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Anthropogenic Analysis of the Interests of Service Provider Users with Parameters of Pekalongan Port Water Health

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ABSTRACT

The quality of the waters has led to a decline in ship visits at Pekalongan Port. Anthropogenic activities are one of the main causes of siltation along the port's shipping channel, which has reached a depth of 3 meters below low water spring (MLWS). This has made fishermen, as service users, increasingly attentive to the tidal conditions when entering or exiting the port. This study aimed to assess the levels of phosphates, nitrates, total suspended solids (TSS), and bacteria along the channel to evaluate environmental health. Additionally, it analyzed the interests of users and service providers using the National Transportation System Indicator, with the Customer Satisfaction Index (CSI) and Importance-Performance Analysis (IPA) methods. Laboratory results showed that the phosphate and nitrate levels at four stations exceeded quality standards. The TSS parameter was only within the acceptable limits at station 1, while the bacterial levels at station 2 (2.8×10^2) and station 3 (4×10^2) were notably high compared to other stations. The CSI analysis indicated that the only criterion meeting the required standard was the tariff indicator for smoothness. Criteria that did not meet the requirements included accessibility, capacity, safety, orderliness, and pollution. The IPA analysis classified one index in Quadrant I, one index in Quadrant II, four indices in Quadrant III, and one index in Quadrant IV.

INTRODUCTION

The Nusantara Fisheries Port (PPN) in Pekalongan is a port located on the northern coast of the Java Sea, directly connected to the open sea. The port has significant strategic potential for fishing vessels, featuring a Fish Auction Place (TPI) with two sections, covering an area of approximately 4,643m², and a pier measuring 536 meters in length. The pier can accommodate up to 30 ships, ranging in size from 10 to 30 GT. However, ship visits to PPN in Pekalongan have decreased between 2015 and 2022, as shown in Table (1).

Table 1. Recapitulation of purse seine and gilnet ship visits at Pekalongan port

Year	Vessel Types							
	Purse seine (> 30 GT)		Purse seine (< 30 GT)		Set gill net		Encircling gill net	
	Arrival	Departure	Arrival	Departure	Arrival	Departure	Arrival	Departure
2015	412	496	1,306	900	1,211	636	228	235
2016	440	458	1,196	1,094	1,789	1,287	365	379
2017	309	336	713	615	519	511	142	147
2018	351	167	679	597	709	864	93	204
2019	326	229	441	329	1,089	1,089	168	168
2020	326	273	544	486	871	871	178	178
2021	249	267	166	160	17	162	75	135
2022	142	257	167	145	113	155	101	109

The arrival of > 30 GT purse seine ships in 2015 to 2022 has decreased by -4% while ships unloading at TPI have only increased by 2%. The arrival of < 30 GT purse seine ships in 2015 to 2022 has decreased by -20% while ships unloading at TPI have declined by -19%. The arrival of set gill net ships from 2015 to 2022 has increased by 77% while ships unloading at TPI only increased by 7%. The arrival of gill net encircing ships from 2015 to 2022 increased by 7% while ships unloading at TPI only increased by 1%.

The decline of ship visits, especially on ships measuring < 30 GT at PPN Pekalongan, needs to be further researched to find out the level of interest of customers (as service users) upon dealing with the service providers associated with water conditions. The quality of water describes the properties that arise from the activities practiced at the port such as ship repairs, liquid waste disposal from ships, port cleaning and TPI so that there are materials that can be categorized as waste, and it is possible that there are various kinds of contents that can affect quality and assessment of aquatic parameters **(Dorji & Fearns, 2016; Masocha *et al*., 2017)** phosphate and nitrate **(Chen *et al*., 2021)** and total suspended solids (TSS).

Biodiversity and biogeochemical processes play a critical role in the existence of detrital materials **(Gonzalez-Hidalgo *et al*., 2013; Chen *et al*., 2014)**, as well as in supporting life in aquatic ecosystems **(Supriyantini *et al*., 2019)**. For example, the presence of bacteria in the water is an indicator of overall ecological health. An increase in bacterial levels in the water is often accompanied by a similar rise in bacteria levels in fish **(Nugraheni *et al*., 2022)**. Additionally, anthropogenic influences around the port, such as land use and industrial activities, along with the inundation caused by tidal flooding (bajir rob), contribute to the increased sedimentation and deposition, resulting in

water siltation **(Hamuna, 2018; Sahambangun *et al.*, 2022; Zainuri *et al.*, 2022; Aprilia *et al.*, 2023; Ridarto *et al.*, 2023)**.

