



ENVIRONMENTAL MANAGEMENT OF PELANTAR FISHERIES PORT, TANJUNGPINANG, INDONESIA

PENGELOLAAN LINGKUNGAN PELABUHAN PERIKANAN PELANTAR, TANJUNGPINANG, INDONESIA

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(Received March 5, 2026; Revised August 3, 2026; Accepted October 10, 2026)

ABSTRACT

Pelantar Tanjungpinang Fisheries Port is the only fish landing site in Tanjungpinang City. It supports small-scale capture fisheries, but its multifunctional use for fisheries, cargo, and passenger activities has increased sanitation and water-quality pressures. This study aims to evaluate environmental management performance and formulate priority strategies for eco-fishing port development. Fieldwork was conducted in April 2025 using observations, laboratory water-quality analysis from three purposively selected sampling stations, questionnaires, and stakeholder interviews. We assessed environmental and operational performance using a 1–5 scoring system; calculated sub-index mean scores; measured gaps against ideal eco-fishing port criteria; and determined priority strategies using the Analytic Hierarchy Process (AHP). The environmental sub-index was 2.38, and the operational sub-index was 2.50, producing an overall index of 2.44 out of 5.00 and placing the port in the low category. The most critical issue was biological contamination, with total coliform reaching 2,400 MPN/100 mL, exceeding the 1,000 MPN/100 mL threshold for port waters. The largest gaps occurred in water-quality monitoring and wastewater treatment, environmental documentation, environmental monitoring and enforcement, and hygienic fish handling. AHP prioritized water-quality management (17.2%), environmental documentation and management systems (15.4%), and monitoring and enforcement (11.4%). Environmental rehabilitation through wastewater treatment, sanitation improvement, routine monitoring, and institutional strengthening should precede physical expansion to support Pelantar's transition toward an eco-fishing port.

Keywords: eco-fishing port, environmental management, fisheries port, sustainability

ABSTRAK

Pelabuhan Perikanan Pelantar Tanjungpinang merupakan satu-satunya tempat pendaratan ikan di Kota Tanjungpinang. Pelabuhan perikanan tersebut mendukung perikanan tangkap skala kecil, tetapi pemanfaatannya yang multifungsi untuk kegiatan perikanan, barang, dan penumpang meningkatkan tekanan terhadap sanitasi serta kualitas air. Penelitian ini bertujuan untuk mengevaluasi kinerja pengelolaan lingkungan dan merumuskan strategi prioritas pengembangan pelabuhan perikanan ramah lingkungan. Pengambilan data dilakukan pada April 2025 melalui observasi, analisis laboratorium kualitas air dari tiga stasiun contoh yang dipilih secara purposif, kuesioner, dan wawancara dengan pemangku kepentingan. Kinerja lingkungan dan operasional dinilai menggunakan sistem skoring 1–5; subindeks dihitung sebagai nilai rata-rata; kesenjangan dianalisis terhadap kriteria ideal pelabuhan perikanan ramah lingkungan; dan strategi prioritas ditentukan menggunakan *Analytic Hierarchy Process* (AHP). Subindeks lingkungan sebesar 2,38 dan subindeks operasional sebesar 2,50 menghasilkan indeks keseluruhan 2,44 dari nilai ideal 5,00 sehingga termasuk kategori rendah. Isu paling kritis adalah kontaminasi biologis dengan total coliform 2.400 MPN/100 mL, melebihi ambang 1.000 MPN/100 mL untuk perairan pelabuhan. Kesenjangan terbesar terdapat pada pemantauan kualitas air dan pengolahan air limbah, dokumentasi lingkungan, pemantauan dan penegakan lingkungan, serta penanganan ikan higienis. Hasil AHP memprioritaskan pengelolaan kualitas air (17,2%), dokumentasi dan sistem manajemen lingkungan (15,4%), serta pemantauan dan penegakan lingkungan (11,4%). Rehabilitasi lingkungan perlu didahulukan sebelum ekspansi fisik untuk mendukung transformasi Pelantar menuju pelabuhan perikanan ramah lingkungan.

