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Mapping of Sunda Kelapa Dredging Material Dispersion Pattern

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Abstract**—**This paper will discuss about mapping the dispersion pattern of the dredging material at Jakarta's port of Sunda Kelapa. The mapping is based on the TSS (Total Suspended Solution) method for fine sand particles and combined with the velocity of the sea current to determine the extent of the dredged material deposit, which is found at 1000 mg/l. With settling velocity of 1 mm/s, the maximum extent from the simulation is 4 kilometers offshore from the dump point covered in 4 hours during high current, and about 1 kilometer from the dump point towards the shore during low current. Taking into account the direction of the current, the optimum window for dredging the port and dumping at the selected location is in November each year.

Keywords**—**Dredging material, dispersion pattern, bay current, image processing, mapping, total suspended solution.

I. Introduction

INDONESIA as a maritime country is very dependent on sea lanes of transportation for the growth if its economy. Ports became the focus point in water transportation network between major cities, but most are located on or near river delta which is very prone to sedimentation. To prevent sedimentation build up that can cause problem on ship traffic in and around the ports, periodical dredgdredging operation is scheduled to keep the depth at optimum condition. One of the side effects of dredging operation is that there are some suspended material carried away by water current around the dredging site. These carried away materials will re-deposit on other location and in turn could be potentially disrupting to local condition, like fishing grounds, shrimp farming, and other activities. Therefore, this research is to map the potential dispersion pattern of the dredging material on areas that potentially affected by the dredging operation.

The Port of Sunda Kelapa is one of the seaports of Jakarta which is formerly Port of Pajajaran Kingdom on the estuary of Ciliwung river. The port grows into Town of Jakarta as known today. The current port of Sunda Kelapa is built in 1610 with a 800m-long channel [1] and extended to 1825m by Dutch Colonial Government in 1817. After Indonesia's independence, the channel is extended to 3250m to provide berth for 70 sail boats arranged in *susun sirih* (diagonally stacked) pattern. Originally serves as major port for fishing ships landing the fish catch from Java Sea and became known as Pelabuhan Pasar Ikan (fish market port), currently with the increasing activity of inter insular people and goods transportation, the Jakarta Governor's Decree stated that Port of Sunda Kelapa no longer handles large scale fishery activities, but local small scale fishing from Jakarta Bay is still allowed. Due to the large number of Indonesian traditional boats at Pasar Ikan, a wood and timber facility is also located there to handle loading and unloading of wood timber to and from Indonesia archipelago. With the development of the modern Tanjung Priok Seaport for handling cargo nearby, Sunda Kelapa focuses on tourism transportation between Jakarta City and *Kepulauan Seribu* isles and the port still serves traditional Indonesian boats on inter insular transportation with its proud and distinct maritime tradition.

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II. Research Overview

A. Hydrographic Overview

Jakarta Bay is a wide area covering from Cape Karawang to the east, and Cape Pasir to the west. The western area contains rocky islands that form Kepulauan Seribu while the eastern area has no islands since the sea condition does not allow for coral to grow. The depth of the bay ranges between 10 to 30 meters with relatively flat seabed. Sea floor material consists of muddy sand from the shore up to 600 meters, while at further than 600 meters the material is mostly sandy mud.

B. Current and Wind Pattern

The wind pattern over Jakarta Bay in the period from December to March is generally at 7 to 16 knots from northwest, which in West Season often forms cumulonimbus clouds with winds up to over 20 knots. Since the average depth of Jakarta Bay is less than 30 meters, it is categorized as shallow and even calm winds are sufficient to cause high surface wave. In December-March and May-November periods, wave top heights ranges between 0,5 to 1 meter while season transition between April-May and November-December known as pancaroba marked by relatively calm sea condition with wave top of 0,5 meter or less[2].

Figure 1 and **Figure 2** shows the current pattern for Jakarta Bay during June-November and December-May Periods with the dumping area is marked by the red circles. Sea current data is by interpolating the OSCAR data and the bathymetry is from Gebco Global Bathymetry. The depth at the area of interest is from 10 to 20 meters and average maximum current velocity is around 0,1 m/s.

Based on the monthly current pattern, it can be seen that from May to August, Jakarta Bay is in calm condition with the wind blows westward. The period around September-October is when the current switches direction toward the shore during wind transition. During November to May also marked with calm current which is dominantly southward to the shores.

