Hydrodynamic Modelling using Software of Mike21 in the Land Reclamation of Jakarta Bay: Current Condition and Master Plan

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Keywords: Reclamation, Current, Jakarta Bay, Mike21.

Abstract: Currently, the land reclamation of Jakarta bay as the manifestation of Presidential Regulation No. 25 of 1995 consists of 4 islands (Named: C (a half), D, G (a half), and N). The land reclamation may cause effects and changes in water condition, especially in hydrodynamic condition. Understanding on effects of reclamation is very important as an effort to manage coastal zone. This research investigates the possible effects in tidal current at two conditions: current condition (4 islands) and master plan (17 islands). The analysis is divided into 3 areas: marine tourism area, port area, and marine life area. The simulation used mike 21 with hydrodynamic module. The simulation has shown that current dominantly goes to the west in highest sea level and dominantly goes to the east in lowest sea level. The fastest current during north-west monsoon occurs in marine tourism area. The fastest current during south-east monsoon occurs in marine biota area. Current speed if master plan (17 islands) is implemented will be slower than current condition.

1 INTRODUCTION

Jakarta Bay is a part of Java sea located in the north of DKI Jakarta, Indonesia. This bay is a shallow water area with an average depth of 15 meters (Coordinating Ministry for Coastal Integrated Economic Development, Capital City, 2014). Population density in DKI Jakarta is one of the factors causing land shortages. Therefore, reclamation is considered by the DKI provincial government to be one of the choices to overcome this problem. Reclamation in DKI Jakarta is the addition of 17 islands covering an area of 5,189 Ha (Agus, 2016).

Reclamation in the Jakarta Bay is feared to change the flow pattern. Ocean currents play an important role in the processes of biology, physics, and chemistry that occur in the sea (Ismunarti, 2013). The problems that occur in Jakarta Bay can be studied with Mike21 software. In general, this software is more friendly on graphic interfaces, easy to use / simple, and able to be undone. It is very different from similar software such as SMS (Surface waterModeling System). This software is a collection of several simulation modules to predict the rate of sedimentation.

The purpose of this study is to determine the current pattern before and after reclamation is finished.

2 METHODS

Research of hydrodynamic modelling in the Jakarta Bay (figure 1A) was carried out for 6 months, from January - March (west season) and from July - September (east season). Modelling used Mike21 software with a Hydrodynamic module.

The monitoring point was based on the area that entered the quality standard according to KEPMEN LH No. 51 of 2004 which was then selected based on field conditions. Based on the minister's decision, the bay area of Jakarta is divided into 3 parts, namely: marine tourism area, port area, and water biota area. Tourist area was with 5 monitoring points, port area was with 23 monitoring points, and water biota area was with 25 monitoring points.

Saputra, R., Perdanawati, R. and Akhwadhy, R.
Hydrodynamic Modelling using Software of Mike21 in the Land Reclamation of Jakarta Bay: Current Condition and Master Plan.
DOI: 10.5220/0008907400002481
In *Proceedings of the Built Environment, Science and Technology International Conference (BEST ICON 2018)*, pages 367-377
ISBN: 978-989-758-414-5

Figure 1: A. Research Location map

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2.1 Model Parameter

Model parameters used the Hydrodynamic module. The hydrodynamic module was carried out in 3 different months, namely during the west season starting from January to April 2016 and during the east season starting from July 2016 to October 2016. The results of the hydrodynamic module will provide output in the form of current speed, current direction, and water level elevation.

2.2 Model Design

Model area used was the Jakarta Bay area which were divided into 2 models namely post reclamation (figure 2) and master plan (Figure 3). In post reclamation condition, there are reclaimed islands C (half), D, G (half), and N. The depth in these conditions ranges from -2 meters to -28 meters. In the master plan, there are 17 reclamation islands as shown above. The depth in this condition ranges from -2 meters to -35 meters.

In the initial stages of modelling, the most important part is the mesh editing process. Mesh elements are automatically formed based on predetermined coastline data and boundary conditions. In this study, editing mesh (Figure 4) used triangular meshing model with a minimum angle of 28 °. The area where meshing reclamation island will be built is made increasingly tight so that the level of accuracy is higher.