Kata kunci: keberlanjutan, pelabuhan perikanan, pelabuhan perikanan ramah lingkungan, pengelolaan lingkungan

INTRODUCTION

The Riau Islands Province is a maritime region dominated by marine waters, where approximately 95% of its total area consists of sea, providing substantial potential for capture fisheries (DKP 2020). Capture fisheries play an important role in regional economic development and coastal livelihoods, particularly in Tanjungpinang City, where fisheries activities serve as a primary source of income for small-scale fishers (Malik and Saribulan 2018). The effectiveness of capture fisheries activities is strongly influenced by fisheries ports, which function as centers for fish landing, distribution, and support services (Lubis 2012).

Pelantar Tanjungpinang Fisheries Port is the only fish landing site in Tanjungpinang City and serves as a vital hub for local fisheries activities. The port is managed by a fishers' cooperative and has not been officially classified as a national fisheries port. In addition to fisheries activities, it is used for cargo handling and inter-island passenger transportation. This multifunctional utilization creates overlapping activities, limited working space, and inadequate port management, reducing operational efficiency and service quality for fishers (Kurniawan *et al.* 2017; Fatoni *et al.* 2021).

Multifunctional port utilization also contributes to environmental problems related to waste management, sanitation, and water quality. Waste from fisheries and non-fisheries activities can degrade environmental quality and negatively affect the hygiene and value of landed fish products (Purbani and Aisyah 2019; Hamzah and Rahmawati 2021). Environmental conditions at fisheries ports are therefore critical not only for maintaining product quality but also for supporting fishers' welfare and sustainable coastal development.

Sustainable and environmentally sound fisheries port management has become a national development priority. The National Fisheries Port Master Plan emphasizes environmentally based port development (Decree of the Minister of Marine Affairs and Fisheries Number 132 of 2023), while the eco-fishing port concept highlights proper waste management, sanitation, environmental documentation, routine monitoring, and sustainable operations (Muninggar *et al.* 2021; Wahyuni *et al.* 2022). Therefore, this study aims to evaluate the environmental management performance of Pelantar Tanjungpinang Fisheries Port and formulate priority strategies to support sustainable capture fisheries development.

METHODS

This study was conducted at Pelantar Tanjungpinang Fisheries Port, Tanjungpinang Kota Subdistrict, Tanjungpinang City, Riau Islands Province, Indonesia. Field data collection was carried out in April 2025. The study area is characterized by multifunctional fisheries, cargo-handling, and inter-island passenger activities.

The study employed a mixed qualitative and quantitative approach using primary and secondary data. Primary data were obtained through direct field observations, laboratory water-quality analysis, structured questionnaires, and semi-structured interviews. Environmental parameters included pH, dissolved oxygen (DO), turbidity, total coliform, clean-water availability, cleanliness and sanitation, solid and liquid waste, and environmental documentation and monitoring. Operational parameters included vessel service capacity, berthing or turnaround time, loading and unloading efficiency, dock utilization, and fish storage and handling capacity.

Water samples were collected purposively from three stations representing the main activity and pollution-source zones: Station 1 at the fish landing and auction area, Station 2 at the vessel berthing basin, and Station 3 near the drainage outlet and mixed passenger-cargo activity area. Sampling points were selected based on activity intensity, potential waste input, and field accessibility. The values presented in the environmental performance table are composite or mean results used for port-level assessment. Water-quality testing was conducted in an accredited laboratory, while sanitation, waste, facility, and operational data were obtained through observation checklists and stakeholder questionnaires.

Respondents consisted of 35 persons. Eight respondents were purposively selected as key informants and Analytic Hierarchy Process (AHP) experts because of their direct knowledge of port management, fisheries operations, environmental control, and local policy. They represented port or cooperative management, the Marine and Fisheries Office, the environmental agency, sanitation or market-related services, and academics. Twenty-seven port users were selected using accidental sampling during fieldwork, consisting of 20 fishers and 7 fish traders. The sample size was based on stakeholder relevance, respondent availability during field visits, and information saturation for port-level environmental and operational assessment.

Secondary data consisted of vessel visits, fisheries production, fuel, ice, and clean-water supply, port facilities, operational records, and environmental management documents. These data were obtained from Pelantar port or cooperative management, the Marine and Fisheries Office of Tanjungpinang City and Riau Islands Province, the local environmental agency, and related port service units. Source triangulation was used to validate observation and interview findings.

