AN INVESTIGATION OF BOAT WAKES WAVE ENERGY: A CASE STUDY OF KEMAMAN RIVER ESTUARY

M.F. Ahmad[1], M. F. Mohamad Yusoff[1], M. L. Husain[2]
W. M. N. Wan Nik[1], A. M. Muzathik[1]
[1]Maritime Technology Department, Faculty Maritime Studies and Science Marine, University Malaysia Terengganu, Malaysia
[2]Institute of Oceanography, Universiti Malaysia Terengganu, Malaysia

Email : fadhli@umt.edu.my

Keywords: Wave Energy, Boat Wakes Wave, Wave Characteristics, Water Level Logger

Introduction. This study involves the wave that is generated by boat passing over the surface of the Kemaman River Estuary. As long as the waves propagate slower than the boat speed when across the water surface, there is an energy transfer from the boat speed to the wave's motion. According to Verney [1], when a boat passes over the water surface, pressure differences are developed at the air-water interface and series of wave are then produced, as well as friction on the water surface by the hull boat. The wave energy produces is related to the bank erosion. The riverbank erosion happen when the boats navigate the estuary or channel a water surge ahead created by the boats will cause a wave motion in the direction of the passing boats. Damage may be caused by the effect of a single wave or the cumulative effect of several wave trains from many boats. Often the general public's are concerned with waves of observably large amplitudes, however damage caused by a wave is a function of both the wave height and wave period.The occurrence and amplitude of the drawdown are controlled by the width of the channel, the local water depth and some boat-related features, such as the shape of hull and the boat speed, e.g., the narrower the width, the larger the drawdown [2],[3]. The aim of the study is to study the energy generated by boat at mangrove area in Kemaman River Estuary. To achieve this aim, the following objectives will be established first to identify boat wakes wave energy in the Kemaman River Estuary, calculate the Energy of Maximum wave (E_{max}) and Energy of entire wave train (E_{Total}) and finally to investigate the relationship between Energy of Maximum wave (E_{max}) and the Energy of entire wave train (E_{total}) induce by all boat types.

Methodology. In this study a series of data collection obtain from water level logger will be measured the parameter of wave characteristic. The three wave gauges were deployed at different water depth level in parallel position (Fig. 1) during low tide and the reading will be obtained during high tide. The data of water height was recorded at one seconds interval. Then the data will be used to calculate the wave energy contributed by boat wake at the study area. The eq. 1 was used in this study [4].

$$E = \frac{\rho g^2 H^2 T^2}{16\pi} \quad \text{eq. 1}$$

Where ρ is mass density of water in unit of kilogram per mete cube, g is acceleration by gravity in meter per second squared. H is the wave high in meter and T is wave period. The calculation for Energy for maximum wave, the T is calculated by using wave peak period where the H is maximum wave height.

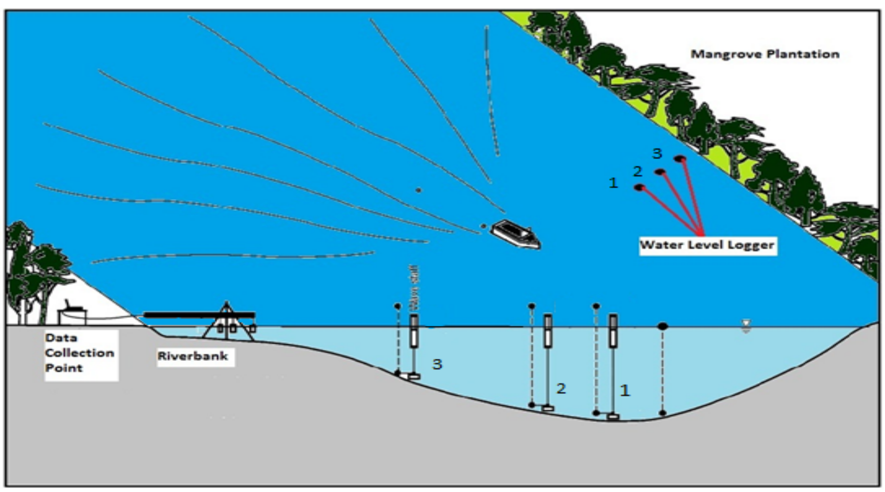

Figure 1 Position of Wave Water Level Gauges

Results and Discussions. Wave energy level induced by boat at Kemaman River is influenced by the wave height (H) and peak wave period (T_{peak}). The maximum energy level will be in high value when the wave in superposition or in constructive interference [5], [6]. The net displacement of medium at any point in certain time is simply the sum of the individual wave displacements. So, wave data wave height (H) and wave period (T) that captured by water level logger is not so affected by the boat speed. From the Fig. 2, it shows the high boat speed 16 knots not produce the maximum wave energy (*J*) but the speed at 8 knots can produces high energy.