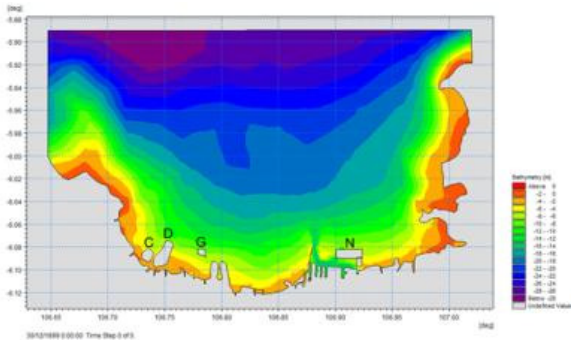

Figure 2. post reclamation of Jakarta Bay

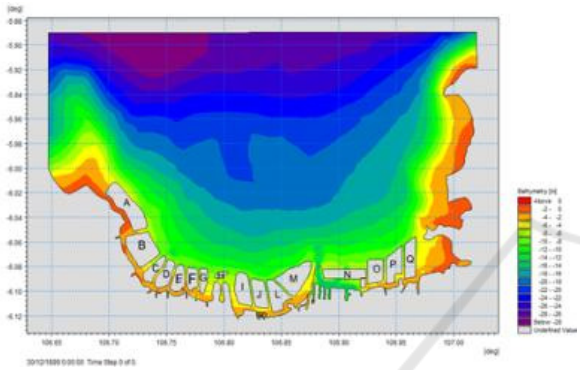

Figure 3. post reclamation of Jakarta Bay

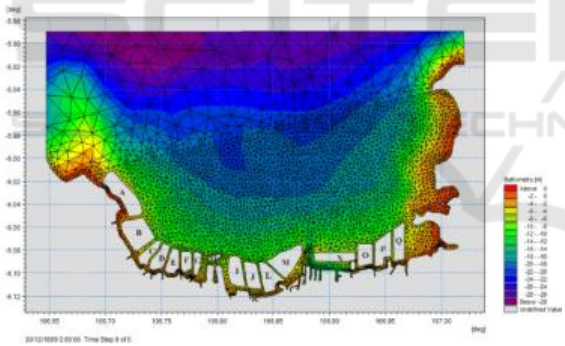

Figure 4. Meshing Model

3. RESULT

3.1 Wind

Wind data is needed to determine the distribution of wind direction from the wind speed that occurs at the research location. Wind data used were wind data from 2013 to 2017 obtained from the Jakarta Meteorology and Geophysics Agency (BMKG). Wind speed and direction in Jakarta Bay from 2013 to 2017 predominantly came from the east with a speed of 3.45 m / s. Wind speed and direction in Jakarta Bay during western season were predominantly originated from the east and northeast with a speed of 3.85 m / s. Whereas during the east season, the wind speed and direction in the Jakarta bay predominantly came from the southeast with a speed of 3.65 m/s.

3.2 Tide

Tidal predictions used NAOTIDE software and were compared with observational data in the Jakarta Bay. Tides in the Jakarta Bay are single daily type with Formzahl number 5.97. The highest elevation is 0.45185 m, while the lowest elevation is -0.44238 m. The validation and the tide observation resulted in an RMSE value 0.00286. Small RMSE value indicates that the tidal prediction value has a relatively small error rate (Syahputra, 2016). This means that tidal prediction data can be used.

3.3 Current

Current data used were measurement data from BRSDM-KP which use ADCP (Acoustic Doppler Current Profiler). Data were taken in June 2015 with coordinates of -6.043011 ° LS and 106.734212 ° BT. The current at the observation point was dominantly from the northwest, which is consistent with the research conducted by Aprilia (2017). The maximum speed reached 12.07 m / s and the minimum speed was 0.1 m / s, while the average speed was 4.843 m / s. As for current speed validation, Jason-2 altimetry satellite data was used (Aprilia, 2017). The RMSE value of 0.023 was obtained. According to Syahputra (2016), small RMSE value indicates that the value of the model results has a relatively small error rate. This means that the current model data from the Mike21 software can be used.

3.4 River Discharge

River discharge data used for input in this study were data of average river discharge into the Bay of Jakarta. Estuaries used included estuary BKT, Muara Ancol, Muara Waduk Pluit, Muara Angke, and Muara Cengkareng Drain. The biggest river debit was the discharge from Angke estuary which was 26.71 m3 / s, while the lowest estuary discharge was the BKT estuary with 3.37 m^3/s.

3.5 Hydrodynamic Modelling from Post-Reclamation and Master Plan

Hydrodynamic modelling results were obtained from the overview in the current pattern of Jakarta bay.

General description of the current condition after recent reclamation at the highest tide in the bay of Jakarta is dominantly towards the east and the northeast (Figure 5.a). The smallest current velocity is between 0 m / s - 0.098 m / s, while the biggest speed is between 0.361 m / s - 0.427 m / s. Whereas the current conditions if master plan is fully implemented in the Jakarta bay are dominantly to the eastward (figure 5.b). According to Bakrie (2017), current patterns are influenced by wind direction and wind speed, besides bathymetry profiles also affect current patterns. The minimum current velocity is between 0 m / s - 0.120 m / s, while the maximum current is between 0.240 m / s - 0.360 m / s General description of the post-reclamation condition when the lowest ebb of the flow in the Jakarta bay predominantly headed west can be seen in Figure 6.b.

