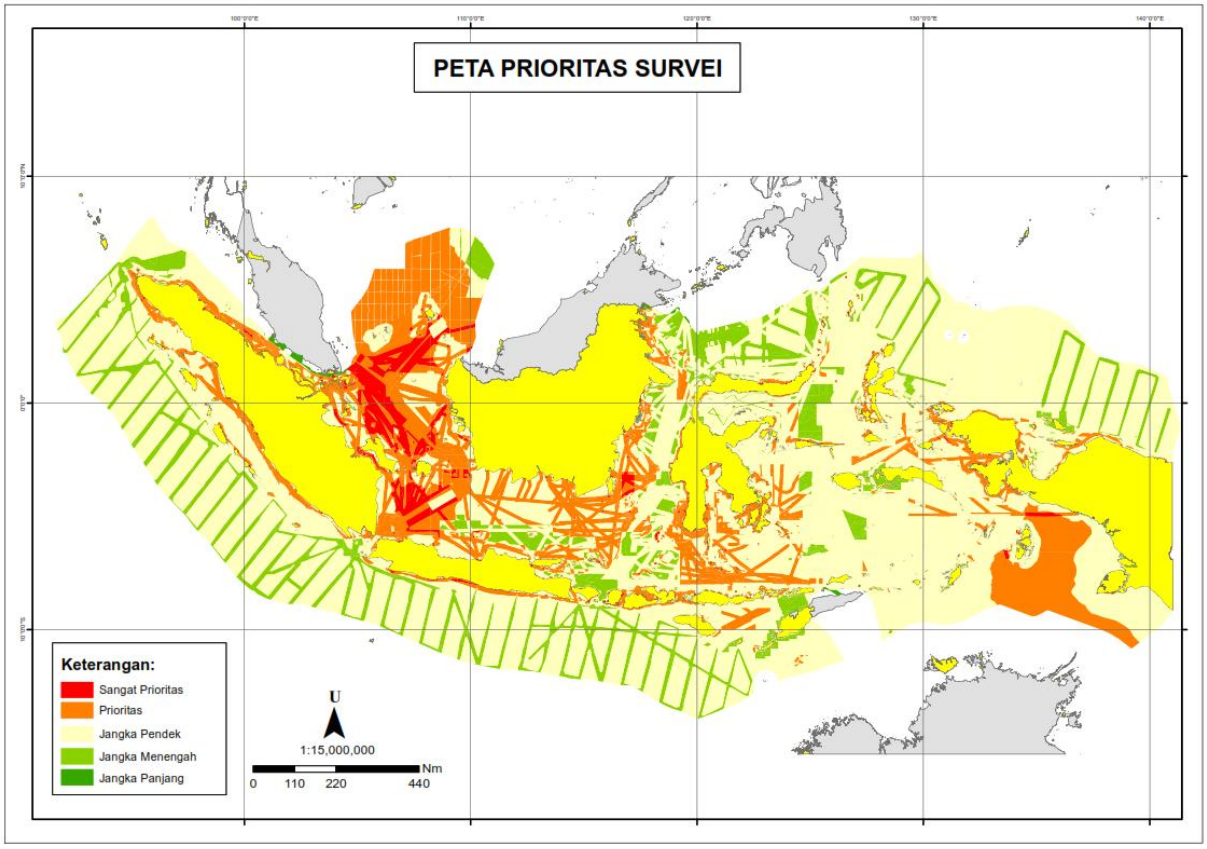

Figure 8. Survey Priority Map
Source: Processing, 2025

The areas that are included in the very category are areas that meet many criteria at once, namely: around ALKI I in the Natuna Waters, the Karimata Strait and the waters of the Makassar Strait to Balikpapan. The area has a high traffic density, is located on the main shipping lanes (ALKI I & II), and is close to the main port. And some segments still have low CATZOC data and ship accident incidence.

SWOT Analysis Results

Internal Factor Analysis

SWOT Internal Factor Analysis (Strengths, Weaknesses, Opportunities, Threats) to determine a strategy for fulfilling hydrographic data coverage to improve the capabilities of Pushidrosal as a national hydrographic institution in order to answer the mandatory Imo Member States Audit Scheme (MIMSAS) involves a comprehensive discussion and study of the strengths and weaknesses that exist in the internal environment. The power to improve Pushidrosal's capabilities is abundant because Pushidrosal has many human resources who are experts in their fields and the advancement of modern survey technology that is always followed by Pushidrosal. The identification of internal factors was obtained from literature studies and Small Group Discussions which were then analyzed by weighting and scoring.