These conditions can impact various stakeholders, including ships, customers, and investors, who must collaborate with service providers, such as the Indonesian Fisheries Port (PERINDO), and engage with fisheries port safety supervisors.

The purpose of this study was to assess the condition of the port waters based on parameters such as nitrate, phosphate, total suspended solids (TSS), and bacteria. This analysis aimed to monitor and anticipate potential pollution and environmental damage in the future **(Baigo, 2018)**. The study also explored customer interest in the condition of the waters and the role of service providers as facilitators in ensuring environmental sustainability at the Port of Pekalongan.

MATERIALS AND METHODS

The quantitative research method used in this study involved primary data obtained from water samples, which were tested in the laboratory of the Regional Health Center and the Pekalongan Regency Environment Office. Sampling was conducted at four stations in May 2023, with a distance of 100 meters between each sampling point. The parameters tested included chemical parameters (nitrate and phosphate), physical parameters (TSS), and biological parameters (total plate count, or ALT). To assess the quality of port waters, samples were taken from four stations in the port area: the port pool, the fish auction place (TPI), and the ship entry/exit channels. This sampling strategy provides an overview of the productivity of estuarine waters, from the sea to the near-shore areas **(Miftakhudin, 2021)**. The research map is shown in Fig. (1).

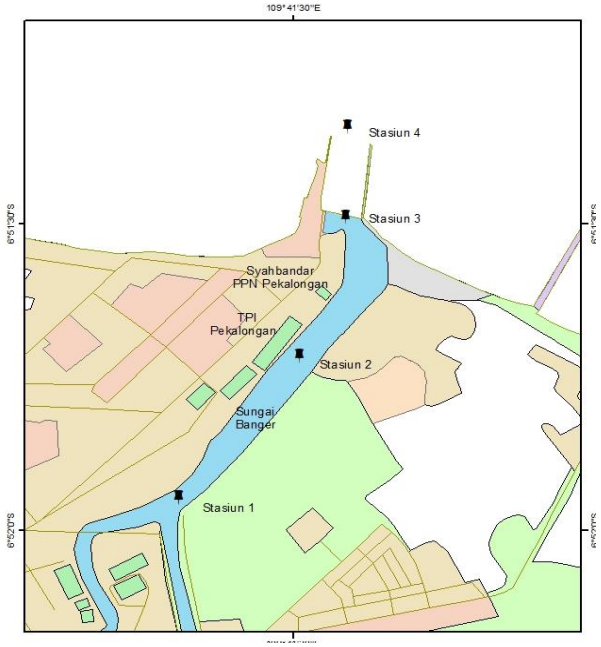

Fig. 1. Research location of Pekalongan Port **(Data Analysis, 2024)**

In addition to water quality data, the study also collected questionnaire responses, field condition surveys, and interview data from port service users, including fishermen who dock at the Port of Pekalongan and unload/land fish at the TPI. Interviews were also conducted with port syahbandar employees, who supervise activities at the port, and with port managers from Perindo. Secondary data were obtained from ship visit records provided by the Pekalongan Office. This method was used to map the relationship between service users and service providers.

Data collection

Customer satisfaction index (CSI)

CSI was used to assess service users' perception of service provision **(Ristanti & Suryanto, 2023)** and was then measured by the following assessment levels:

Table 2. CSI Criteria **(Gaus, 2017)**

No	CSI Values	CSI Criteria
1	> 0.81	Highly Fulfilled
2	0,66-0.81	Fulfilled
3	0.51-0.65	Quite Fulfilled
4	0.35-0.50	Less Fulfilled
5	< 0.35	Unfulfilled

The assessment step based on the questionnaire that was distributed was then analyzed with the following steps:

The mean importance sore (MIS) was used to determine the average level of interest of service users **(Setiawan, 2022)**, as follows:

$$MIS = \frac{\sum_{i=1}^{n} Yi}{n}$$

Where:

n: Number of Respondents, Yi: Value of Importance of the ITH indicator

Weight factor (WF) was used to determine the MIS percentage weight per overall MIS indicator **(Setiawan, 2022)**, as follows:

$$WF = \frac{MISi}{\sum_{i=1}^{p} MISi} \times 100\%$$

Where:

P: Pth Importance Indicator, MIS: Mean Importance Score

Weight score (WS) was calculated by multiplying WF by the average performance level (MPS) **(Setiawan, 2022)**, as follows:

Wsi= WFixMPS

Where:
MPS: Mean Performance Score

The formula used to calculate the customer satisfaction index (CSI) **(Setiawan, 2022)** was as follows:

$$CSI = \frac{\sum_{i=1}^{p} WSi}{HS} \times 100\%$$

Where:

p: The pth Importance Indicator, HS: Highest Scale.

Metode analysis importance-performance analysis (IPA)

Quadrant analysis, often used in performance improvement studies, is a relatively simple method that presents results in an easy-to-understand format. It helps measure the relationship between service or product quality assessment priorities and consumer perceptions of the service or product. This method can also be used to assess consumer loyalty in relation to satisfaction factors **(Fajri *et al.*, 2019)**, with customer satisfaction being the top priority **(Zakaria *et al*., 2019)**.

The data for this analysis were collected through a survey using a questionnaire. Service users were asked to provide assessments based on variables derived from the National Transportation System Index (SISTRANAS), which were grouped according to specific assessment indicators **(Amaliyah *et al.*, 2020)**.

The quadrant scheme consists of 4 with the following categories:

Quadrant I "Defense Performance" Maintaining Achievement (High Importance & High Performance)

Quadrant II "Tendency to Overkill" Maintaining Excessive Achievement (Low Importance & High Performance)

Quadrant III "Low Priority" is not focused on goals (Low Importance & Low Performance)

Quadrant IV "Improve Performance" Factors that need to be improved (High Importance & Low Performance).

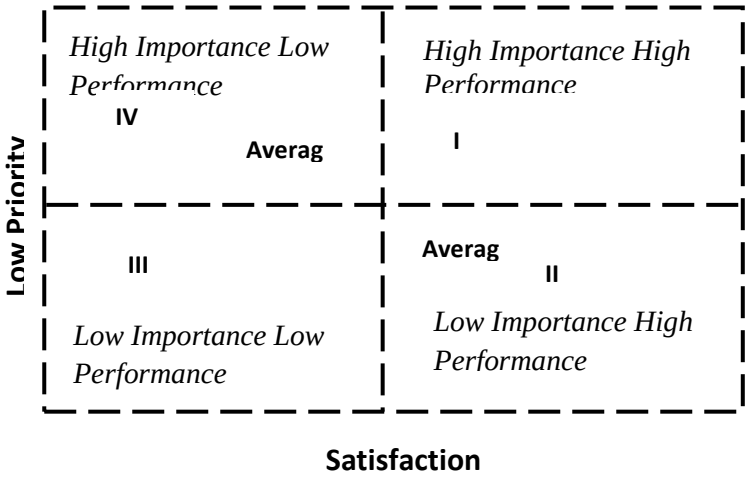

Fig. 2. Quadrant of IPA analysis **(Setiawan, 2022)**

National transportation system indicators (SISTRANSAS) provids port service indicators for service providers and port operators so that they get proper guidelines and ensure that service users get maximum service, following the design and dimensions, as shown in Table (3).

Table 3. National transportation system indicators (SISTRANSAS)

Indicator valuation	Dimensions	
	Service user network	Service provider network
High accessibility	Areas that need transportation access must be affordable	Services can meet the needs of the region and population
Port capacity	Service capacity is proportional to user needs	Capacity is fulfilled according to user needs
Affordable rates	Average expense rate below the transportation needs rate	Rates based on service user development needs
Guaranteed safety	Mitigation and anticipation of safety and health for service users are fulfilled	Safety and health are accommodated according to the interests of service users
Service regularity	Measurable level of regularity with applicable standards	Orderliness puts service users first
Smooth & fast activities	Utilization of appropriate facilities according to the needs of service users	Quantity of scheduled and on-time service users
Low pollution	Pollution levels and environmental health are guaranteed	There are pollution prevention regulations

Data source: **Wibowo (2017)**.

