University of Utrecht

Morphodynamics of Wave-dominated Coasts
GEO4-4434
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Practical 3

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Course coordinator: Prof. dr. G. Ruessink

A. Kotilis	6631032
M. De Botton Falcon	6748546
E.J.V. Smolders	6008399

1 3.1 Theoretical study

- *Plot the evolution of the wavelength L as a function depth h for the following three periods : $T = 6$ s, $T = 9$ s and $T = 12$ s. Consider a water depth varying between 0 and 140 m, with a step size of 0.5 m. Did you expect the results?*

Figure 1.1 shows the evolution of the wave length for three different periods over a water depth from 0 to 140 m. For $T = 6s$, the wavelength increases until the depth is $20m$. While the depth increases further, the wavelength remains constant and equal to $55m$. For $T = 9s$, the wavelength increases up to $\approx 60m$ depth after which it remains constant at around $125m$. Finally, in the case of $T = 12s$, the wavelength rises up to $120m$ water depth and it remains constant at approximately $224m$.
It can be concluded that for all periods there is a region where the wavelength increases with increasing depth which makes the shallow water case, and the region that the wavelength is constant which is the deep water case. As expected, the larger the period, the larger the wavelength. Moreover, in deep water the wavelength is constant with depth and quadratic dependent on T, $L = \frac{gT^2}{2\pi}$. In shallow water, $L = T\sqrt{gh}$, thus the wavelength increases with increasing depth.

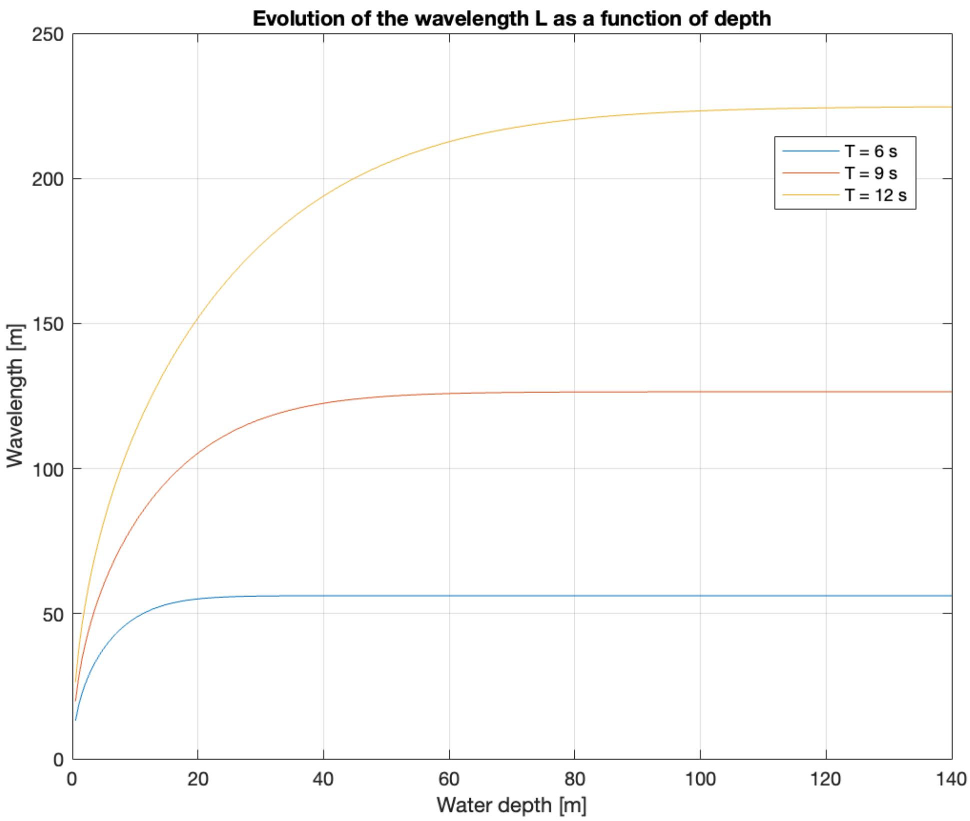

Figure 1.1: Evolution of the wavelength L as a function of depth h for different periods.

- *Plot the evolution of the ratio h/L as a function of the depth h for the same three periods.*

In Figure 1.2, the ratio between depth and wavelength is presented as a function of depth for three periods, $T = 6s$, $T = 9s$ and $T = 12s$. It can be observed that the ratio h/L decreases with decreasing water depth.

- *Plot on the same figure two horizontal lines delimiting the shallow, intermediate and deep water regimes ($h/L \lesssim 0.05$: swallow water, $h/L \gtrsim 0.5$: deep water).*

The two horizontal lines that are plotted in Figure 1.2, delimitate the shallow, intermediate and deep water regimes. For all cases there is an increasing trend, however, the slope is smaller for higher values of T.