Table 1. Results of the Strengths Factor Matrix (Strength)

No	Factor	Average Rating	Weight	Score (Weight × Rating)
S1	HR experts in the field of hydrography	4.00	0.26	1.04
S2	Modern survey technology	3.71	0.24	0.93
S3	National Authority	3.71	0.25	0.93
S4	Relations with IHO & IMO	3.29	0.25	0.82

Total Strength		1.00	3.68

Source: Processing, 2025

Table 2. Results of Matrix Factors Weaknesses

No	Factor	Average Rating	Weight	Score (Weight × Rating)
W1	Budget constraints	2.14	0.25	0,54
W2	Infrastructure is not even	2.57	0.25	0,64
W3	Weather dependency & access	2.86	0.25	0,72
W4	The GIS is not optimal	2.29	0.25	0,57
	Total Weakness		1.00	2,47

Source: Processing, 2025

Analysis of External Factors

Analysis of SWOT external factors (Strengths, Weaknesses, Opportunities, and Threats) to determine the Strategy for Fulfilling Hydrographic Data Coverage to Improve the Capabilities of Pushidrosal as a National Hydrographic Institution in order to Answer the Mandatory IMO Member States Audit Scheme (MIMSAS) involves a comprehensive discussion and study of opportunities and threats in the external environment. The opportunity to improve the capabilities of Pushidrosal is abundant because the need for quality hydrographic data is increasing and the support from the international institutions IHO and IMO for Pushidrosal.

Instead, threats in the external environment should be carefully considered when strategizing. The complexity of Indonesia's geographical conditions, the pressure of the IMO MIMSAS audit poses obstacles to the capabilities of Pushidrosal.

The identification of external factors of opportunities and threats in this manuscript was obtained from literature studies and small group discussions which were then analyzed by weighting and scoring.

Table 3. Opportunities Factor Matrix Results

No	Factor	Average Rating	Weight	Score (Weight × Rating)
O1	Increasing need for hydrographic data	4.14	0.26	1.08
O2	Support from IMO & IHO	4.14	0.26	1.08
O3	Advances in survey technology	3.71	0.24	0.89
O4	Inter-institutional, private and academic cooperation	3.57	0.24	0.86
	Total Opportunity		1.00	3.91

Source: Processing, 2025

Table 4. Threat Factor Matrix Results

No	Factor	Average Rating	Weight	Score (Weight × Rating)
T1	Geographic complexity	2.71	0.25	0.68
T2	IMO MIMSAS audit pressure	2.71	0.25	0.68
T3	International Competition	3.00	0.25	0.75
Q4	Impacts of climate change	3.00	0.25	0.75
	Total Threat		1.00	2.86

Source: Processing, 2025

Interpretation of SWOT Positions

The results of SWOT Scoring and Strategy Positions are as follows:
IFAS score = S – W = 3.68 – 2.47 = 1.21
EFAS score = O – T = 3.91 – 2.86 = 1.05

The figure below shows that the position of Pushidrosal's strategy is in Quadrant I (SO – Aggressive), which means the institution is in a strong position and has a great opportunity to improve its performance through an expansion strategy and optimization of internal strengths.