Environmental and operational performance was evaluated using indicators derived from the eco-fishing port concept (Muninggar *et al.* 2021; Wahyuni *et al.* 2022), water-quality standards for port waters (Government Regulation of the Republic of Indonesia Number 22 of 2021), and fisheries port performance studies (Lubis 2012; Fatoni *et al.* 2021). Each indicator was scored from 1 to 5: 1 = very poor or not compliant; 2 = poor or mostly not compliant; 3 = moderate or partly compliant; 4 = good or compliant with minor limitations; and 5 = very good or fully compliant. Quantitative water-quality parameters were scored against applicable standards, whereas facility, governance, and operational indicators were scored by triangulating observations, questionnaires, interviews, and documents.

The environmental sub-index (E), operational sub-index (O), and overall eco-fishing port index (EFI) were calculated as equally weighted arithmetic means, following the linear additive aggregation approach for composite indicators (OECD-JRC 2008): $E = \sum Se_i / n_e$; $O = \sum So_i / n_o$; and $EFI = (E + O) / 2$, where Se_i and So_i are the environmental and operational indicator scores, and n_e and n_o are the respective numbers of indicators. Index categories were 1.00–1.80 = very low, >1.80–2.60 = low, >2.60–3.40 = moderate, >3.40–4.20 = high, and >4.20–5.00 = very high. These categories were determined using equal class intervals, calculated as the score range divided by the number of classes [(5.00–1.00)/5 = 0.80] (Pimentel 2010).

Gap analysis compared existing scores with ideal eco-fishing port conditions. Existing indicator scores were obtained by averaging stakeholder questionnaire scores and validating them with field observations and interviews. The gap was calculated as $Gap_i = S_{existin} g_i - S_{ideal} g_i$, where the ideal score was 5, representing full compliance (Muchsam *et al.* 2011; Muninggar *et al.* 2021; Wahyuni *et al.* 2022). Negative values indicated deficiencies requiring improvement.

Priority strategies were determined using AHP (Saaty 1980). The hierarchy

consisted of the research objective, criteria, sub-criteria, and alternative strategies. Pairwise comparisons were completed by the eight key informants using Saaty's nine-point scale. Individual judgments were aggregated using the geometric mean and normalized to obtain priority weights. Consistency ratio (CR) was assessed using $CR = CI/RI$, where $CI = (\lambda_{max} - n)/(n - 1)$. A CR below 0.10 was considered acceptable (Saaty 1980; Munthafa and Mubarak 2017; Saidah *et al.* 2024).

RESULTS AND DISCUSSION

Environmental performance of Pelantar Fisheries Port

The environmental performance assessment covered water quality, sanitation, clean-water availability, waste management, and environmental governance. Table 1 presents observed conditions, reference standards, scores, and interpretations.

The pH value (6.78) and turbidity (4.49 NTU) remained within the port-water standards. Dissolved oxygen reached 5.94 mg/L, exceeding the minimum standard of 5.0 mg/L and indicating good oxygen conditions for port waters; therefore, it was scored 4. The most critical issue was total coliform at 2,400 MPN/100 mL, exceeding the 1,000 MPN/100 mL threshold for port waters. Thus, microbiological pollution was more urgent than the measured physicochemical constraints.

Field observations indicated that the high coliform level was likely associated with domestic wastewater entering drainage channels, organic residues from fish handling, inadequate washing-water management, limited sanitation facilities, and the absence of wastewater treatment before discharge. Similar fisheries-port studies report that fish landing, domestic waste, vessel activities, and poor sanitation increase pollution pressure and affect hygiene conditions (Purbani and Aisyah 2019; Hamzah and Rahmawati 2021). Immediate interventions should therefore focus on wastewater treatment, drainage improvement, routine cleaning, and hygienic fish handling.

Operational performance of the port

Operational performance remained below ideal conditions, particularly for turnaround time, loading and unloading flow, and facility capacity (Table 2). The number of vessels served was 20–25 vessels

per day compared with an ideal capacity of 30–35 vessels. Using average values, capacity utilization was approximately 69.2% (22.5/32.5 vessels). Congestion nevertheless occurred because fisheries, cargo, passenger, and trading activities shared a narrow working space.