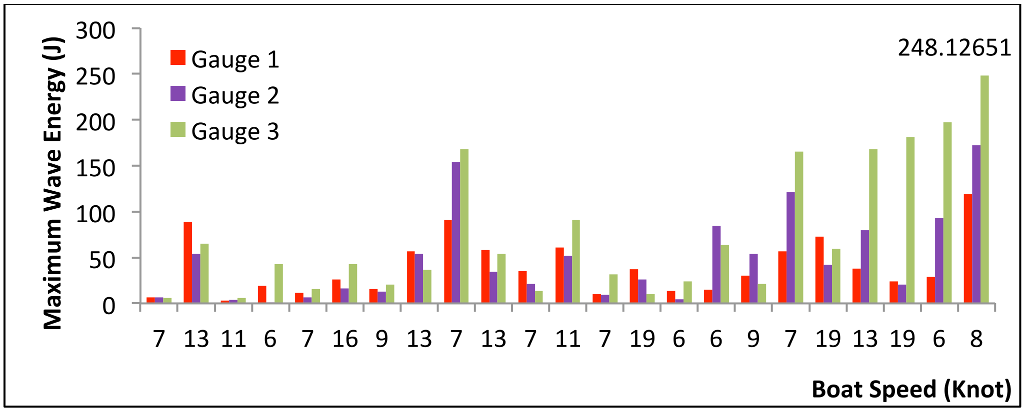

Figure 2 Maximum Wave Energy and Boat Speed for Three Gauges

Maximum energy produces increases with the distance from riverbank shore (see the difference values of maximum wave energy at gauge 1 and gauge 3). The response was variable when the shape of the offshore profile was less significant because of the depth of water become so relative to the energy produces.

According to Parchure et. al [7] states that large vessel tent to generate large drawdown and small wave height, while small vessel, such as pleasure craft, generate small drawdown and large wave height. The size of boat doesn't determine the value of wave number. Even the small boat can produces the total of wave number more than the big boat.The wave number will manipulate the total wave energy produce by boat when crossing the river. The wave train will create the repeated wave oscillations that have many wave height (*H)* and wave period (*T)* value. Greater wave oscillation created will produce high value of energy total.

Fig. 3 shows the relation of total wave energy and boat speed. The value of total wave energy produces in the one wave train per boat crossing at Kemaman River is not so affected by the boat speed. Difficult to state the speed wave at high throttle will get the total high energy.

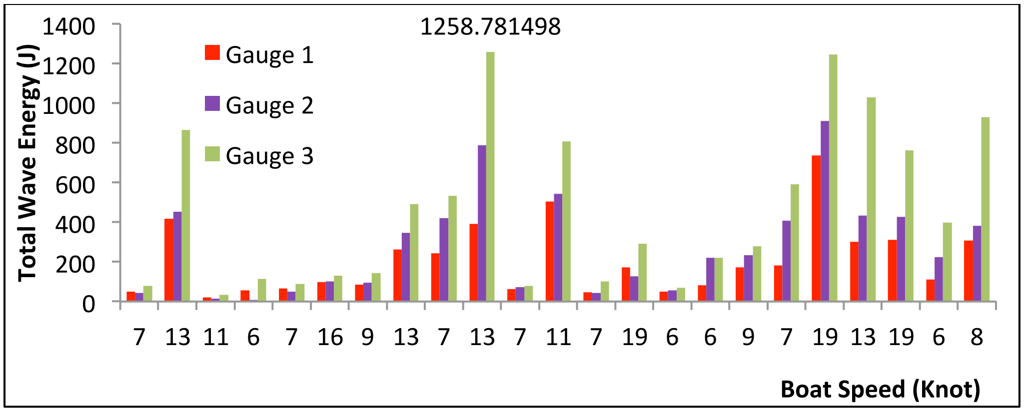

Figure 3 Total Wave Train Energy and Boat Speed for Three Gauges

From Fig. 4, a correlation (R^2 = 0.664) has been found between the total energy of the wave train and the energy of the maximum wave as calculated by Equation;

$$E_{total} = 9.228 E_{H\max}{}^{0.842}. \qquad \text{eq. 2}$$

where $E_{total}$is total energy in Joules and $E_{Hmax}$is energy produced by maximum wave height

Using the equation, when energy of maximum in the wave train is finding from the boat wave wake, the value of total wave train energy will be easily obtain. This formula is valid only at Kemaman River for the depth water 0.1 meter until 1.8meter and the boat speed is around 5- 30 knots for Fishing Boat and Passenger Boat.

