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Research Paper

The Economic and Safety Improvement Feasibility of Urban Ocean Fishing Port Modernization – Study Case of Nizam Zachman

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Abstract

The Nizam Zachman Jakarta Ocean Fishing Port (PPSNZJ), the largest fishing port in Indonesia, is currently experiencing overcapacity. This results in ships being moored in rows parallel to berths, indicating the insufficient number of berths in the port. This configuration poses a safety hazard due to the proximity of the moored ships, making it challenging to evacuate them in the event of a fire or other natural disasters. This study was conducted to propose an alternative concept for facility development in urban ocean fishing ports, with PPSNZJ as a study case. The study included a site visit to understand the actual berthing configuration of ships, data collection from the port technical execution unit, and observation of existing fish cargo handling operations. The collected data was analyzed to determine berth capacity and storage productivity, which was used to calculate the number of additional berths required to accommodate loading, unloading, and mooring ships. Based on the design calculations, an alternative development layout is proposed, which fulfils the berth capacity and safety requirements. This study also revealed that the development cost is relatively competitive compared to similar projects.

Keywords: *berth structure; fishing port; masterplan; port planning; port productivity; port safety.*

Introduction

An ocean fishing port is a vital infrastructure for the fishing industry, facilitating the landing, storage, and distribution of fishery products. It serves as a gateway for fishermen to bring their catch to the market [, enabling]the industry to contribute to the economy and provide employment opportunities for many people. Additionally, an ocean fishing port is significant in ensuring food security for a country, as it provides a consistent supply of fresh seafood for consumption. Apart from its economic importance, an ocean fishing port plays a crucial role in regulating the fishing industry, enforcing fishing laws and regulations, and promoting sustainable fishing practices. While there are alternative protein sources, it is also known that the demand for fish is growing significantly, with the annual per capita of fish consumption having doubled since the 1960s [2]. Therefore, the presence of a functional and efficient ocean fishing port is crucial for the growth and development of the fishing industry and the overall well-being of the community.

In recent years, many countries have responded to the need to improve ocean fishing ports by upgrading existing ports. The Port of Killybegs in Ireland, which was completed in 2004, was developed with € 50 million in funding to upgrade the port facilities [3]. The Port of San Diego, California, received a grant of $ 24 million from the US Department of Transportation to upgrade its Tenth Avenue Marine Terminal starting in 2017 [4]. The upgrade included the construction of a new refrigerated cargo terminal, a modernized truck gate, and new on-dock rail infrastructure [5].

The development of existing ocean fishing ports is as challenging as constructing new ones. Upgrading an existing port can be complicated and time-consuming, particularly when the port needs significant improvements to meet current standards. One of the primary challenges of developing an existing ocean fishing port is maintaining the port's operation while making the necessary upgrades. This can be particularly difficult when the port’s operation is essential to the local economy and any disruption can cause significant economic losses.

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Environmental considerations are also important when developing existing ports, as they must adhere to local and international regulations for safe and sustainable operations. Another challenge is keeping up with changing technology and fishing practices, as existing ports may need to adapt to new methods and equipment to remain competitive. Despite these challenges, the development of existing ocean fishing ports is necessary to ensure their continued relevance and to support the growth and sustainability of the fishing industry.

However, fishing port development can be even more challenging when the port is located in an urban area. Firstly, areas available for expansion are typically very limited, especially in situations where the fishing ports are outdeveloped by other facilities and infrastructure in the city [6]. Secondly, unlike other specialized ports such as container and oil terminals, fishing ports have relatively low profitability. Therefore, the development of fishing ports often relies on government subsidies, which ultimately means there is a limited development budget.

One of the ports that face the above challenges is the Nizam Zachman Jakarta Ocean Fishing Port (PPS Nizam Zachman Jakarta or PPSNZJ), which is the largest fishing port in Indonesia [7]. Situated on the northern coast of the capital, PPSNZJ was built in 1980, but landward expansion is limited since the city is fully occupied. On the other hand, there is a need to improve the port since PPSNZJ is currently facing both natural and technical challenges. One of the natural problems of PPSNZJ is land subsidence, which makes the PPSNZJ area often inundated by coastal flooding, so improvement of the berth facilities is needed. However, a more prominent technical problem in PPSNZJ is the insufficient amount of berth places. The current harbor area of PPSNZJ is 400,000 m^2 with a total berth length of 2,852 m. With the current capacity, the PPSNZJ can only facilitate up to 494 ships in a parallel berth configuration [8]. The number of berthing ships recorded in July 2018 was 756, which indicates that the port is currently overcapacity. This forces the fishermen to moor their ships parallel to one another, creating an unideal berthing configuration. The latest observation of PPSNZJ in July 2020 documented the crowded harbor as shown in Figure 1.