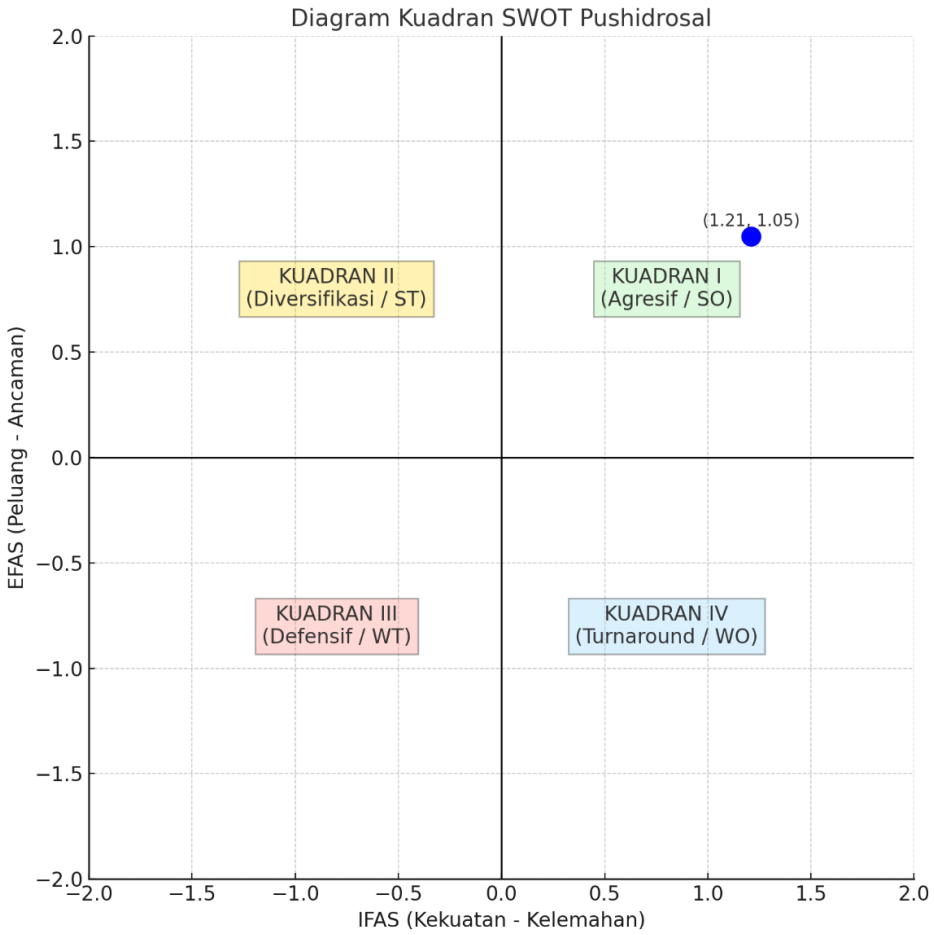

Figure 9. SWOT Quadrant Chart
Source: Processing, 2025

Discussion

Data coverage fulfillment strategies cannot be done haphazardly, given the limited time and resources. The results of scoring and GIS are an objective basis to prioritize the areas with the highest navigation impact. The implementation of the SO (Strength-Opportunity) strategy is recommended, namely taking advantage of the technical and legal advantages of Pushidrosal to establish partnerships and accelerate mapping. The WO strategy is also important to cover internal shortcomings with external support.

Policies

In order to answer the Mandatory IMO Member States Audit Scheme (MIMSAS) and improve the capabilities of Pushidrosal as a National Hydrographic Institution, a strategic policy that is comprehensive, structured, and answers the actual challenges of fulfilling national hydrographic data is needed. This strategic policy serves as the main framework before the formulation of a more technical operational strategy. In this study, it has been formulated that the policy is:

> *"The realization of a strategy to fulfill national hydrographic data coverage through increasing the production capacity of hydrographic data by integrating modern survey technology and expert human resources, initiating a national program for joint hydrographic surveys across sectors, developing an integrated digital-based national hydrographic information system, and strengthening the role of maritime diplomacy and regional capacity through training and technical cooperation to improve the capabilities of Pushidrosal as a National Hydrographic Institute in order to answer the Mandatory IMO Member States Audit Scheme (MIMSAS)*."

Strategy and Effort.

Based on the results of the identification of internal factors (Strengths) and external (Opportunities), the following are four combined SO (Strength-Opportunity) strategies that can be used as a reference in determining Pushidrosal's strategic efforts in fulfilling hydrographic data to answer the mandate of the IMO Member States Audit Scheme (MIMSAS):

Table 5. SO Combined Strategy to Respond to MIMSAS

Strategy Code	Strategy Description	**Its relation to MIMSAS**	**Combined Factor (S-O)**
SO1	Increase the production capacity of hydrographic data through the integration of modern survey technology and expert human resources to meet national and international needs.	Ensure the availability of accurate and up-to-date data according to the MIMSAS audit elements (SOLAS V/9).	S1, S2, O1, O3
SO2	Initiating a national hydrographic survey program with government, private, and university institutions by utilizing the authority of the Pushidrosal and the support of IHO-IMO.	Improve inter-agency coordination and build an efficient national survey ecosystem.	S3, S4, O2, O4
SO3	Develop a digital-based national hydrographic information system (open-data portal) by integrating survey outputs from all stakeholders.	Meet the aspects of openness, integration, and interoperability of navigation data in MIMSAS audits.	S2, S4, O3, O4
SO4	Enhancing the role of maritime diplomacy and regional capacity through training and technical cooperation.	Supporting international cooperation and expected regional contributions in IMO audits.	S1, S3, S4, O2

Source: Processing, 2025

a. Strategy 1, SO1, Increase the production capacity of hydrographic data through the integration of modern survey technology and expert human resources to meet national and international needs.

   By utilizing human resource competencies (S1) and modern survey technology (S2) to accelerate the fulfillment of national marine data coverage through re-surveying priority areas, as well as updating ENC and *CATZOC* according to IHO standards. MIMSAS audits require the availability of accurate and up-to-date hydrographic data to

ensure shipping safety (SOLAS V/9). This strategy ensures that Pushidrosal has a reliable and fast technical capacity in producing data in accordance with IMO audit elements.