RESULTS

1. Marine topography

1.1 Depth of river

The decrease in the number of fish arrivals and landings at Pekalongan, especially on ships < 30 GT, is due to even siltation in the Pekalongan shipping channel so that ships only enter and carry out activities at the port by relying on tidal conditions. Table (4) exhibits the water depth survey data.

Table 4. Depth data of Pekalongan PPN ship shipping channels

Stasiun	Depth	Information
1	3.23 mtr	Port Pool inlet
2	2.55 mtr	Fish Landing Sites
3	1.35 mtr	Port inflow
4	2.6 mtr	Port Pier

The depth along the ship entry/exit channel to the port pool didn't meet the standards set by the Decree of the Minister of Transportation No. 432 of 2017, which specifies that the depth of the collecting port should range from -7 to 9 mLWS. However, survey data indicate that the depth reached 2 to 3 mLWS. Significant siltation was observed at stations 2 and 3, where shipping and fisheries activities are concentrated.

1.2 Sampling of vessel

Table (5) exhibits the results of testing the water samples of the river channel leading to the port.

Table 5. Test results of Pekalongan Port Channel water samples

Stasiun	Phosphate	Nitrate	TSS	Bacteria (ALT)
1	0.3	0.3	20	1x103
2	0.4	0.3	30	2.8 x 102
3	0.09	0.4	37	4x102
4	0.02	0.3	23	1.7x102

Description: Quality standards are based on the Decree of the Minister of Environment no 22 of 2021 concerning Environmental protection. Phosphate: 0.015 mg/l, TSS: 20 mg/l, Nitrate: 0.008 mg/l.

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The analysis showed that the phosphate and nitrate parameters at all four stations exceeded the quality standards, while only station 1 met the TSS quality standards. The bacteria parameters, measured by total plate count/total bacteria,

revealed that stations 2 and 3 had significantly higher levels compared to the other stations.

The laboratory results indicate poor water quality, which could lead to complex challenges and increased competition between ports **(Suryantoro, 2021; Iman *et al.*, 2024)**. One consequence is the increase in nutrient levels (nitrate and phosphate), which accumulate in the waters and water bodies. This accumulation leads to higher sedimentation, contributing to persistent shallowness in the port.

1.3 Geospacial analysis

The results of laboratory tests were then represented by geospatial data, as shown in Fig. (3).

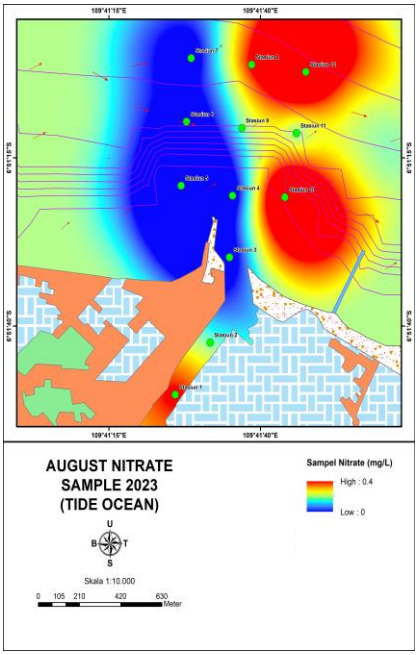

Fig. 3. Geospacial analysis of nitrate **(Data Analysis, 2024)**

The analysis showed that stations 1 and 2 (rivers and harbor pools) experienced an increase in nitrate content compared to stations 3 and 4 (inlet and open sea).

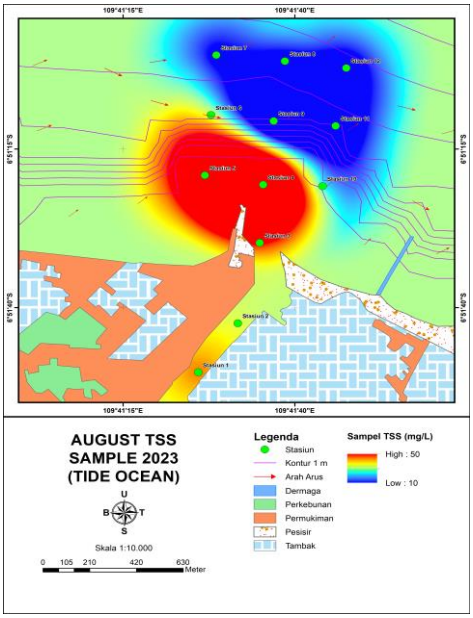

Fig. 4. Geospacial analysis of TSS **(Data Analysis, 2024)**

The analysis showed that stations 3 and 4 (inlet and open sea) experienced an increase in nitrate content compared to stations 1 and 2 (rivers and harbor pools).