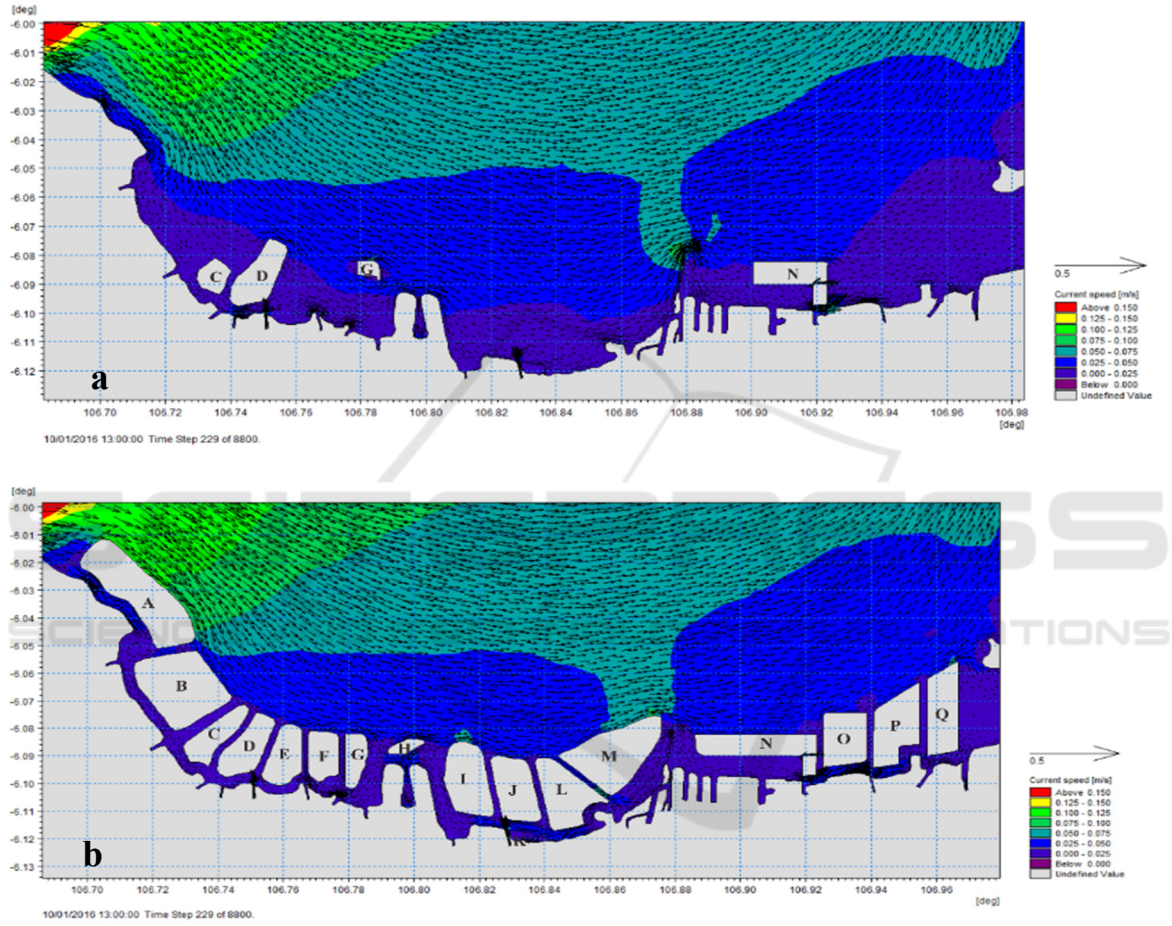

Figure 5. Current pattern at the highest tide in the west season: a) post reclamation b) master plan

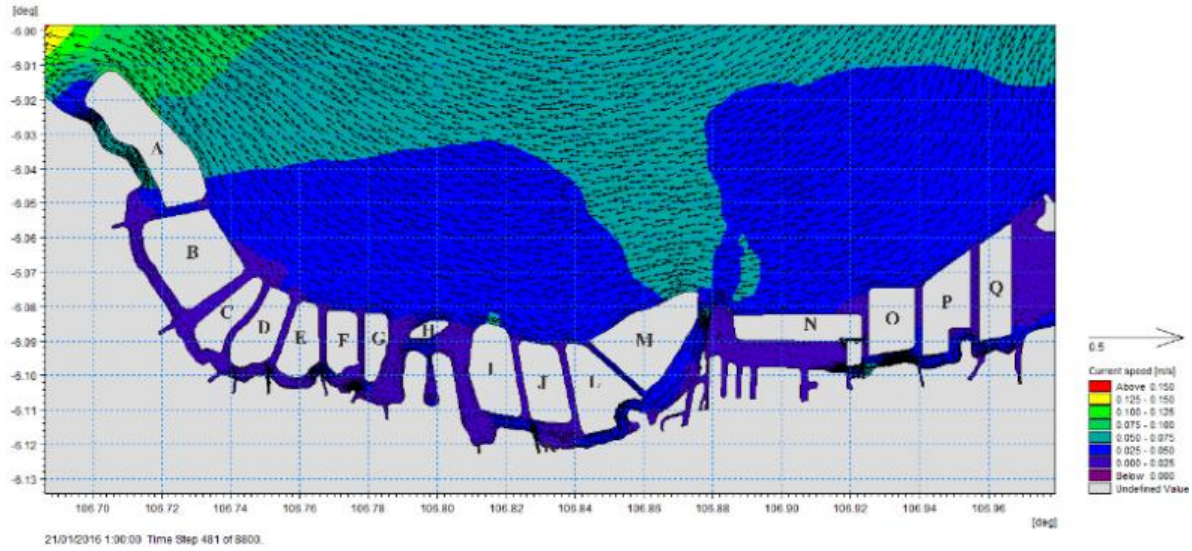

Figure 5. Current pattern at the highest tide in the west season: a) post reclamation b) master plan