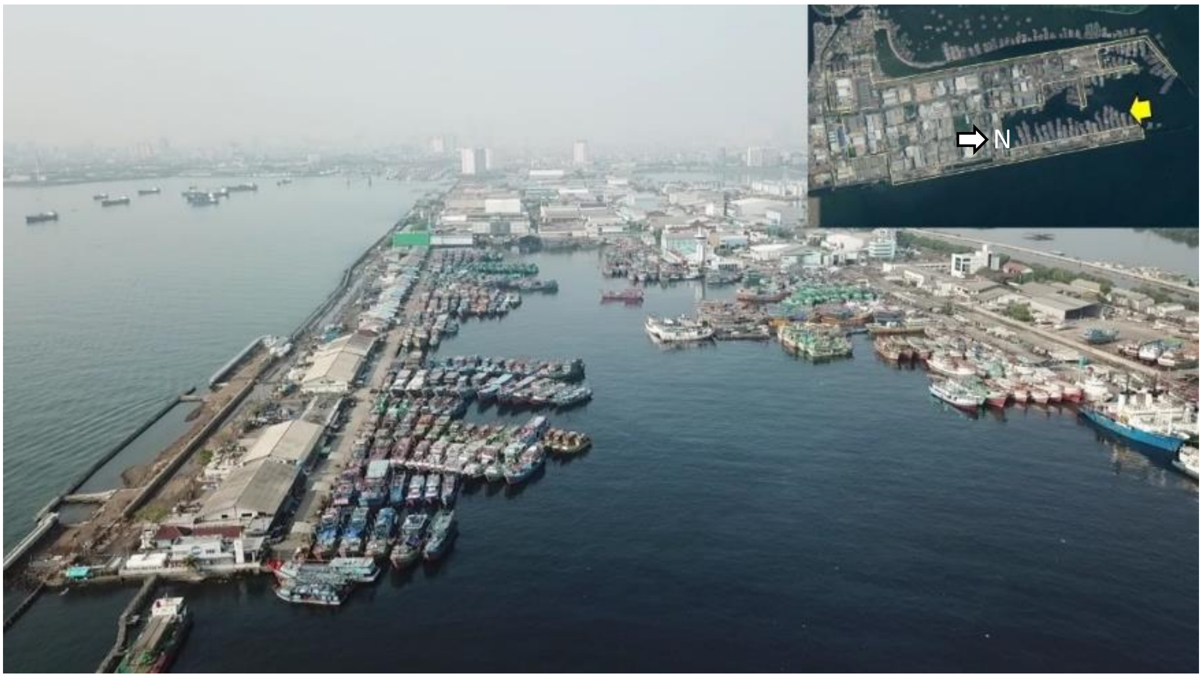

Figure 1 Overview of Nizam Zachman Fishing port. The yellow arrow in the inset indicates the viewing perspective.

The overcapacity of the berth facilities has led to the berth facilities having multiple unorganized rows of moored ships. This arrangement makes the cargo handling inefficient, where fishermen have to go over several ships before they can unload their cargo on land. With ship production expected to increase in the coming years, there is a need to solve this situation. However, a more significant impact is in the aspect of safety. In February 2019, a ship moored in the port caught fire, which quickly spread to adjacent ships. Since the ships were moored in multiple rows, it was difficult to evacuate the adjacent ships to safety, which resulted in a total of 34 ships being

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burnt [9]. When the ships have proper mooring space, it is not difficult for them to be evacuated in emergency situations.

Because of the existence of multiple concerns and risks, there is a need to immediately improve the PPSNZJ to ensure port operational safety and its compliance with modern standards. The aim of this study was to explore the feasibility of urban ocean fishing port development that solves the mentioned concerns with a reasonable cost of development. PPSNZJ was chosen as the case study since it is the largest fishing port in Indonesia and has the potential to be expanded in the future. The study was arranged as follows: (1) assessment of the existing port conditions in terms of ships, fish production, and physical conditions; (2) analysis of the type and amount of required facilities to meet the current number of ships and cargo; (3) proposition of a development concept that is based on the conducted analysis; and (4) estimation of the capital cost.

Methodology and Design Calculation

General Methodology

The general workflow of this study is presented in Figure 2. The first part consisted of collecting the required data to create a new port development concept. The main data required were the number of yearly incoming and outgoing ships, fish production, and existing layout. In addition, the existing physical conditions of the port were observed to better understand the current needs and design limitations. After the required data had been obtained, the number of required berths was established and their typical layout was designed. With the proposed design, it is expected that the ships can be operated safely within the harbor and cargo can be handled more efficiently. To make the planning more comprehensive, the cargo handling productivity was also taken into consideration. After the concept had been analyzed, the new development concept was drawn, comprising short-term as well as medium-term development. Finally, the estimated cost for the development was calculated.

The main data source for this study was the Indonesia General Directorate of Capture Fisheries [1]. The data is limited to 2019, which is the most up-to-date data available. However, the results of this study should also be relevant for future years, providing a general perspective on the economic feasibility of the development of urban ocean fishing ports.

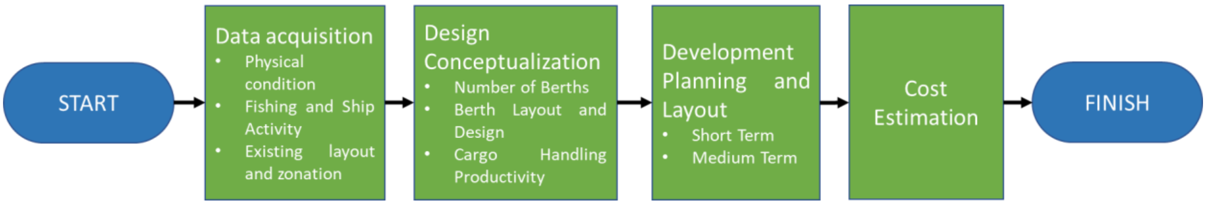

Figure 2 General research flowchart.