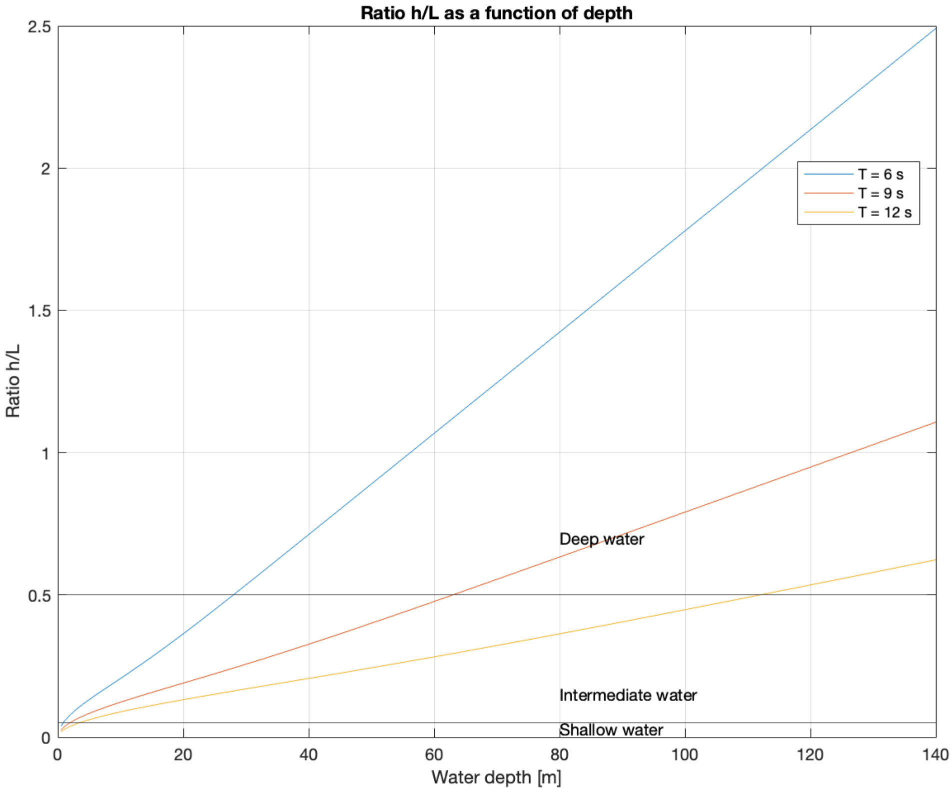

Figure 1.2: Evolution of ratio h/L as a function of depth for different periods

- *For each wave period, determine visually the water depth ranges defining the three regimes.*

From Figure 1.2 the water depth ranges can be visually determined for the three regimes. For $T = 6s$, the shallow regime is lower than $1m$ depth, intermediate water from $1m$ to $27m$ and deep water for depths bigger than $27m$. For $T = 9s$, shallow water is for depths below $2m$, up to $62m$ depth is the intermediate regime and thereafter are the deep waters. For $T = 12s$, depths below $4m$ are for the shallow regime which changes to intermediate up to $110m$ depth and subsequently into deep water regime.

- *On a second figure, divided in 2 subplots, plot the evolution of c and c_g as a function of h(for each subplot, the 3 periods should be represented). Plot also the curve of equation $c = \sqrt{gh}$ on both subplots. Comment on your findings.*

In Figure 1.3, the phase velocity(upper) and the group velocity(bottom) can be seen as a function of depth. Waves with high period travel faster than waves with low period. It can also be observed that for small depths the phase speed is increasing with the square root of depth($c = \sqrt{gh}$), and it is independent of wavelength(non-dispersive waves). However, as the depth increases the phase speed is converging to $c = gT/2\pi$ and is becoming independent of depth as the wave does not interact with the bottom. Comparing with the theoretical line for the shallow water case, it can be seen that the approximation is in agreement with the results for small depths.
The same behaviour can be noticed in the group velocity figure. However, in this case a maximum is observed in the shallow water regime due to shoaling. In the shallow water regime, it can also be noted that $c = c_g$, while in deep waters the group velocity is half of the phase velocity.