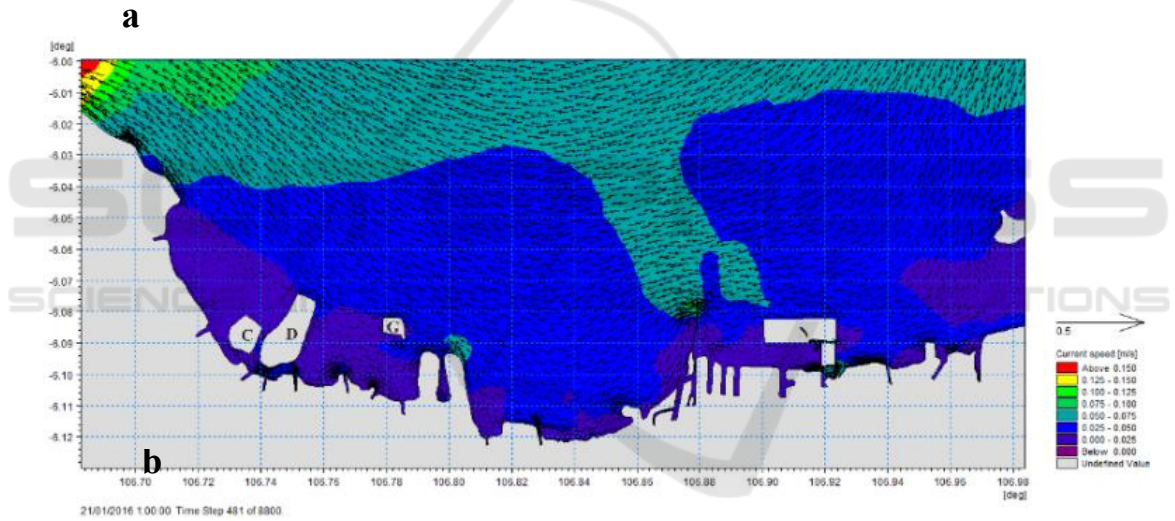

Figure 6. Current pattern at the lowest tide in the west season: a) post reclamation b) master plan

This is directly proportional to the wind pattern during the west season that is dominantly from east to west. According to Bakrie (2017), current patterns are influenced by wind direction and wind speed, besides bathymetry profiles also affect current patterns. The smallest current velocity is between 0 m / s - 0.096 m / s, while maximum current velocity was between 0.386 m / s - 0.483 m / s. The current pattern at the lowest ebb tide in the Jakarta bay was dominantly to the northwest - west (figure 6.b). This is because the geographical location of the Jakarta Bay, between the east end and the west end, is not parallel with the west end and is slightly down south. The minimum current velocity was between 0 m / s - 0.120 m / s, while the maximum current was between 0.120 m/s - 0.240 m/s.

General description of post-reclamation flows during the east season when the highest tides in the Jakarta bay predominate towards the west and northwest can be seen in Figure 7.b. This is due to the wind coming from the southeast. According to Bakrie (2017), current patterns are influenced by wind direction and wind speed, besides bathymetry profiles also affect current patterns. The smallest current velocity was between 0 m / s - 0.151 m / s, while the biggest speed was between 0.151 m / s - 0.302 m / s.

Figure 7 b is a general description of the master plan condition during the east season when the highest tide in the bay of Jakarta is dominantly towards the west and the northwest. This is due to the wind coming from the southeast. The smallest current

velocity was between 0 m / s - 0.149 m / s, while the largest speed was between 0.148 m / s - 0.297 m / s.