Port Existing Condition

Physical Condition

Figure 3 shows a perspective view of the northern part of the PPSNZJ berths. As can be observed, the elevation of each berth is different, with the elevation tending to be higher in the northern part of the port. These differences were initially designed so that higher berths could accommodate larger ships and lower berths could serve smaller ships. However, an unintended consequence of these differences in berth elevation is that some areas are inundated when the tide level is high due to land subsidence. Figure 4 demonstrates this phenomenon clearly, where part of the road in the +6.00 m berth is inundated while the +7.00 m, shown as the farther part of the road in the figure, remains dry. The depth of the port ranges from -0.5 m to -8.4 m [10], assuming that the berth structure elevation refers to a depth of -4 m.

Figure 3 Elevations of existing berths. The yellow arrow in the inset indicates the viewing perspective.

Figure 4 Inundation on the western part of the berth. The yellow arrow in the inset indicates the viewing perspective.

As discussed in the Introduction section, the development of PPSNZJ is limited landwards. However, it is also limited westwards and eastwards. On the west side, National Capital Integrated Coastal Development (NCICD) piles have been erected as shown in the lower right of Figure 3. Similarly, it is not feasible to develop eastwards since this would affect the operation of ships heading to the nearby larger port, namely Sunda Kelapa Port, and by extension the Tanjung Priok Port, which is the largest port in Indonesia. Based on this physical assessment of PPSNZJ, it is clear that the proposed development plan should have a high berth elevation. It can also be concluded that the only feasible way to develop PPSNZJ is by developing seawards to the north. The development to the north also complies with the Fishing Port Operational Working Area limit issued by the national government, where the effective working area is only up to 300 m to the north from the tip of the existing breakwater.

Fishing and Ship Activity

The number of incoming and outgoing ships in the PPSNZJ area is shown in Figure 5. Based on this data, it can be estimated that there are 9.37 of incoming ships and 10.69 outgoing ships on a daily basis. The number of incoming and outgoing ships has generally decreased since 2015. Nonetheless, production levels have reached their highest point in 2018, as shown in Figure 6. The average fish production between 2014 and 2018 amounted to 106,495.618 tonnes, with an average production per ship of 31.56 tonnes. The current berth zonation of PPSNZJ is displayed in Figure 7, with ships moored in up to 11 rows in a parallel configuration, rendering it difficult for ships to disembark from their mooring positions.

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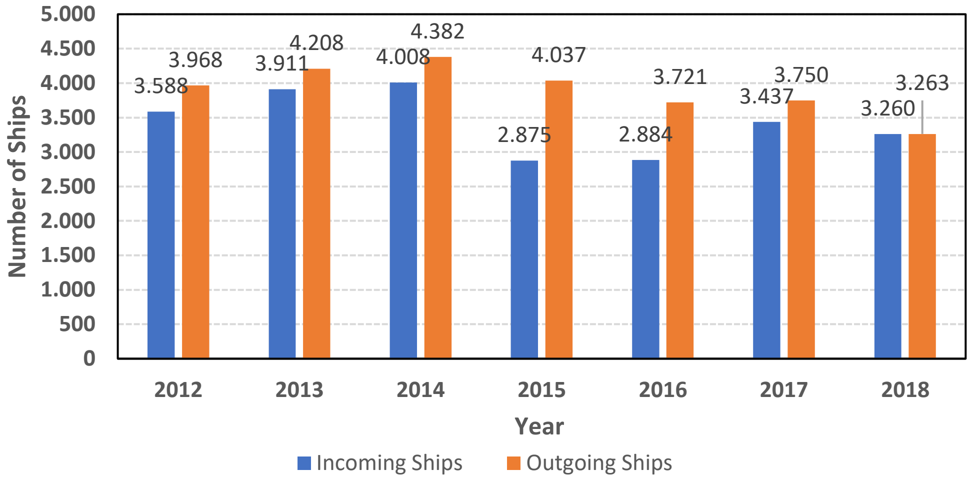

Figure 5 Number of incoming and outgoing ships in 2012-2018 [8].