Pushidrosal's efforts in Strategy 1 are:

1) Efforts to Modernize Hydrographic Survey Tools and Technology.
   Procure and upgrade hydrographic survey systems such as MBES (Multi-Beam Echo Sounder), LiDAR bathymetry, and marine drone systems (USV/AUV) to accelerate and improve the quality of survey coverage.
2) Efforts to Improve Human Resource Competency Through Certification and Training.
   Organizing national and international certified technical training (e.g. IHO Cat B/A) for Pushidrosal personnel to have expertise according to global standards, while increasing international competitiveness.
3) Efforts to Strengthen R&D Collaboration with Research and Industry Institutions.
   Establish strategic cooperation with BPPT/BRIN, marine engineering colleges, and survey tool vendors to adapt new technologies and improve the efficiency of the survey process.

Strategy 2, SO2, Initiates a national hydrographic survey program with government, private, and university institutions by utilizing the authority of the Pushidrosal and the support of IHO-IMO.

By utilizing national authority (S3) and international relations (S4) to develop joint survey programs with other institutions (Ministry of Transportation, BIG, KKP, BRIN), the private sector, and academia to accelerate national data coverage efficiently. *MIMSAS* audits the country's capacity in inter-agency coordination and the ability to build an interconnected maritime ecosystem. This strategy encourages Pushidrosal as the main driver in building national collaboration for ocean mapping.

Pushidrosal's efforts in Strategy 2 are:

1) Efforts to Establish a National Hydrographic Survey Consortium.
   Establish a forum or consortium involving Ministries/Institutions (KKP, BIG, BPPT, Dishidros TNI AD/AU), academics, and the industrial sector to identify survey needs and develop joint action plans.
2) Efforts to Utilize IHO and IMO Support in Joint Projects.
   Propose collaborative activities within the framework of IHO CB (Capacity Building) or IMO technical cooperation that can be used as a legal/formal platform to attract foreign support.
3) Cost-Sharing Scheme Efforts for Survey Activities.
   Designing a sharing funding model between government agencies and strategic partners (SOEs, private oil and gas, and ports) in national priority area survey projects (ALKI, strategic ports, super priority tourism areas).

b. Strategy 3, SO3, Develop a digital-based national hydrographic information system (open-data portal) by integrating survey outputs from all stakeholders.

Integrating all survey data (from Pushidrosal and partners) into a GIS-based information system that meets the principles of openness, interoperability, and in accordance with IHO data standards. *MIMSAS* requires member countries to provide transparent, accessible, and verified navigation data. This system will strengthen Indonesia's maritime information governance and support the audit process in a systematic and sustainable manner.

Pushidrosal's efforts in Strategy 3 are:

1) Efforts to develop the National Hydrographic Data Portal (PDHN).

Build a web-GIS-based digital platform as an open data repository that presents information on seabed survey results and thematic maps interactively, supporting the principle of open government data.

2) Efforts to Integrate Multi-Agency Survey Data with the IHO S-100 Standard.
Develop an interoperability protocol to combine data from Pushidrosal, KKP, BIG, and other agencies in one international standard (S-57/S-100) to ensure data accuracy and up-to-dateness.
3) Efforts to Prepare National Hydrographic Data Governance Regulations.
Encourage the birth of policies or Perpres/Integrated Hydrographic Management Agency that regulates the division of roles, data access, information security, and periodic update mechanisms.

c. Strategists 4, SO4, Enhancing the role of maritime diplomacy and regional capacity through training and technical cooperation.

Optimizing relations with IHO and IMO (S4) as well as recognition as a National Hydrographic Institute (S3) to expand Indonesia's strategic role in regional hydrographic forums, including through training, technical assistance, and data exchange. One aspect of the MIMSAS audit is the state's contribution to international cooperation in the field of shipping safety and navigational information. This strategy will demonstrate Pushidrosal's leadership regionally and strengthen the trust of the international community.
Pushidrosal's efforts in Strategy 4 are:

1) Efforts to Organize Regional Training under the auspices of IHO/IMO.
Making Pushidrosal a training hub in Southeast Asia by organizing technical training in hydrography, marine data processing, and the creation of ENC (Electronic Navigational Charts) for neighboring countries.
2) Bilateral and Multilateral Cooperation Efforts in the Field of Hydrographic Surveys.
Enhance technical partnerships with partner countries such as Japan (JHOD), the United Kingdom (UKHO), and Singapore (MPA) to share best practices, field training, and joint surveys in cross-border areas.
3) Efforts to Participate in International and Regional Maritime Forums.
Increase the representation of Pushidrosal in forums such as EAHC (East Asia Hydrographic Commission), IHO Assembly, to strengthen Indonesia's position as a regional leader in hydrography.