Average vessel turnaround time reached 2–3 hours per vessel compared with an ideal of no more than 1 hour. The turnaround-time ratio was approximately 2.5, meaning that service took 2.5 times longer than the ideal. Manual handling, narrow dock space, overlapping activities, and limited storage increased queuing and fish-quality risks (Gumilang *et al.* 2017; Fatoni *et al.* 2021; Sitanggang *et al.* 2025).

Eco-fishing port index

The environmental and operational scores were integrated into the eco-fishing port index. Table 3 reports the category ranges,

while Figure 1 compares actual values with the ideal score using a bar chart that clearly displays the magnitude of each gap.

The environmental sub-index was 2.38, and the operational sub-index was 2.50; both were classified as low. The overall index was 2.44 out of the ideal 5.00. The low environmental value was driven by biological contamination, sanitation constraints, limited clean-water support, and weak documentation and monitoring. The low operational value reflected prolonged turnaround time, manual handling, and insufficient storage support.

Comparable eco-fishing port assessments show that low scores commonly reflect weak environmental infrastructure, insufficient monitoring, and limited institutional capacity (Muninggar *et al.* 2021; Wahyuni *et al.* 2022). Pelantar therefore requires simultaneous improvement in environmental governance and operational efficiency.

Table 1. Environmental performance parameters, observed values, reference standards, scores, and interpretation at Pelantar Tanjungpinang Fisheries Port in 2025.

Parameter	Observed Value	Reference Standard/Ideal Condition	Reference Basis	Score*	Interpretation
pH	6.78	6.5–8.5	Government Regulation No. 22/2021	4	Within acceptable range for port waters
Dissolved oxygen (mg L ⁻¹)	5.94	>5.0	Government Regulation No. 22/2021	4	Good condition
Turbidity (NTU)	4.49	≤5.0	Government Regulation No. 22/2021	4	Acceptable condition
Total coliform (MPN 100 mL ⁻¹)	2,400	≤1,000	Government Regulation No. 22/2021	1	Exceeds standard; biological contamination is critical
Clean-water availability	Limited supply; inadequate sanitation points	Adequate water for operation and sanitation	Lubis 2012; PER.08/MEN/2012	2	Insufficient basic facility support
Cleanliness and sanitation	Waste accumulation and poor drainage	Clean working area and proper sanitation	Muninggar <i>et al.</i> (2021); Wahyuni <i>et al.</i> (2022)	1	Poor sanitation condition
Solid and liquid waste pollution	Domestic, fish-handling, and vessel waste observed	No uncontrolled waste discharge	Government Regulation No. 22/2021; Muninggar <i>et al.</i> (2021)	1	Major pollution source in port waters
Environmental documentation and monitoring	Incomplete documents and irregular monitoring	Updated documents and routine monitoring	Government Regulation No. 22/2021; Wahyuni <i>et al.</i> (2022)	2	Environmental governance remains limited

Source: Field observation, laboratory analysis, and stakeholder survey (2025).

*Score range: 1 = very poor/not compliant, 2 = poor, 3 = moderate, 4 = good/compliant with minor limitations, and 5 = very good/fully compliant. Environmental sub-index = mean of eight scores (19/8) = 2.38.

Table 2. Operational performance indicators, ideal standards, quantitative efficiency metrics, scores, and interpretation at Pelantar Tanjungpinang Fisheries Port in 2025.

Operational Indicator	Existing Condition	Ideal Standard**	Efficiency Metric	Score*	Interpretation
Vessels served per day	20–25 vessels	30–35 vessels	Capacity utilization = $22.5/32.5 = 69.2\%$	3	Below ideal volume, but peak congestion occurs due to limited spatial arrangement
Vessel berthing/turnaround time	2–3 h vessel ⁻¹	≤1 h vessel ⁻¹	Turnaround time ratio = 2.5	2	Service time is 2.5 times the ideal
Loading and unloading efficiency	Slow; frequent queuing	Fast and orderly	Observation and stakeholder score	2	Low efficiency caused by manual handling and overlapping activities
Dock and fish-storage capacity	Functional but narrow; limited storage	Adequate dock and cold-chain support	Facility condition score	3	Functional but insufficient during peak periods

Source: Field observation and stakeholder survey (2025).

*Score range: 1 = very poor to 5 = very good. Operational sub-index = mean of four scores = 2.50.

**Ideal standards were adapted from Lubis (2012), Regulation of the Minister of Marine Affairs and Fisheries Number PER.08/MEN/2012, Fatoni *et al.* (2021), and Sitanggang *et al.* (2025).