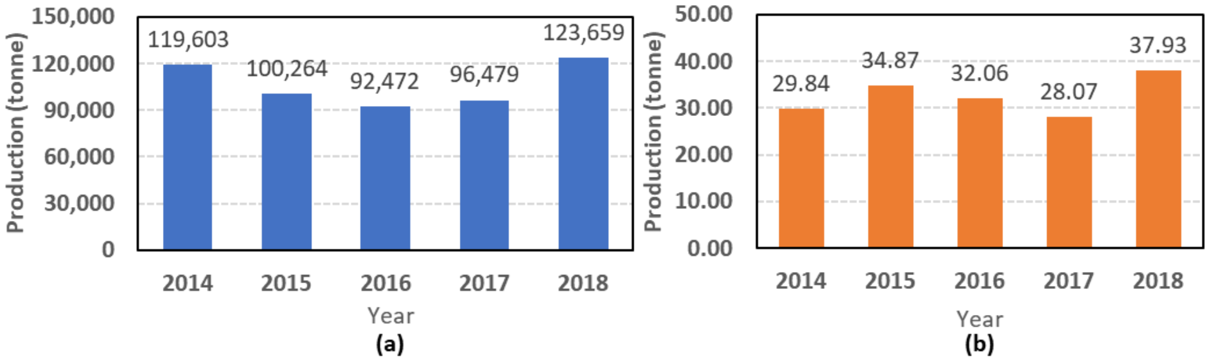

Figure 6 Fish production data of Nizam Zachman Port for 2014-2018: (a) total fish production (b) fish production per ship [8].

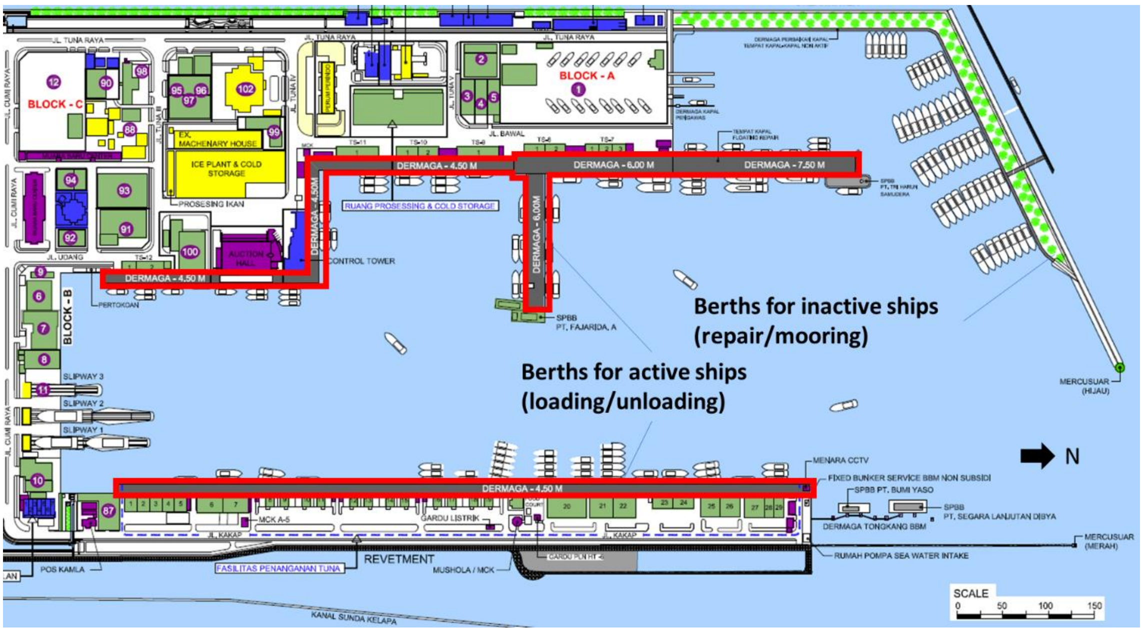

Figure 7 Existing berth zonation in PPSNZJ [1].

The current cargo handling method is relatively traditional with the operation conducted as follows: (1) the fish are unloaded from the ship to a carrying truck; (2) after the truck reaches its full capacity, the fish are carried to a designated cold storage or fish auction; (3) the fish are transported from cold storage to the fish market hours before the fish auction to be sold in the evening. Ships on the second row and beyond are only moored and do not have any unloading activity. This means that the unloading activity is only limited to ships that are right on the side of the berth.

Design Conceptualization

Number of Berths

Based on the previous section, it is clear that more berths are required for ship unloading. The required number of ship berths can be calculated by the following Eqs. (1) to (3):

$$B_L = d_L \; x \; n_L \tag{1}$$

$$B_U = d_U \; x \; n_U \tag{2}$$

$$B_M = d_M \; x \; n_M \tag{3}$$

where B_L, B_U, and B_M are the number of required berths for loading, unloading, and mooring respectively, d is the duration, and *n* is the number of ships. Rounding up the data from the previous section, the number of required berths is 10 for incoming and 11 for outgoing ships. A previous study by Ramli & Ernaningsih [11] suggested a similar number with both incoming and outgoing ships requiring 10 berths. In this study, it was directly observed that the berth time for ship loading is approximately 0.5 days, while ship unloading takes approximately 6 days. Therefore, the total requirement for loading and unloading is 66 berths. Moored ships, however, can stay in the port for up to 30 days. Assuming that the number of daily moored ships is equal to the number of incoming ships, berths for mooring should accommodate 330 ships.

Improvements to the existing berths are required to accommodate the required berths calculated in the previous subchapter. Further, additional berths may be required to be built in the north of the port, which is the only available expansion area. The ship data acquired from PPSNZJ is shown in Table 1.