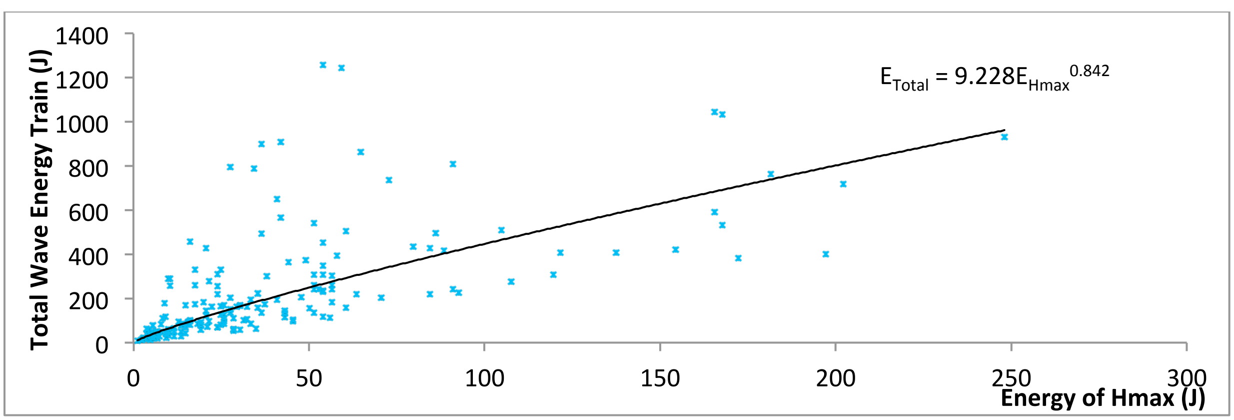

Figure 4 Relationship between Total Wave Energy Train and Maximum Wave Energy

In analyzing boat wave wakes, the two parameters of maximum wave height and the corresponding wave period for the highest wave (often termed the maximum wave) have therefore been adopted as the primary measures. The relationship of total wave energy train and energy of maximum wave height give the information data to control the level of erosion occurs on the specific site. From the Eq. 2, when the wave height increase the total energy also will increase. It is mean that the wave height is the determination factor for the level of erosion. The importance of quantifying wave wakes with simple measures is critical when assessing small boat wave wake impacts. If the measures are complicated, statistically difficult to represent or costly to collect and collate, regulatory authorities may be reluctant to pursue a path of boating management through scientific understanding. So in this case, the wave wakes must be reducing to make sure the erosion can be lower.

Conclusions. The results of the analysis have found that, the maximum energy from wave train depends on wave height and wave period peak. When wave height and wave peak period is high, the wave energy also will increase.

Wave height is potentially greater where there are gently sloping profiles because the depths are less. So, the depth have general trend between producing the wave height and the influence the value wave energy.

Using the field experiment data, the energy of the entire wave train (not just the individual wave) was calculated for each passing boat. A correlation ($R^2 = 0.664$) has been found between the total energy of the wave train and the energy of the maximum wave. An energy relationship that was fitted to the data can be used to estimate the total energy of the wave train where the characteristics of the maximum wave are known:

Boat passenger wave wake is easier to analyze as the accompanying wave periods are low and the wave wake behaves as deep water wave wake in all but the shallowest of water. The salient conclusions reached are:

i. For the deep water condition, there is a clear relationship between vessel waterline length and the period of the maximum wave.
ii. Wave height alone is a poor indicator of erosion potential
iii. Derived wave wake parameters such as energy, power and energy per unit wave height (which is applicable to short period, small craft wave wake), are better measures of erosion potential
iv. A single operating criterion may either not encompass all erosive wave wake components or be overly restrictive for at least some vessel types.

v. Multiple operating criteria such as a combination of wave energy and period limits appear to offer the best solution.
vi. Simplified operating criteria have been derived for several rivers and, with existing knowledge, can be applied to all small recreational vessels.

Recommendations. This study can be improved by getting the effect of wave that is induced by boat that have been calculated on this study and compare with the next study in a different area. The data can be analyzed to have several data and type of boat for relation of wakes wave induce by boat will generate some of energy and may be this energy generated can be used for other resources of renewable energy for the mankind. Hence, the data from the boat can be used for designing other type of hull that does not induce the vey much wave. Thus, the effect of wave to the erosion factor can be reduced.

Acknowledgements. The author would like to thanks to the Department of Maritime Technology, University Malaysia Terengganu (UMT) and the Institutes of Oceanography (INOS), UMT for providing supervision, facilities to collect wave data and Department of Fisheries Kemaman Malaysia for providing the fishing and speed boat information.

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