Table 3. Environmental, operational, and overall eco-fishing port index values and categories in 2025.

Assessment Dimension	Sub-index Value	Category Range	Category	Key determining factors
Environmental sub-index	2.38	>1.80-2.60	Low	High coliform, limited clean water, poor sanitation, waste accumulation, and irregular monitoring
Operational sub-index	2.50	>1.80-2.60	Low	Prolonged turnaround time, manual handling, limited dock and storage capacity
Overall eco-fishing port index	2.44 of 5.00	>1.80-2.60	Low	Comprehensive environmental and operational improvement is required

Source: Primary data analysis (2025).

Classification: 1.00-1.80 = very low; >1.80-2.60 = low; >2.60-3.40 = moderate; >3.40-4.20 = high; >4.20-5.00 = very high (equal class interval = $(5.00 - 1.00)/5 = 0.80$; see Methods).

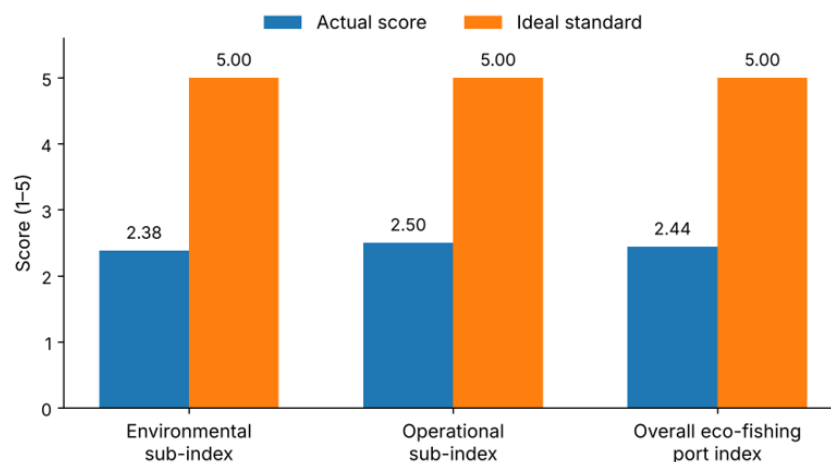


Figure 1. Comparison of actual environmental, operational, and overall eco-fishing port index values with the ideal eco-fishing port standard in 2025.

Gap analysis of facilities and governance

Gap analysis was used to explain why performance remained low and identify components most distant from ideal conditions. Three causes were identified. Institutional gaps arise because the port is managed by a cooperative and is not fully integrated into a formal fisheries-port management system. Financial gaps limit investment in wastewater treatment, sanitation points, drainage, and cold-chain facilities. Governance gaps are reflected in incomplete environmental documents, irregular water-quality monitoring, limited enforcement, and the absence of clear SOPs for waste, drainage, and hygienic fish handling.

The largest gaps (-3.00; Table 4) occurred in water-quality monitoring and wastewater treatment, environmental documentation, environmental monitoring and enforcement, and fish-handling quality. This pattern shows that governance and sanitation infrastructure should be strengthened before physical capacity

is expanded.

Priority strategies for environmental management

Pairwise comparison judgments from the eight expert respondents were aggregated using the geometric mean and normalized to produce strategy weights. The consistency ratio was 0.09, below the 0.10 threshold, indicating acceptable judgment consistency. Table 5 presents the six highest-ranked strategies; the remaining alternatives each had weights below 5%, and all alternative weights summed to 100%.

Water-quality management was the highest priority (17.2%), followed by environmental documentation and management systems (15.4%) and environmental monitoring and enforcement (11.4%). These priorities indicate that sanitation infrastructure and governance are prerequisites for operational and economic improvement.

Table 4. Gap analysis of environmental facilities, operational capacity, and governance indicators at Pelantar Tanjungpinang Fisheries Port in 2025.