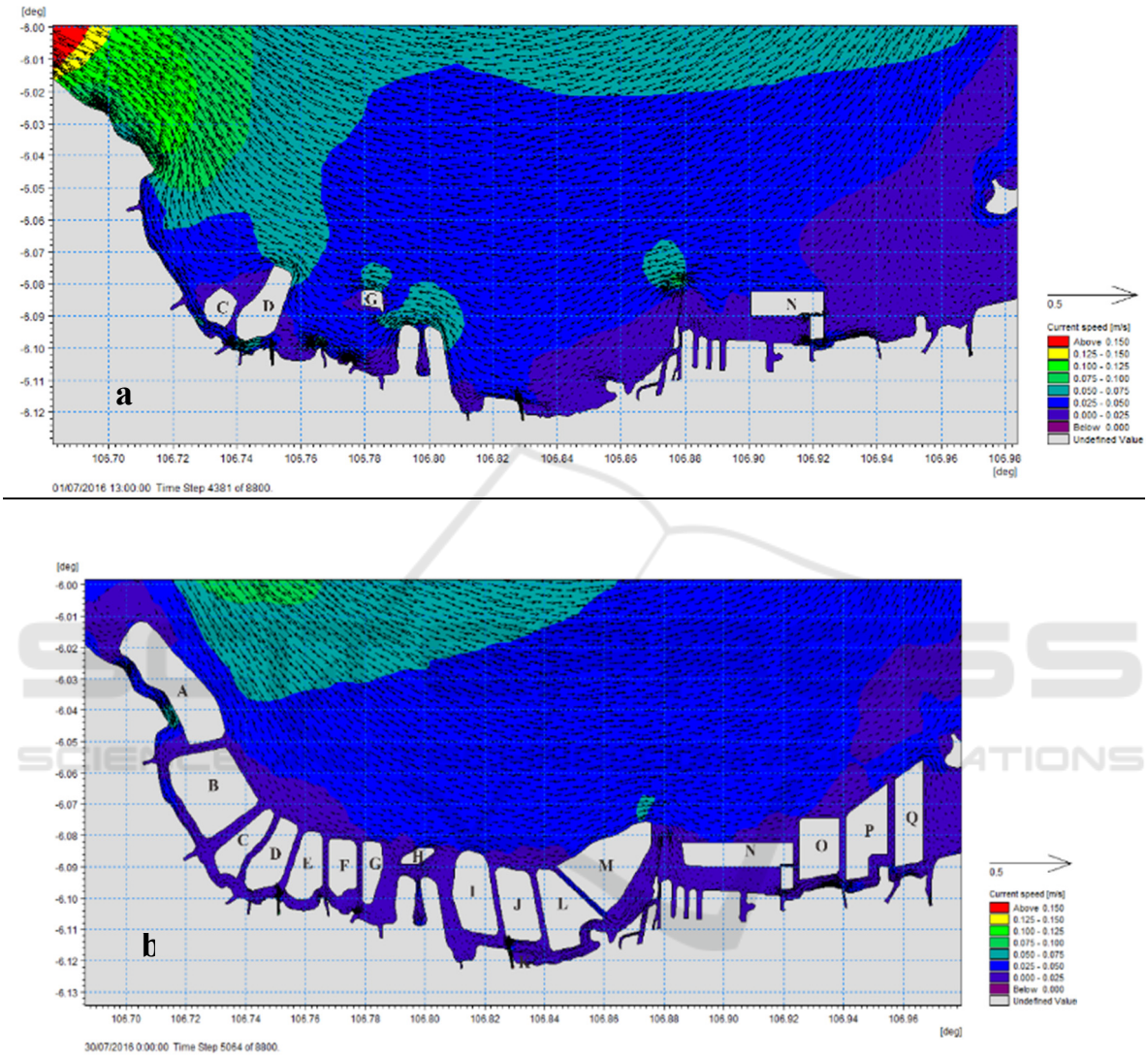

Figure 7. Current pattern at the highest tide during the east season: a) post reclamation b) master plan

Figure 8.a shows general description of post-reclamation current conditions in the east season when the highest tide flows in the Jakarta Bay predominantly head towards the east and the northeast. This is due to the wind coming from the southeast. The smallest current velocity was between 0 m / s - 0.151 m / s, while the biggest speed was between 0.452 m / s - 0.603 m / s. Whereas Figure 8.b is a general description of the current during the east season when the lowest ebb flows in the bay of Jakarta are dominantly towards the east and the northeast. This is due to the wind coming from the southeast. According to Bakrie (2017), current patterns are influenced by wind direction and wind speed, besides bathymetry profiles also affect current patterns.

The smallest current velocity was between 0 m / s - 0.140 m / s, while the largest speed was between 0.560 m / s - 0.700 m / s.

During the west season, the current dominantly goes to the east, while when it recedes, the current is dominantly to the west. This is due to the wind during the dominant western season heading east. During the east season, the current is dominantly towards the west, while when it recedes, the current is dominantly to the east. This is due to the wind during the east season heading west. According to Bakrie (2017), current patterns are influenced by wind direction and wind speed, besides bathymetry profiles also affect current patterns.