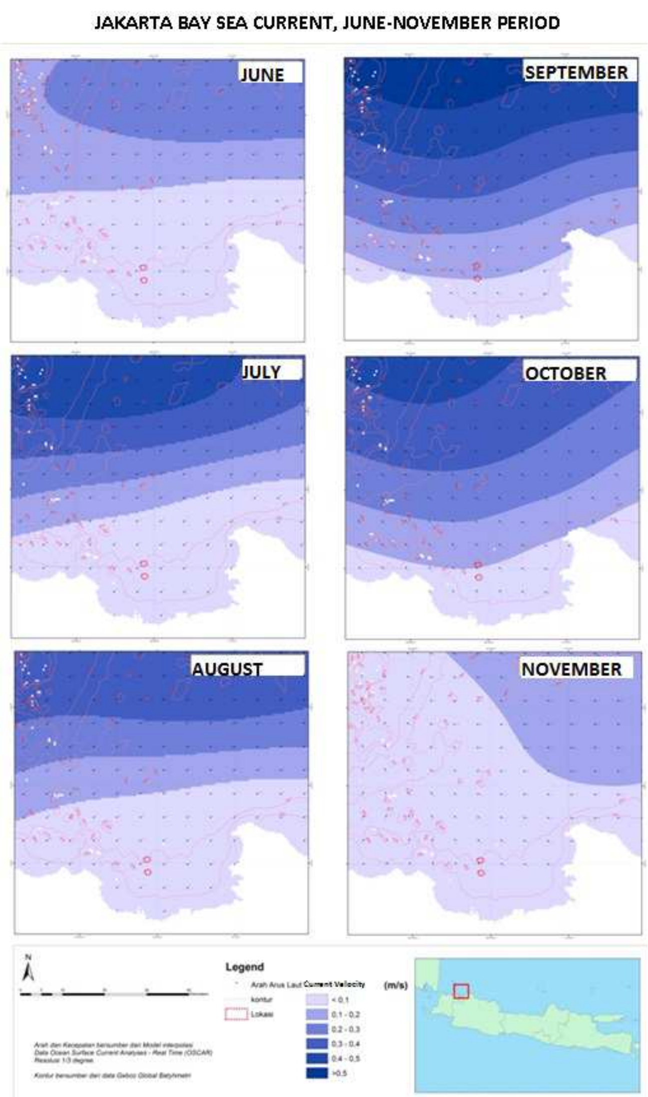

Figure 1 Jakarta Bay current flow June-November

III. Sediment Deposit Analysis Method

Identification of the dispersion pattern is based on Total Suspended Solution method, with the process shown in **Figure 3**. The first process is to correct the pixel (radiometric) value of the image so the represented value is object reflectance instead of Digital Number (DN) [3].

A. TOA Reflectance Conversion

This process is to extract the raw TOA planetary reflectance from the metadata.

$$\rho\lambda' = M_\rho Q_{cal} + A_\rho \qquad (1)$$

where $\rho\lambda'$ is planetary reflectance, $M\rho$ is metadata band-specific multiplicative rescaling factor, $A\rho$ is metadata band-specific additive rescaling factor, Q_{cal} is quantized and calibrated standard product pixel values (Digital Number).