Table 1 Incoming and outgoing ship specifications [8]/

GT (ton)	Overall Length (m)	Ship Width (m)	Ship Draft (m)
21-30	19.8	5.31	1.78
31-50	21.39	5.62	1.83
51-100	25.54	6.29	1.99
101-200	32.61	7.73	2.66
>200	38.79	8.63	3.33

Berth Layout and Design

A new berth layout for the development was then determined based on the known ship dimensions and the number of required berths. The berth layout criteria are given to ensure the safety of the berthing activity to avoid collisions and provide adequate space for ship movement. In general, the two most common configurations of berth layout for loading and unloading in a fishing port are parallel and finger piers. According to Thoresen [12], the clearance between ships for parallel configurations should be at least 10% of the ship's length. The distance between the ship and the parallel end of the berth should be at least 15% of the ship's length. To simplify the calculation of the berth length requirement, it was assumed that one ship should at least have a clearance of 15% from its total length, which also complies with Velsink [13]. The definition sketch is shown in Figure 8.

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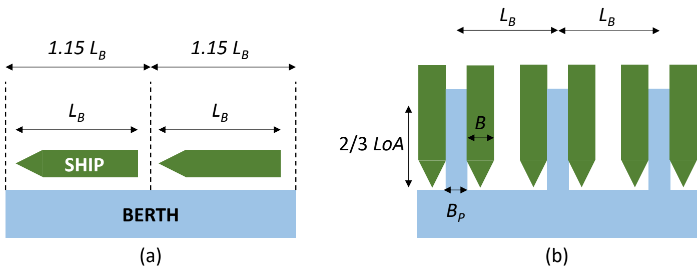

Figure 8 Definition sketch for (a) parallel and (b) finger pier berths [5].

For the finger pier configuration, the general formulas are as follows [13]:

$$L_B = 2{,}5 \times B + B_p \quad (4)$$

$$L_{pier} = {}^{2}/_{3} \times LoA \quad (5)$$

where L_B is the clearance between piers, L_{pier} is the length of the pier, B is the width of a ship, B_p is the width of the pier, and LoA is the overall length of a ship. According to Velsink [13], the required apron width for loading and unloading berths is between 1.5 to 4 m, where 3 m for each side of a finger pier was chosen as the standard.

Based on the data in Table 1, it can be calculated that the berth requirement for one ship for a parallel berth is 37.50 m. The existing berth length is 1,249.5 m, which means it can only accommodate up to 33 large ships. The finger pier configuration can accommodate two ships every 25.33 m. To maximize the berth area, a finger pier configuration was chosen. As for the mooring berths, ships can be moored perpendicular to the berth faceline. The required space for perpendicular berthing is 1.3 of the ship's width [13]. Based on a 101-200 tonne ship, the required space for each ship on the mooring berth is 10.05 m. The length of the existing mooring berth area is 775 m, which can ideally accommodate 77 ships.

Productivity Analysis

Berth Capacity

Productivity was calculated by using the data for unloaded ships per hour as follows:

$$THS = \frac{Cargo\ tonne\ per\ ship}{Unloading\ time} \quad (6)$$

where THS is the unloading productivity in tonne/hour/ship. Based on the data from Figure 6(b), the amount of captured fish from each ship is 31.56 tonnes. The unloading time is 6 days with 24 hours of operational time. Therefore, the unloading productivity of one ship is 0.219 tonnes/hour. The capacity for each berth was calculated as follows:

$$C_{TON} = \frac{N \times THS \times W_H \times W_D}{K} \quad (7)$$

where C_{TON} is the handling capacity in tonnes/year, N is the number of berths, W_H is the productive time per day in hours, W_D is the productive time per year, and K is a correction factor assumed at 1.1. The unloading process is assumed to operate every day except on public holidays and with 24 work hours per day. Therefore, using W_H = 24 hours and W_D = 350 days, we obtain C_{TON} as 110,376 tonnes/year. This exceeds the yearly average production between 2014 to 2018, as shown in Figure 4a, which was 106,495 tonnes/year.

Types and Number of Cargo Handling Equipment

Cargo handling tools consist of forklifts, hand trucks, and conveyors. For determining the type of forklifts and hand trucks, the fish container must be determined. Fish are contained within fish boxes and fish pallets. Each fish box is assumed to contain 56 kg of fish based on the FAO standard [14], while the larger fish pallet can contain 135 to 145 kg. Conveyors, on the other hand, are used only for ship supply loading activities. Cargo handling vehicles consist of refrigerated and pickup trucks. Refrigerated trucks carry the unloaded fish to the cold storage, while pickup trucks transport to the fish auction.

The number of tools used depends on the number of berths. Assuming that there will be one cargo handling tool per berth, the distributed number of forklifts and hand truck is 38 and 22 respectively for unloading berths. Six conveyors are placed at the loading berths. The number of vehicles, however, was calculated based on the distribution of fish to the cold storage and the fish auction as discussed in the next subchapter.

Storage Distribution Productivity

Factors included in the captured fish productivity calculation for cold storage are: (1) fish auction capacity; (2) distribution to cold storage; (3) cold storage capacity requirements; and (4) cold storage area requirement per tonne. In this study, the cold storage capacity and requirements were not calculated but were considered sufficient. The productivity calculation is shown in Table 2. By having the ratio of distribution to the fish auction and the cold storage, the number of required cargo handling vehicles was calculated as shown in Table 3.