By implementing a gradual and integrated SO (Strength - Opportunity) strategy, Pushidrosal can not only meet the elements of MIMSAS audits, but also improve Indonesia's position in the field of global hydrography in a sustainable manner.

CONCLUSION

Pushidrosal continues to face major challenges in fulfilling comprehensive hydrographic data coverage, particularly in terms of limited survey areas, data quality (CATZOC), and uneven coastal-scale sea maps (Band 3), which are vital for meeting IMO audit requirements through the *MIMSAS* scheme. Through GIS-based scoring, priority survey zones have been identified around strategic waterways and major ports, while SWOT analysis positions Pushidrosal in an aggressive strategic (SO) stance, utilizing internal strengths to leverage external opportunities. The formulated strategies include modernizing survey technologies, fostering inter-agency collaboration, developing a national hydrographic information system, and enhancing international engagement, supported by fleet optimization and human resource development. Future research should focus on integrating real-time data assimilation and adaptive survey modeling to strengthen decision-making and ensure continuous compliance with evolving international hydrographic standards. The author

expresses gratitude to Seskoal, Pushidrosal staff, and supervisors for their guidance and support, while acknowledging the research's limitations and remaining open to constructive feedback for future improvement.

REFERENCE

Addor, N., Do, H. X., Alvarez-Garreton, C., Coxon, G., Fowler, K., & Mendoza, P. A. (2020). Large-sample hydrology: recent progress, guidelines for new datasets and grand challenges. *Hydrological Sciences Journal*, *65*(5), 712–725.

Basaran, I. (2016). The evolution of the International Maritime Organization's role in shipping. *J. Mar. L. & Com.*, *47*, 101.

Christodoulou, A., & Echebarria Fernández, J. (2021). Maritime Governance and International Maritime Organization instruments focused on sustainability in the light of United Nations' sustainable development goals. In *Sustainability in the Maritime Domain: Towards Ocean Governance and Beyond* (pp. 415–461). Springer.

Contarinis, S., Kastrisios, C., & Nakos, B. (2023). Marine protected areas and electronic navigational charts: legal foundation, mapping methods, IHO S-122 portrayal, and advanced navigation services. *Euro-Mediterranean Journal for Environmental Integration*, *8*(1), 67–87.

IHO. *Standards for Hydrographic Surveys (S-44)*. 6th ed., Monaco: IHO, 2020.

IMO. *SOLAS Consolidated Edition*. IMO Publishing, 2020.

Listiyono, Y., Pramono, B., Prakoso, L. Y., Prihantoro, K., & Sianturi, D. (2021). Marine defense strategy in securing Indonesian archipelagic sea lanes (Alki) to realize maritime safety and maintain Indonesian soility. *International Journal of Education Social Science Research*, *4*, 224–237.

Miettinen, A. (2024). *Finland's policies on procedures for the promulgation of the mandatory instruments of the International Maritime Organization (IMO) and for ensuring the compliance of the maritime administration*.

Nasution, A. M. (2018). The Role Of The TNI Navy's Hydro-Oceanographic Centre in Managing Sustainable Fisheries (A Study on Providing Hydrographic Data for Managing Sustainable Fishery). *Jurnal Pertahanan*, *4*(3).

Ponce, R. (2019). Multidimensional Marine Data: The next frontier for Hydrographic Offices. *The International Hydrographic Review*.

Pulungan, E. D. (2024). From Archipelago to Maritime Hub: Indonesia's Quest to Become the World's New Maritime Axis. *Jurnal Ilmiah Ilmu Sosial*, *10*(2), 106–117.

Pushidrosal. *Nautical Map of Indonesia and CATZOC*. Jakarta, 2023.

Saaty, T. L. *The Analytic Hierarchy Process*. McGraw-Hill, 1980.

Sinapi, L. (2021). Ocean's knowledge: the role of the International Hydrographic Organization in the incoming decade. *Bulletin of Geophysics and Oceanography*, *3*, 57–63.

Standard, I. H. O. G. (2017). *International Hydrographic Organization*.

Suhartotok, C. K. S. (2020). *The Implementation of Indonesian Navy's Hydrography and Oceanography Center in Supporting the Government Vision to Realize Indonesia as the Global Maritime Fulcrum*.

Suwonnawong, P. (2024). *Development of international shipping standards under the auspices of the IMO and their implementation in practice: a case study of Thailand*.