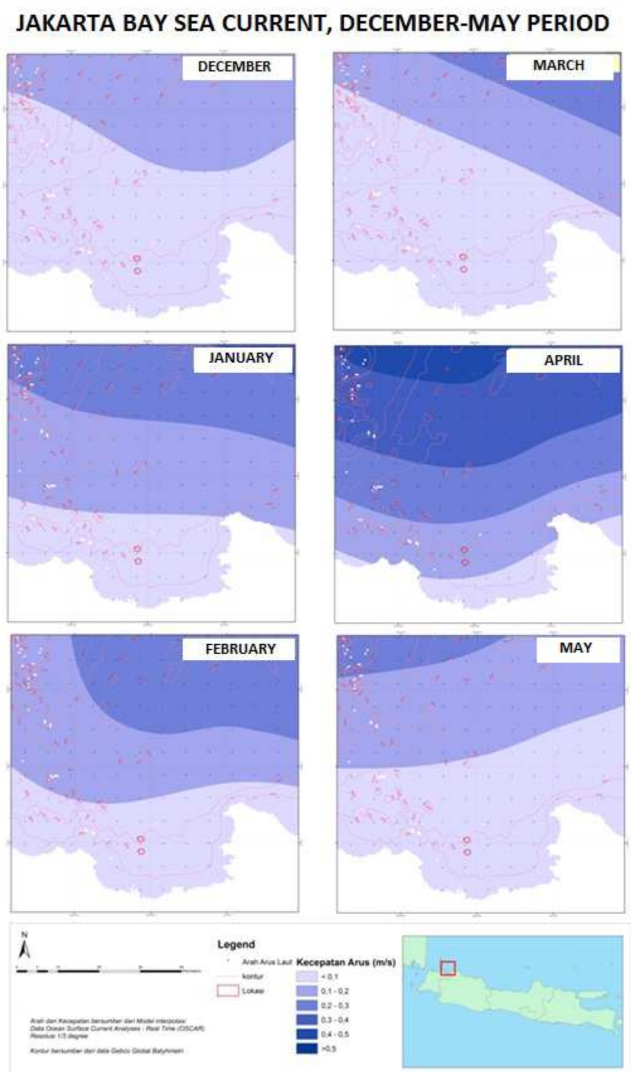

Figure 2 Jakarta Bay current flow December-May

B. Sun angle-corrected TOA Reflectance

To compensate the varying amount for reflected energy due to the position of the sun above the local observation area, this process is to provide a more dependable value, which is:

$$\rho\lambda = \frac{\rho\lambda'}{\cos(\theta_{SZ})} = \frac{\rho\lambda'}{\sin(\theta_{SE})} \qquad (2)$$

where $\rho\lambda$, $\theta_{SE,}$ and θ_{SZ} areTOA planetary reflectance, local sun elevation angle, local solar zenith angle ($\theta_{SZ} = 90° - \theta_{SE}$).

C. TSS (Total Suspended Solids) Algorithm

After image correction, the TSS composition is detected through image sharpening [4]. This method is capable of converting sun-corrected image value (reflectance irradiance) into TSS composition value.

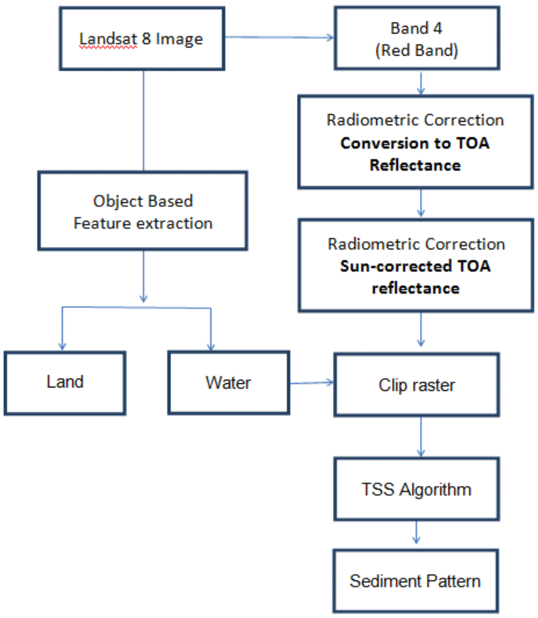

Figure 3 Process flow diagram

IV. DREDGE MATERIAL DISPERSION ANALYSIS

Identification of the dispersion pattern is based on Total Suspended Solution method. Based on data and information from the effect of lifted seabed mud [5], the concentration of suspended solids of Jakarta Bay is estimated at 1000 mg/l for the waters around the seaports, with settling velocity of 1 mm/s, the dispersion pattern of the resulting suspended solids due to dredging activity can be calculated as:

$$t_s(s) = \frac{D(m)}{v_s(mm/s)} \qquad (1)$$

where t_s is the settling time for a specified depth (D) of a particle with specific descent (settling) velocity (v_s). The maximum possible extent of material dispersion is calculated from the following equation:

$$d_{max}(\mathrm{m}) = \mathrm{v_{sc}} \times \mathrm{t_s} \qquad (2)$$

where d_{max} is the maximum horizontal distance can be attained by a descending mud/sand particle carried by the sea current (v_{sc}). This calculates the maximum distance a mud/sand particle will settle after carried away by the sea current from the dumping location.

For the southern disposal point with local depth of 10 m, the settling time for the lightest suspended solid material based in (1) yields the result of 10^4 seconds, or 2 hours and 47 minutes. Therefore, the maximum predicted potential extents of the dispersion of dumped material with descend time of ten thousand seconds yields the maximum distance of 1000 m during calm seas with current velocity of 0,1 m/s.