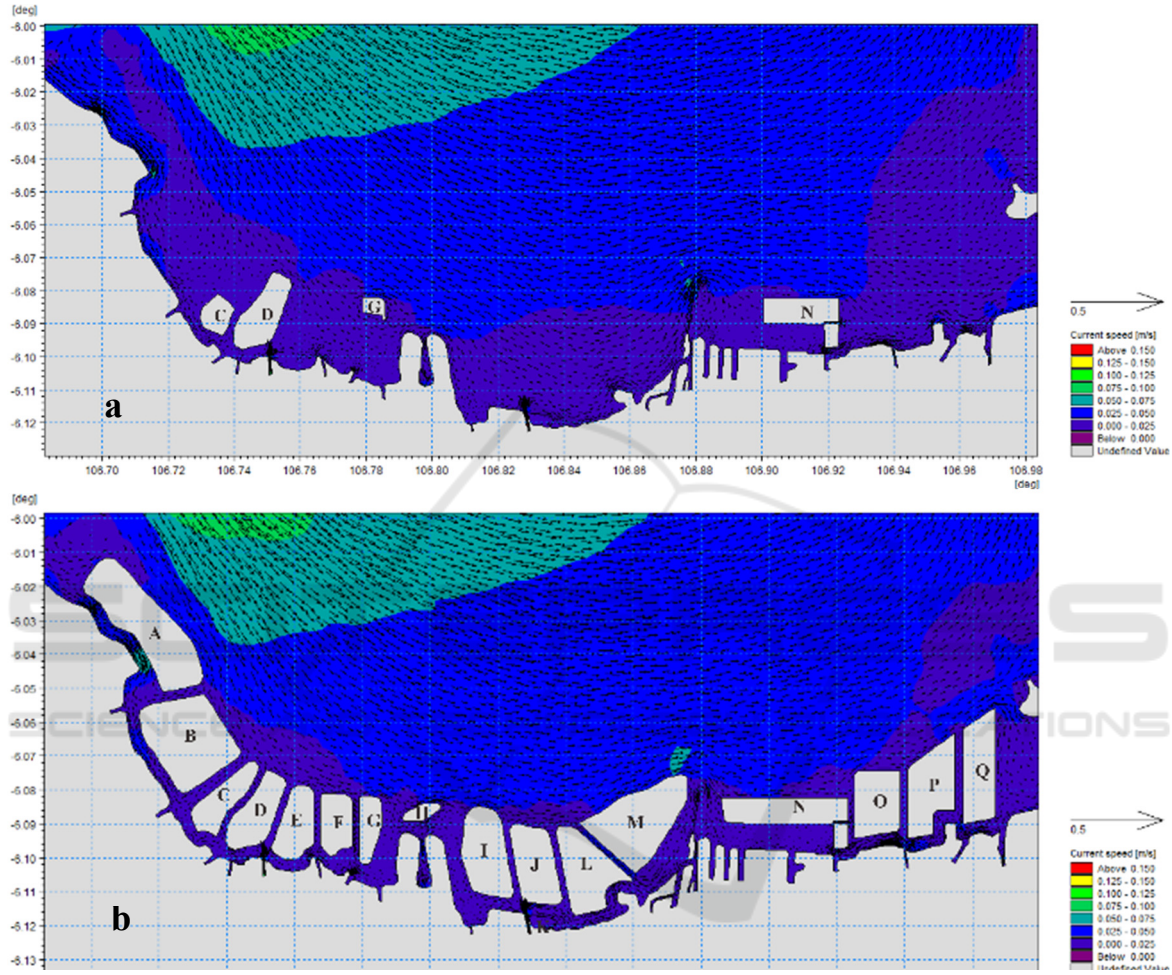

Figure 8. Current pattern at the lowest tide during the east season: a) post reclamation b) master plan

3.6 Hydrodynamic in The Marine Tourism Area

The maritime tourism zone includes Ancol Beach area and Pantai Indah Kapuk. Figure 7 shows that during the west season, the average current velocity in the master plan condition experienced an insignificant decrease compared to in the post reclamation condition. This is because the point of monitoring, that is in the marine tourism area, is far from the reclamation island plan. Whereas during the east season, the average speed in the aster plan experienced an insignificant decrease compared to in the post reclamation condition. However, at the observation point 27, there was a significant decrease in current velocity.

This is because the observation point 27 is between the reclamation islands J and L and the distance between reclamation islands J and L is relatively narrow, so that the current speed slows down. According to Kurniawati (2017), in the vicinity of

reclamation islands there was a flow of currents because of the obstructed landscape of the island and because the area blocked by the reclamation island had a small tendency.

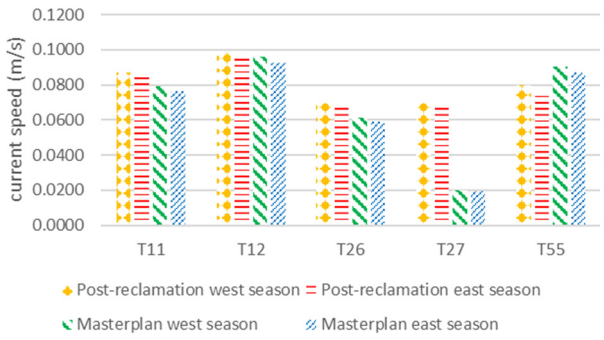

Figure 9. Current condition in the marine tourism area

3.7 Hydrodynamic in The Port Area

The Port Zone includes Tanjung Priok Port, Nizam Zaman Port, Muara Baru, and Muara Kamal Port. Figure 10 shows that during the west and east seasons, average velocity in the master plan is smaller than the current in the time of post reclamation. This is because there were several monitoring points in the port area which experienced a significant decline. At the observation point 8 during the east and west seasons, there was a significant change in current patterns. This happened because in the pre and post reclamation conditions, there was no reclamation island, while in the condition of the master plan, the current pattern changes because of the islands E and F.