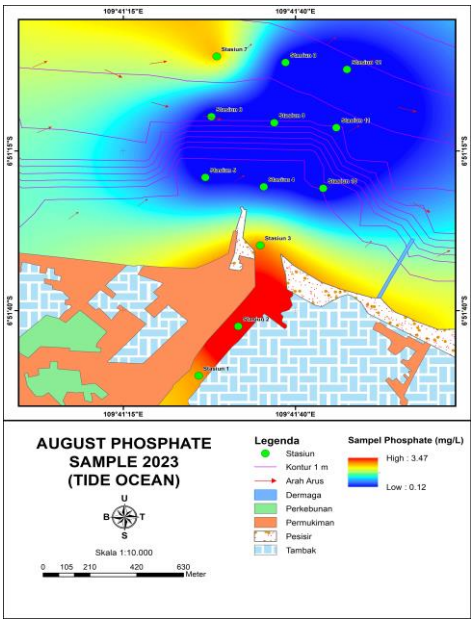

Fig. 5. Geospacial analysis of TSS **(Data Analysis, 2024)**

The analysis showed that stations 1 and 2 (rivers and harbor pools) experienced an increase in nitrate content compared to stations 3 and 4 (inlet and open sea).

1.4 CSI analysis

These issues result in difficulties in managing the interests of service users in relation to service providers, including aspects such as responsiveness, emotional, social, and physical factors. As a result, service users are likely to choose the best service from providers they believe can meet their needs and interests **(Hasanuddin *et al.*, 2022)**. A CSI analysis is essential to evaluate the value of these needs and interests **(Mutia et al., 2022)**. Table (6) exhibits the results of the CSI analysis.

Table 6. Results of CSI analysis of service providers with interests of service users

Sistransas Indicator	Service Providers (X)	Interests Service user (Y)	Average (X)-(Y)	Criterion CSI
Accessibility	1,40	3,21	-1,81	Unfulfilled
Port capacity	4,52	4,10	0,42	Less Fulfilled
Affordable rates	4,46	3,26	1,20	Highly Fulfilled
Safety	1,40	3,22	-1,82	Unfulfilled
Regularity	1,31	3,10	-1,79	Unfulfilled
Smooth and fast	4,20	3,12	1,08	Highly Fulfilled
Low pollution	1,28	3,24	-1,96	Unfulfilled

The analysis results show that only two variables are considered to be met by service users: tariff and smoothness/speed. However, since the majority of respondents are fishermen, these results reflect the interests of fishermen as users of port services. Fishermen generally do not pay tariffs because the port does not charge a fee for ships that land fish at the TPI Pekalongan. The speed of service at the TPI, particularly for loading, unloading, and auctions, is considered good because many fish collectors/middlemen are already present, allowing the auction process to proceed quickly and fishermen/ship to receive auction payments promptly.

Fishermen expressed concerns about the inadequate port capacity, as it can only accommodate about 20 ships. Around the TPI area, some boats are docked without sufficient activity, which interferes with the movement of ships entering and exiting the port channel and carrying out activities at the TPI. Access to the port, including the route for ships entering and exiting, must account for tidal conditions to prevent ships from running aground in the shipping channel, which could block other ships. Currently, the depth of the waters is experiencing siltation, with sediment levels sourced from residential waste and waste from ships and port activities, causing the water depth to range from approximately 2 to 3 mLWS.

Safety and regularity were not assessed because the shipping channel entering the port does not ensure safe movement for fishermen's ships. Additionally, there is no designated berthing area for ships that have landed fish outside the port pool. Since water access is limited to a single lane, many ships are left waiting along the channel as they enter the port pool.