Table 2 Productivity calculation from berth to fish auction.

	Distribution to Fish Auction	**Distribution to Cold Storage**
Methodology and equations	Fish Auction Capacity = Fish Auction Area / Daily Area Requirement per tonne	Distribution of Fish to Cold Storage = Daily Productivity - Fish Auction Capacity; Daily Productivity $= N \times THS \times W_H$
Available Data	Fish Auction Area: 3,350 m^2 Daily Area Requirement per tonne: 30 m^2/tonne	N: 66 ships THS: 0.219 tonne/hour/ship WH: 24 hours
Result	Fish auction capacity = 111.67 tonne/day	Daily Productivity = 346.896 tonne/day; Fish distribution to cold storage = 235.226 Tonne/day

Table 3 Productivity calculation from the berth to fish auction.

	Transportation to Cold Storage	**Transportation to Fish Auction**
Number of Vehicles	= Amount of Fish to Cold Storage/Daily Productivity x Number of Berths = 45 units	= Fish Auction Capacity/Daily Productivity x Number of Berths = 21 units

Result and Discussion

Layout

The layout of the proposed development concept is shown in Figure 9. In general, the main differences between the existing layout and the new layout are: (1) the extensification of berths by building new structures in front of the existing breakwater and (2) the intensification of the existing berth area by building finger piers to support more ships. Development is planned to be conducted in the short term and the medium term. The short-term development is the construction of a new berth in the north, which can accommodate an additional 105 ships for loading and unloading and 365 ships for mooring. These new berths are prioritized so ships can be relocated temporarily to these berths during medium-term development, which prevents the fishing ships from being completely unable to operate during the construction of the new berths. The medium-term development itself improves the current west and east berths by adding finger pier berths. The medium-term development will accommodate 54 ships for loading and unloading and 154 ships for mooring. After the development is completed, the port can accommodate a total of 159 ships for loading and unloading and 519 ships for mooring. The number of available berths for loading and unloading significantly surpasses the requirement by fully optimizing the available space.

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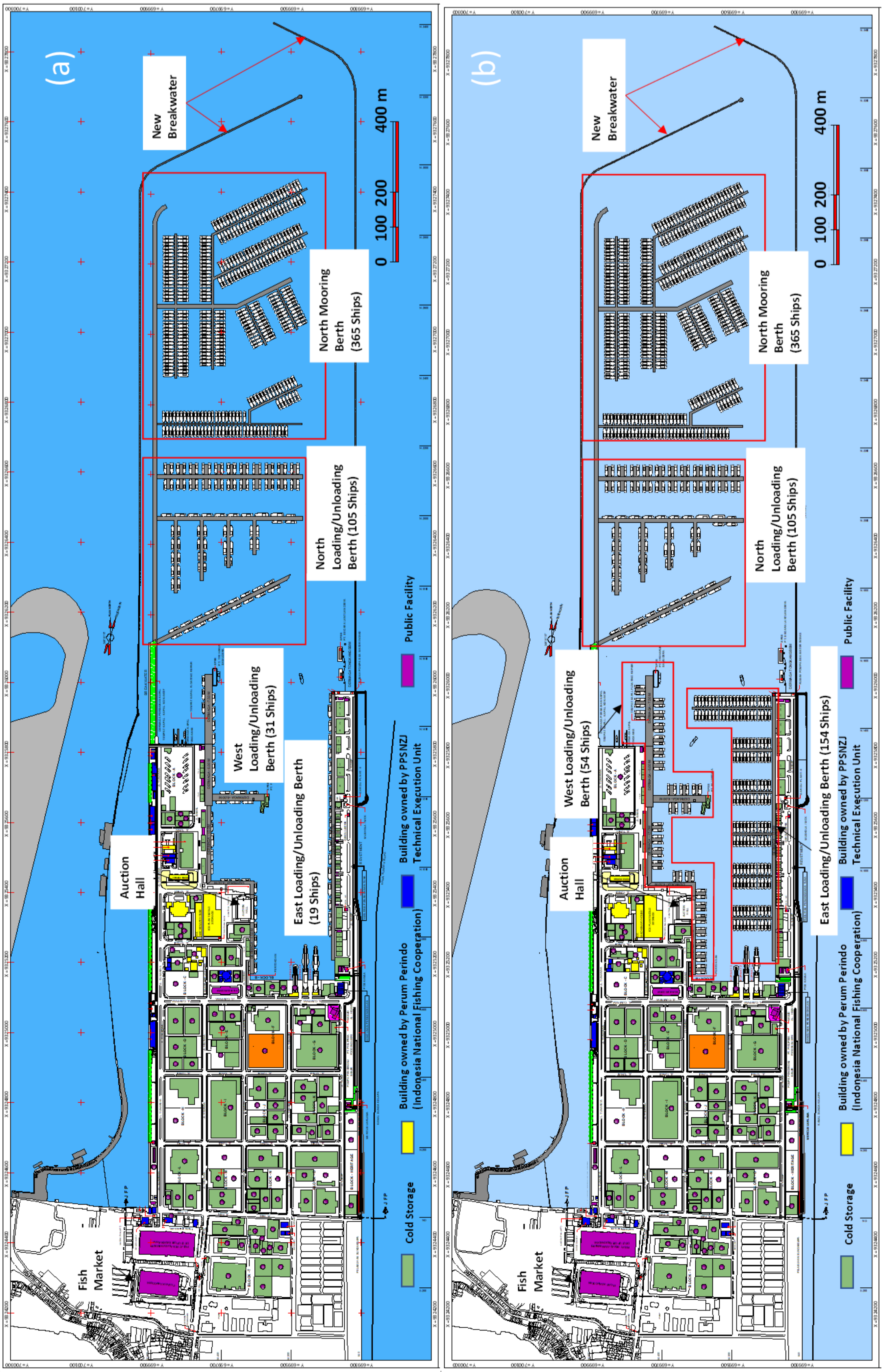