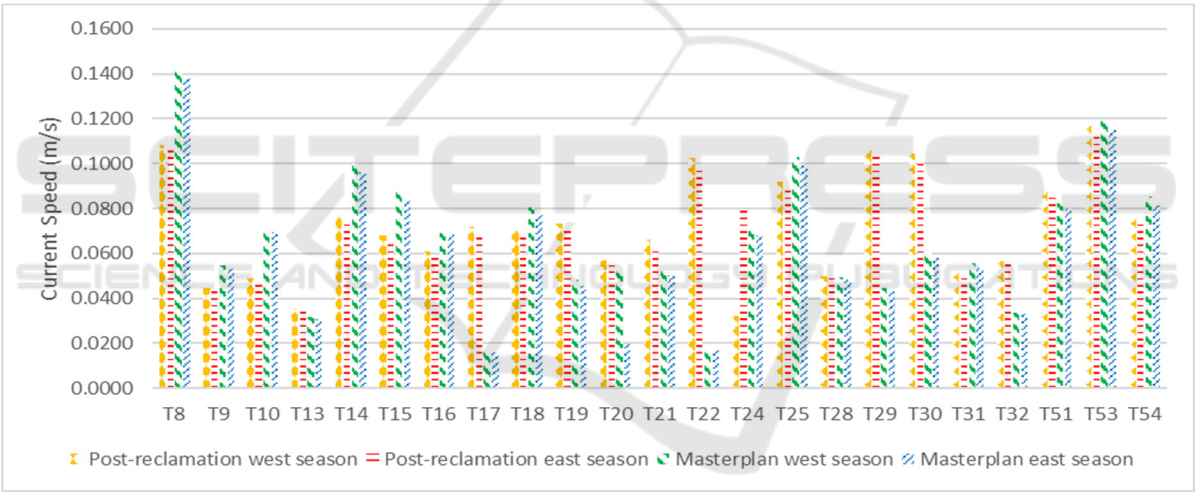

Figure 10. Current condition in the port area

At the observation point 17 during the east and west seasons, there was a significant change in current patterns. This was because point 17 is between the P and Q reclamation islands where the distance between the two reclaimed islands is relatively narrow so that it forms something like a canal. At observation point 22 during the east and west seasons, there was a significant change in current velocity. This was because observation of point 22 is at the end between N and O reclamation islands. At observation point 29 during the east and west seasons, there was a significant change in current velocity. Meanwhile in the condition of the master plan, the current tended to be slower than in the post-reclamation condition. This happens because point 29 affects the reclamation island F. At the observation point 30 during the east and west seasons, there was a change in the flow velocity due to the reclamation island H.

In the port area, the current has been weakening since the reclamation started. This is because the

currents that hit the reclamation island cause small currents. According to Kurniawati (2017), in the vicinity of reclamation islands there was a flow of currents because of the obstructed landscape of the island and because the area blocked by the reclamation island had a small tendency.

3.8 Hydrodynamic in The Marine Biota Area

Marine biota zones cover zones where the marine biota lives. Figure 11 shows that during the west and east seasons, average velocity in the master plan condition is smaller than the current at the time of post reclamation. This was because there are several monitoring points in the port area which experienced a significant decline. At the observation point 33 during the east and west seasons, there was a significant change in speed and current pattern. This is because the observation point 33 is at the end between reclaimed islands D and E. At the observation point 35 during the east and west seasons, there was a change in the current pattern. This happened because of the reclamation islands B and C.

At the observation point 36 during the east and west seasons, there was a change in the flow velocity due to the reclamation of islands A and B so that the current velocity becomes weak.

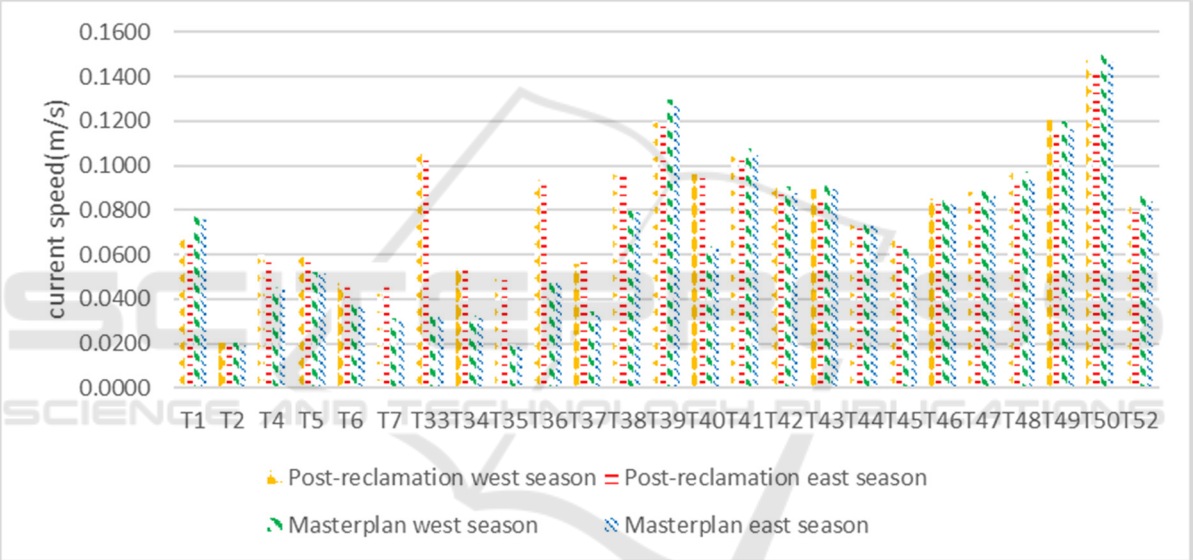

Figure 11. Current condition in the marine biota area

3.9 Hydrodynamic in Any Area

Figure 12 shows during the west season, the velocity of currents in the maritime tourism zone is greater than it is in the port area and marine biota area. Whereas during the east season, the current velocity in the marine biota area is greater than it is in the marine tourism area and port area.