The most concerning issue is pollution, as indicated by the high levels of sediment and the foul smell around the port due to garbage along the water's edge. This significantly reduces the quality of port waters, and the results of laboratory analyses, which included water and ship preservative samples, indicating a significant relationship between pollution and water quality. Fig. (6) exhibits an analysis diagram of IPA.

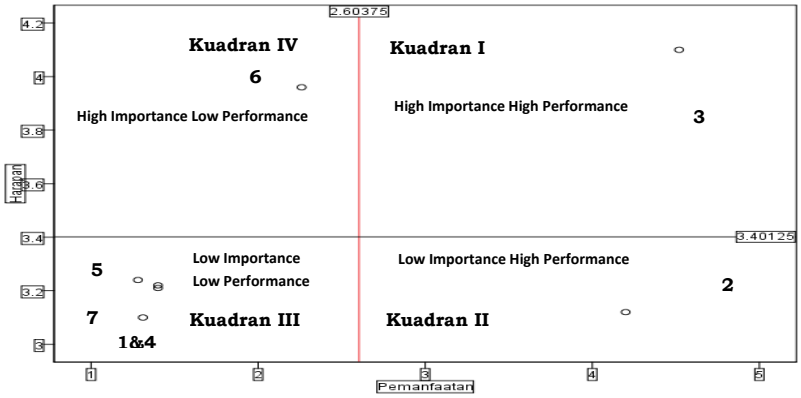

Fig. 6. Science analysis using Cartesian diagram **(Subardi, 2023)**

DISCUSSION

High accessibility is placed in Quadrant III (Low Importance, Low Performance), as the transportation service network has not been adequately developed. Survey data shows that the sea transportation route for ships, from the shipping channel to the port pool, has a depth of only 2 to 3 mLWS and generally experiences siltation **(Lojek *et al.*, 2021)**.

Port Capacity is located in Quadrant II (Low Importance, High Performance). The availability of piers and port channels is quite adequate, with easy access for fishermen, as ships can directly enter the port from the open sea. The ship movement channel is about 96 meters wide, and the port pool is about 200 meters wide. However, some ships are docked along the shipping channel, which interferes with the movement of other ships entering the port.

Affordable rates are located in Quadrant I (High Importance, High Performance). Ship berthing rates are very economical since the port of Pekalongan does not impose berthing fees.

Safety is placed in Quadrant II (Low Importance, High Performance). While the port's safety performance is generally good, there is a concern regarding fishing boats

docked at crowded piers. The lack of mitigation measures or plans for emergencies, such as ship fires or collisions, results in substandard safety conditions.

Ship Orderliness is located in Quadrant III (Low Importance, Low Performance). There is no regulation or regularity to manage service users' activities at the port, leading to disorganization.

Smoothness and Speed are placed in Quadrant IV (High Importance, Low Performance). Port activities cannot be measured by time units, as ships often remain idle at the port, with little to no loading or unloading. Instead, ships spend most of their time undergoing repairs and maintenance in the dock/port pool.

Low Pollution is placed in Quadrant III (Low Importance, Low Performance). Pollution levels are significant, as some ships discharge waste into the water, leading to a noticeable decline in water quality.

CONCLUSION

The water quality conditions at the port of Pekalongan indicate that at stations 1 and 2, the nitrate and phosphate parameters exceeded the quality standards. For the TSS parameters, only station 1 met the quality standards. The ALT parameters at station 2 were recorded at 2.8×10^2, and at station 3, 4×10^2, which are relatively high compared to other stations. This situation resulted in heavy port activities, which compromised water quality, as the service provider did not offer adequate facilities to accommodate and process waste.

Based on the CSI analysis, only the tariff and smoothness indicators met the criteria. Indicators that did not meet the criteria included accessibility, capacity, safety, orderliness, and pollution.

The scientific analysis shows that the tariff index is classified in Quadrant I (High Importance, High Performance), reflecting the importance of maintaining service performance and quality. The safety index is classified in Quadrant II (Low Importance, High Performance), indicating that safety standards are already being met but should be maintained. The accessibility, safety, orderliness, and pollution indices are classified in Quadrant III (Low Importance, Low Performance), suggesting that these areas have low priority but require improvement. Finally, the smoothness and speed index is classified in Quadrant IV (High Importance, Low Performance), indicating that these factors are critical for performance but need significant improvement to maintain service quality.

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