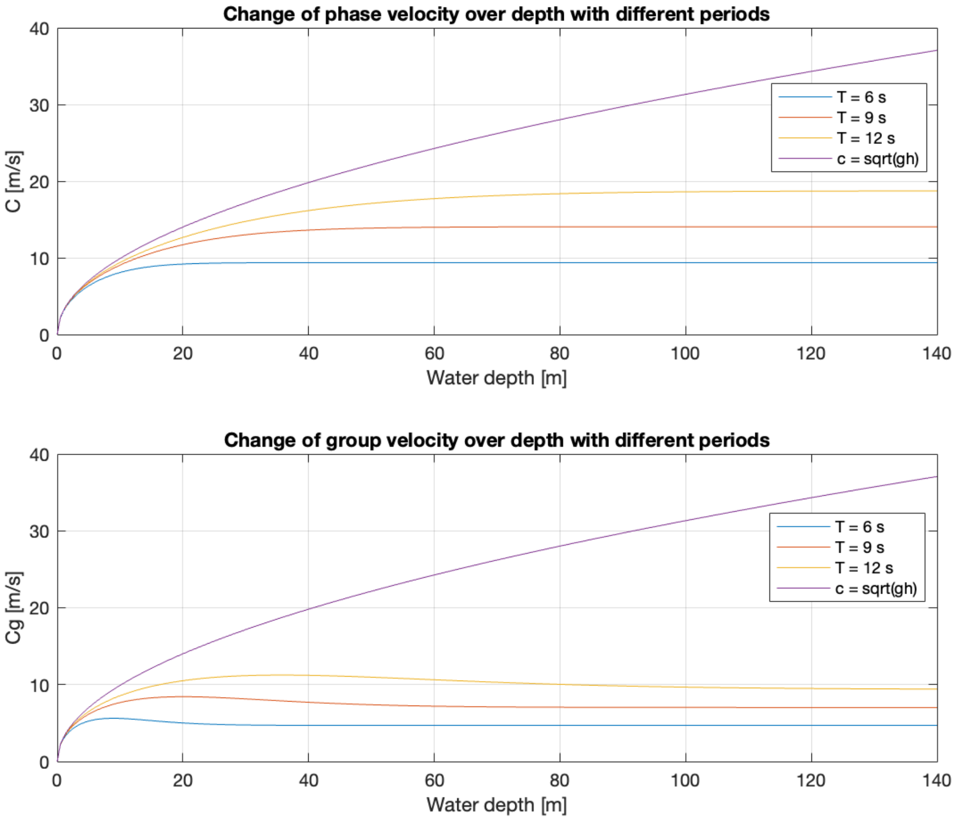

Figure 1.3: Evolution of phase velocity c and group velocity c_g as a function of depth for different periods, comparing with the theoretical velocity given by $c = \sqrt{gh}$.

2 3.2 Egmond dataset

- *Estimate L for each position and each tide. Use the period measured by the offshore buoy, see Table 9.1.*

Figure 2.1 shows the evolution of the wavelength at each cross-shore position for each tide. Furthermore, an estimation of the wavelength L at the different sensor positions for the three different tides is shown in table 1. Clearly, the wavelength decreases from position P1 to P5 for all tides because the water depth decreases resulting in waves with a shorter wavelength. Furthermore, there is a small increase in wavelength at P6 compared to P5 which is due to the fact that there is a small increase in the water depth at that location. Also, it is seen that the wavelength during low tide decreases the most from position P1 to P5.

Wavelength [m]			
Sensor position	Low tide	Mid tide	High tide
P1	43.41	40.61	34.29
P3	35.72	34.82	30.4
P4	25.47	27.17	25.31
P5	23.82	26.95	25.05
P6	28.15	29.13	26.49

Table 1: Estimation of the wavelength [m] at the different sensor locations for the low, mid and high tide measurements.