Figure 9 Development concept in (a) short term and (b) medium term.

Cost Calculation

The design criteria for the berth structure refer to the existing berth design in PPSNZJ, referred to as Jakarta Fishing Port Type-A [15]. Unit price analysis and base material price for the berth and breakwater structures were obtained from a local construction price guidebook [16]. The structure has an elevation of +7.00 m from the seabed, which is the same as the highest existing berths and has been proven to be safe against coastal flooding. The berths are constructed on top of piles with 5 m center-to-center spacing. The total length number of the new piers is 1,470 m. The wharfs and trestles, which act as the connecting structures to the wharfs, have a total length of 2,640 m and 3,049, respectively. A summary of required materials and the construction unit price of each material is shown in Table 4. The procurement price is based on the Jakarta Fishing Port Type-A price, which was 1,661860521 times the materials and construction price.

The new berths require new breakwater structures on the mouth of the port to ensure calm and safe operation. The new breakwater is a rubble mound structure that consists of a core layer, a filter layer with a 20-cm aggregate, and a natural rock armor with a 50-cm aggregate. The breakwater was designed at +1.45 m elevation above MSL with varying depth. The total of required breakwater material volume and its price are shown in Table 5. Summarizing the total construction cost, which also includes the procurement of cargo handling equipment, the calculated cost in USD is shown in Table 6. Based on the references, the obtained price per meter length of trestle or pier is 2,934 USD.

Table 1 Calculation of berth structure cost.

Material	Amount	Unit	Total Price (IDR)
Concrete	56,488.52	m^3	48,318,987,644
Formwork	131,150.11	m^2	7,946,662,354
Rebar (D16)	1,080,107.93	g	10,254,189,180
Rebar (D22)	2,429,144.86	kg	23,027,967,258
Fender	735.00	unit	2,352,000,000
Pile	1,843.00	unit (30 m)	24,969,200,000
Total			116,869,006,436
Total with Procurement			292,760,020,962

Table 2 Calculation of breakwater cost.

Material	Amount	Unit	Total Price (IDR)
Core	18022.463	m^3	5,767,188,026
Filter	46253.237	m^3	10,406,978,225
Armor	101306.444	m^3	25,326,611,093
Geotextile	12328	m^2	157,810,358
Total			41,658,587,702
Total with Construction Cost*			41,866,880,640
Total with Procurement Cost**			121,413,953,857

* Assumed to be 0.05 of the total material price for berth construction

** Assumed to be 1.9 of the total with construction cost

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Table 3 Productivity calculation from berth to cold storage and fish auction

Structure/Equipment	Properties	Cost (USD)*
Berth Structure	North Loading/Unloading Trestles: 1 x 422 m Trestle 1 x 1448 m Trestle 2 x 415 m Trestle 22 x 30 m Finger Pier North Mooring Berth: 1 x 2244 m Trestle West Loading/Unloading Berth (54 Ships): 24 x 30 m Piers East Mooring Berth (154 Ships): 5 x 115 m Piers 1 x 230 m Piers	20,911,430
Breakwater	Construction: West Breakwater: 1558 m East Breakwater: 1524 m	8,672,425
Equipment Capital Cost		
Forklift[1]	38 units	3,255,506
Conveyor[2]	6 units	25,923
Hand Truck[3]	22 units	3,497
Refrigerated Truck[4]	45 units	712,085
Pick-up Truck[5]	21 units	700,000
Total Cost		**34,280,866**

*Assumed at 1 USD = 14,000 IDR
[1] Price from machinio.com, accessed 26 January 2021
[2] Price from alibaba.com, accessed 26 January 2021
[3] Price from monotaro.id, accessed 26 January 2021
[4] Price from mytruk.my, accessed 26 January 2021
[5] Price from lautanberlian.co.id, accessed 26 January 2021

Comparison to Other Port Projects

Comparable information regarding the total construction price of ocean fishing ports in Indonesia is relatively limited. However, the obtained cost per meter for the length of piers seems to be reasonable. There are other recent fishing port development projects in Indonesia, such as the Fish Landing Port of Cisolok and the River Fishing Port of Baturusa, where the development cost USD 10,071,429 and USD 2,350,000, respectively [17,18]. However, considering the scale, Nizam Zachman is the only ocean fishing port in Indonesia. Therefore, the estimated development cost can be considered competitive. Ultimately, perhaps the most compelling argument is when the total price is compared to the latest masterplan issued by the PPSNZJ authority [8], where the total price was 35,484,696 USD only to improve the existing wharf.