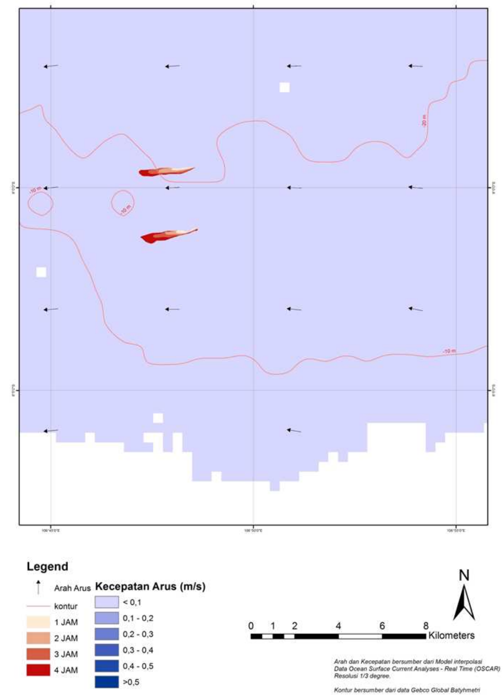

Figure 4 Simulated material dumping pattern for May to August period

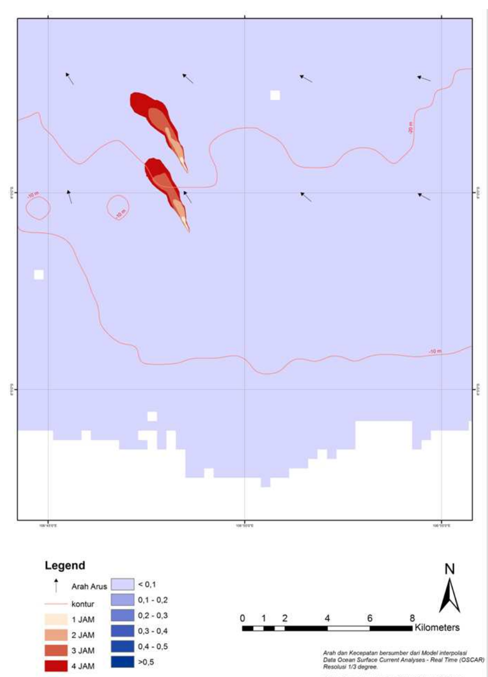

Figure 5 Simulated material dumping pattern for November

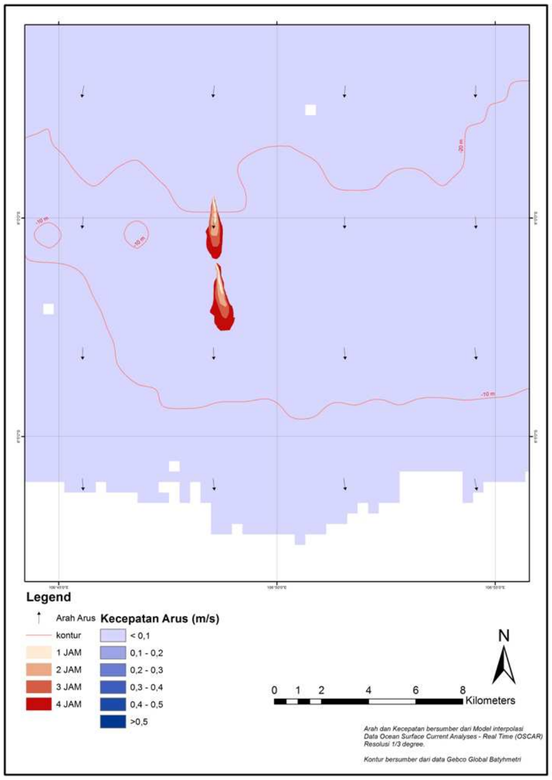

Figure 6 Simulated material dumping pattern for December to March period

Figures 4 to **6** shows examples of the simulated dispersion pattern at the proposed dumping area with maximum time period of 4 hours. **Figure 4** shows the pattern for May to August generally westward for as long as 1 km, nearing Anyer Island, a tourism location. **Figure 5** for November, which shows the pattern flows towards north-west to deeper area and stronger current. **Figure 6** shows the resulting pattern for December to March period, which drifts back southward potentially disturbing port areas and high traffic zones.

V. Conclusion

This work presents a simulated prediction of dredge material dumping dispersion pattern around the designated dumping location, and the effects it may potentially cause on the surrounding area. From the simulated result, the best possibility to commence dredging and dumping is in November of each year. The next window for Sunda Kelapa dredging activity and the related dumping activity is in November 2016.

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