At the observation point 37 during the east and west seasons, there was a change in the flow pattern due to the reclamation islands A and B. At the observation point 38 during the east and west seasons, there was a change in the current pattern. This happened because of the reclamation island A, the current speed at point 38 becomes slower because the point is along the coast and adjacent to the reclamation island A.

In the area of marine biota, the current has been weakening since the reclamation process started. This is because the currents that hit the reclamation island cause small currents. According to Kurniawati (2017), in the vicinity of reclamation islands there is a flow of currents due to blocked islands and the area blocked by reclaimed islands that has a small tendency.

The decrease in current velocity occurs along with the reclamation island. According to Kurniawati (2017), in the vicinity of reclamation islands there is a deflection of the flow because it is blocked by the

span of the island and the area blocked by the reclamation island has a small tendency.

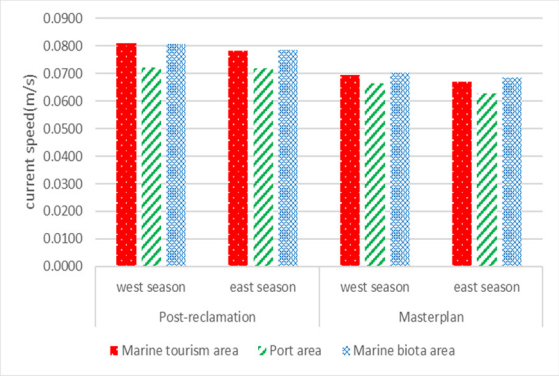

Figure 12. Current condition any area

3.10 Impact of Changes on Current Patterns

The impact of changes on current patterns caused by reclamation is very influential to the physical, chemical and biological activities that occur at sea. According to Ismunarti (2013), ocean currents play an important role in the processes of biology, physics, and chemistry that occur at sea. In addition, the weakening of the current will also result in high sedimentation rates. According to Miftachurraazaq (2017), if the flow is faster, the sediment concentration will decrease, whereas if the current is weak, the sediment concentration will increase.

4 CONCLUSIONS

Current modelling results of marine tourism areas current velocity in post-reclamation conditions during the western season is greater than it is in master plan conditions. The current velocity in port area in post-reclamation conditions is greater than it is in the master plan conditions, while in the marine biota area, the current velocity in post-reclamation conditions is greater than it is in the master plan condition. Whereas during the eastern season, the current velocity of the marine tourism area in the post-reclamation condition is greater than it is in the master plan condition. Current velocity of the port area in the post-reclamation condition is greater than it is in the master plan condition, and in the marine biota area, the current velocity in the post-reclamation condition is greater than it is in master plan condition. This is caused by the bending of the current due to the reclamation island so that the current becomes small.

During the west season, current speed of the marine tourism area is faster than those of the port area and marine biota, while during the east season, the current Speed in the marine biota area is greater than it is in the marine tourism area and port area.

ACKNOWLEDGEMENTS

I would like to thank BRSDM-KP for supplying data and making software mike21. I also want to show my gratitude to BMKG Jakarta for supplying data, and to Islamic University of Sunan Ampel Surabaya for permission to use laboratory of computer to run this software.

REFERENCES

Agus Setiawan. 2016. Technical Report on the Field of Hydrodynamics and Geomorphology of the Reclamation Activity Study Team. BalitbangKP. Jakarta.

Aprilia, Evasari. 2017. Three-Dimension Hydrodynamics Modelof Sedimentation Distribution Pre and Post Reclamation Jakarta Bay. Final Assigment Departement of Geomatics Engineering. Faculty of Civil Engineering. Institut Teknologi Sepuluh Nopember. Surabaya

Bakrie, D D. 2017. Evaluation of Trophic State with Modelling of Mike 21 Ecolab and Mitigation Strategies in Jakarta Bay. Thesis postgraduate Program Faculty Engineering. Universitas Indonesia. Depok

Ismunarti, Dwi H. 2013. Study of Flow Patterns in the Waters of West Nusa Tenggara and their Simulations Using a Mathematical Model Approach. Oceanographic Study Program, Majoring in Marine Science, Faculty of Fishery and Marine Science. Diponegoro University. Bulletin Journal of Oceanography Marina July 2013. vol. 2 page 1 - 11

Kepmen LH No 51. 2004. Sea Water quality standards. State Minister of Environment.

Kurniawati. D S. 2017. Modelling Analysis of Tss Distribution and Its Impact to Phytoplankton in Jakarta Bay. Thesis postgraduate Program Faculty Engineering. Universitas Indonesia. Depok

Miftachurrazaq, Izhad. 2017. Modeling of Sediment Distribution to Analysis the Impact of Reclamation to The Shallowing of Benoa Bay. Final Assigment Departement of Geomatics Engineering. Faculty of Civil Engineering. Institut Teknologi Sepuluh Nopember. Surabaya

Perekonomian, K, K. 2014 . Integrated Development of the State Capital Coast, Jakarta.

Syahputra, Hendry. 2016. Comparative Analysis of the Accuracy of the Tidal Prediction Model: A Case Study in the Larantuka Strait, East Flores, East Nusa

Tenggara. Journal of oceanography program, Faculty of Fishery and Marine Science, Diponegoro University. Semarang.