Conclusion

A concept development layout of an urban ocean fishing port aimed at better productivity and safety was designed in this study. By expanding beyond the fishing port operational area limit up to 1.1 km northwards, parallel mooring can be minimalized and it will be easier for ships to approach and leave the berths. After medium-term development has been completed, the port can accommodate 519 ships for mooring and 159 ships for loading and unloading. The estimated price is also relatively reasonable and below the proposed price from the official development plan by PPSNZJ.

It should be noted that this study took several assumptions to simplify the plan development. Ship operational and cargo handling time accuracy can be further improved by conducting direct observations. It is also recommended to have a more comprehensive calculation regarding the procurement and construction costs.

Therefore, more systematic studies that incorporate these aspects are recommended to obtain more accurate results.

References

[1] Sharaan, M., Negm, A., Iskander, M. & El-Tarabily, M., *Analysis of Egyptian Red Sea Fishing Ports*, Int. J. Eng. Technol. **9**, pp. 117-123, 2017.

[2] Blasiak, R., Spijkers, J., Tokunaga, K., Pittman, J., Yagi, N., & Österblom, H., *Climate Change and Marine Fisheries: Least Developed Countries Top Global Index of Vulnerability*, PLoS One, **12**, pp. 1-15, 2017.

[3] Department of Agriculture Fisheries and Food, *Killybegs Harbour Centre Environmental Report*, Feb. 2009.

[4] Port of San Diego, *Port of San Diego Maritime Tenth Avenue Marine Terminal Modernization Project – Tiger,* https://www.portofsandiego.org/sites/default/files/media/files/2020/03/TIGER Project Status Summary Report %28Dashboard%29 - March 2020.pdf (1 May 2023).

[5] ICF, *International Final Environmental Impact Report Tenth Avenue Marine Terminal Redevelopment Plan and Demolition and Initial Rail Component*, San Diego, CA, 2016.

[6] Seo, G.-H., Kim, J.-B. & Oh, Y.-S. *On the Development of Urban Fishing Ports in Busan - Focusing on the Development Demands of Interested Parties*, J. Korean Navig. port Res., **34**, pp. 493-501, 2010.

[7] Hutapea, R.Y., Solihin, I. & Nurani, T.W., *The Role of Nizam Zachman Oceanic Fishing Port to Support Tuna Industries,* Mar. Fish. J. Mar. Fish. Technol. Manag., **8**, pp. 187-197, 2018. (Text in Indonesian)

[8] Indonesia General Directorate of Capture Fisheries, *Development Planning of Nizam Zachman Ocean Fishing Port, North Jakarta: Final Report*, 2019. (Text in Indonesian)

[9] Berita Satu, *Out of 34 Burnt Ships in Muara Baru, 10 of Them Are Allegedly Illegal*, https://www.beritasatu.com/megapolitan/540231/dari-34-kapal-terbakar-di-muara-baru-10-diduga-ilegal (27 January 2021). (Text in Indonesian)

[10] Indonesia General Directorate of Capture Fisheries, *2017-2022 Master Plan Review of Nizam Zachman Ocean Fishing Port*, 2016.

[11] Ramli, M.S. & Ernaningsih, D., *Feasibility Technical Analysis of Berth Structure Size and Mooring Area in Nizam Zachman Jakarta Ocean Fishing Port,* J. Ilm. Satya Minabahari, **4**, pp. 41-53, 2018. (Text in Indonesian)

[12] Thoresen, C.A., *Port Designer's Handbook, ed. 3., ICE Publishing, 2014*.

[13] Velsink, H., *Ports and Terminals: Planning and Functional Design*, Fac. Civ. Eng. Delft Univ. Technol., 1993.

[14] Food and Agriculture Organization (FAO), *Fish Boxes*, in https://www.fao.org/3/p3407e/P3407E09.HTM (2 May 2023).

[15] Larasati, A.D., *Zonation-Based Port Operation in Nizam Zachman Jakarta Ocean Fishing Port Jakarta, DKI Jakarta, Undergraduate report*, *Ocean Engineering*, Institut Teknologi Bandung, Bandung, 2019. (Undergraduate report)

[16] Pandu Bangun Persada Nusantara, *Journal of Building Construction, Interior, & Material Prices, ed. 36*, Jakarta, 2017.

[17] Bisnis.com, *Cisolok Port Finally Built*, accessed from https://ekonomi.bisnis.com/read/20190404/99/907823/pelabuhan-ikan-cisolok-akhirnya-dibangun (27 December 2023). (Text in Indonesian)

[18] Bangkapos.com, *Baturusa River Fishing Port Costs 32.9 Billion Rupiahs and Still Not Finished*, Available online from: https://bangka.tribunnews.com/2022/02/18/video-proyek-pelabuhan-perikanan-sungai-baturusa-bernilai-rp-329-miliar-belum-rampung (27 December 2023). (Text in Indonesian)

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