No.	Indicator	Existing Score*	Ideal Standard/Reference	Gap Value	Priority Improvement Direction
1	Waste management and cleanliness	3.25	5; clean port, sufficient bins, scheduled 3R handling	-1.75	Strengthen collection, provide 3R facilities, and implement daily cleaning
2	Clean water supply	3.55	5; sufficient water for landing, washing, ice handling, and sanitation	-1.45	Increase storage, distribution points, and alternative water sources
3	Vessel service capacity	3.65	5; efficient vessel flow and adequate berthing arrangement	-1.35	Normalize dock use, improve scheduling, and separate activity zones
4	Water-quality monitoring and WWTP	2.00	5; routine monitoring and treatment before discharge	-3.00	Monitor at least twice annually and construct wastewater treatment
5	Environmental documentation	2.00	5; updated documents and regular audit	-3.00	Prepare, update, and audit environmental documents
6	Environmental monitoring and enforcement	2.00	5; integrated team, SOPs, and enforcement	-3.00	Establish a team with SOPs, sanctions, and reporting
7	Fish-handling quality	2.00	5; hygienic handling, clean water and floor, cold-chain support	-3.00	Improve facilities and conduct routine quality assessment
8	Loading and unloading efficiency	3.00	5; fast, orderly, and safe landing process	-2.00	Optimize flow, increase equipment, and provide cold storage

Source: Primary data analysis (2025).

*Existing scores were obtained by averaging stakeholder questionnaire scores and validating them through interviews and field observations. Ideal score = 5 (full compliance). Gap = existing score - ideal score.

Table 5. Highest-ranked AHP priority strategies for environmental management at Pelantar Tanjungpinang Fisheries Port.

Rank	Strategy	Weight (%)	Priority level
1	Water-quality management improvement	17.2	Very high
2	Environmental documentation and management systems	15.4	High
3	Environmental monitoring and enforcement	11.4	High
4	Wastewater treatment facility development	9.2	Moderate
5	Clean-water and sanitation infrastructure	6.7	Moderate
6	Cold storage and fish-handling facilities	5.4	Supporting

The quantitative metrics reinforce this conclusion. Although service-capacity utilization was 69.2%, the turnaround-time ratio reached 2.5. Increasing vessel volume without improving sanitation, spatial flow, and handling facilities could intensify waste generation, congestion, and fish-quality deterioration.

Implications for sustainable port management

Biological contamination is the main sustainability constraint. Untreated domestic wastewater, drainage discharge, organic fish residues, washing water, and limited sanitation enter the port environment. These conditions reduce the hygienic quality of landed fish, increase risks for fishers, traders, and consumers, and weaken competitiveness by reducing product value and buyer confidence.

Short-term actions should include segregated waste bins, daily cleaning schedules, drainage maintenance, clean-water points near fish-handling areas, separation of fisheries from passenger and cargo activities, and SOPs for handling, floor washing, and waste disposal. Medium-term actions should include wastewater treatment, grease traps or sedimentation units, cold storage or insulated boxes, and routine monitoring at the same three stations.

Institutional strengthening should clarify the roles of cooperative management, the Marine and Fisheries Office, environmental and sanitation agencies, fishers, and traders. An integrated management team should prepare documents, monitor water quality, supervise cleaning, enforce SOPs, and publish periodic progress reports. Community participation can be implemented through training, waste-segregation incentives, problem-reporting channels, and participatory cleanliness monitoring. These actions translate the blue-economy principles of ecological sustainability, competitiveness, and inclusive coastal

development into immediately applicable port management (Ujjianti *et al.* 2024).

CONCLUSION

Pelantar Tanjungpinang Fisheries Port had an overall eco-fishing port index of 2.44 out of the ideal 5.00, with an environmental sub-index of 2.38 and operational sub-index of 2.50; all were in the low category. Total coliform reached 2,400 MPN/100 mL, exceeding the 1,000 MPN/100 mL port-water threshold and reflecting inadequate sanitation, untreated wastewater, poor drainage, and non-hygienic fish handling. The largest gaps concerned water-quality monitoring and wastewater treatment, environmental documentation, monitoring and enforcement, and fish-handling quality. AHP prioritized water-quality management (17.2%), environmental documentation and management systems (15.4%), and monitoring and enforcement (11.4%). Local government and port managers should therefore allocate budgets for wastewater treatment, routine monitoring, environmental document completion, sanitation SOPs, and institutional coordination before expanding capacity. The scoring-gap-AHP framework is scalable to other small and multifunctional fisheries ports that face similar sanitation, institutional, and infrastructure constraints, although indicator thresholds should be adjusted to local regulations and port characteristics.

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