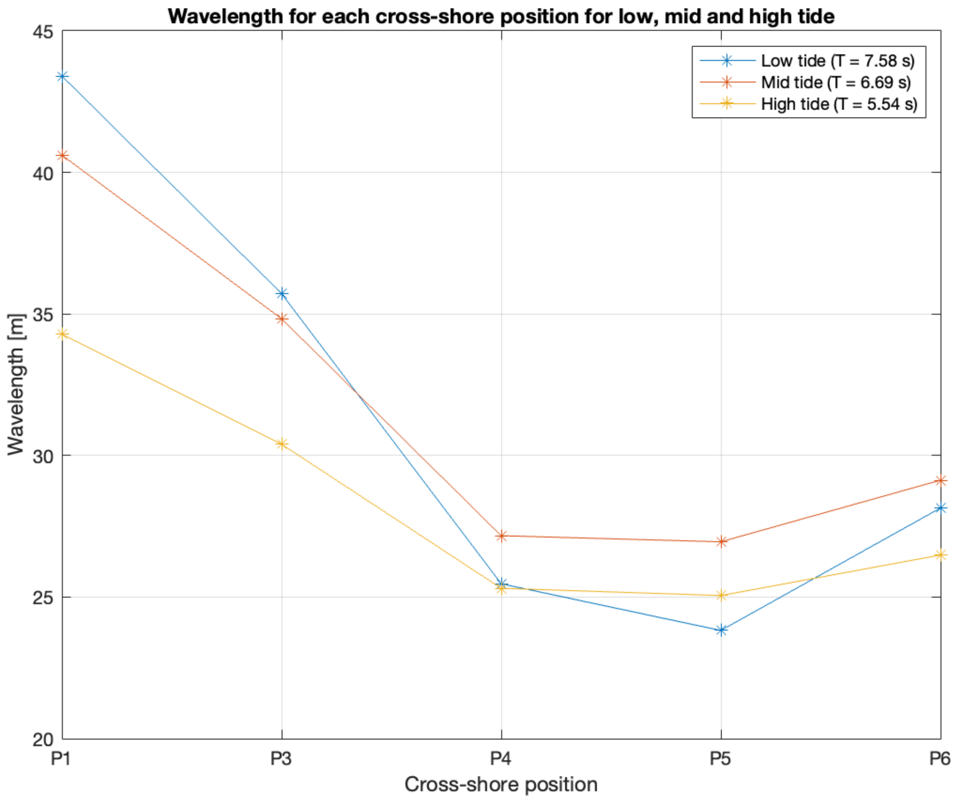

Figure 2.1: Evolution of wavelength L as a function of cross-shore position for low, mid and high tide.

- *When are we in the shallow, intermediate or deep water regime?*

Figure 2.2 shows the ratio h/L for the measurement points during low, mid and high tide as a function of water depth. If the measurement points are below a ratio of 0.05, they are in shallow water. This is the case for the first 3 measurement points during low tide, i.e. at position P1, P3 and P4, which explains the rapid decrease of the wavelength with sensor position during low tide as observed in Figure 2.1. The rest of the measurement points are all observed to be in the intermediate regime.

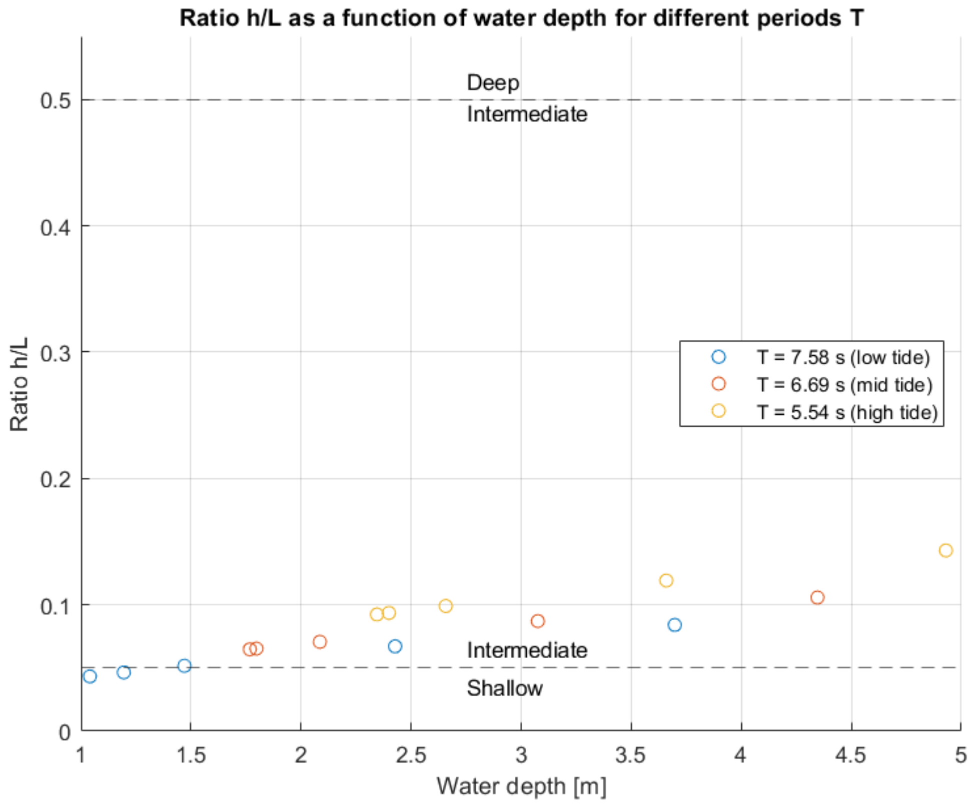

Figure 2.2: Ratio h/L for the periods $T = 7.58, 6.69, 5.54$ s as a function of water depth. The dashed horizontal lines represent the boundary between shallow/intermediate and intermediate/deep water.