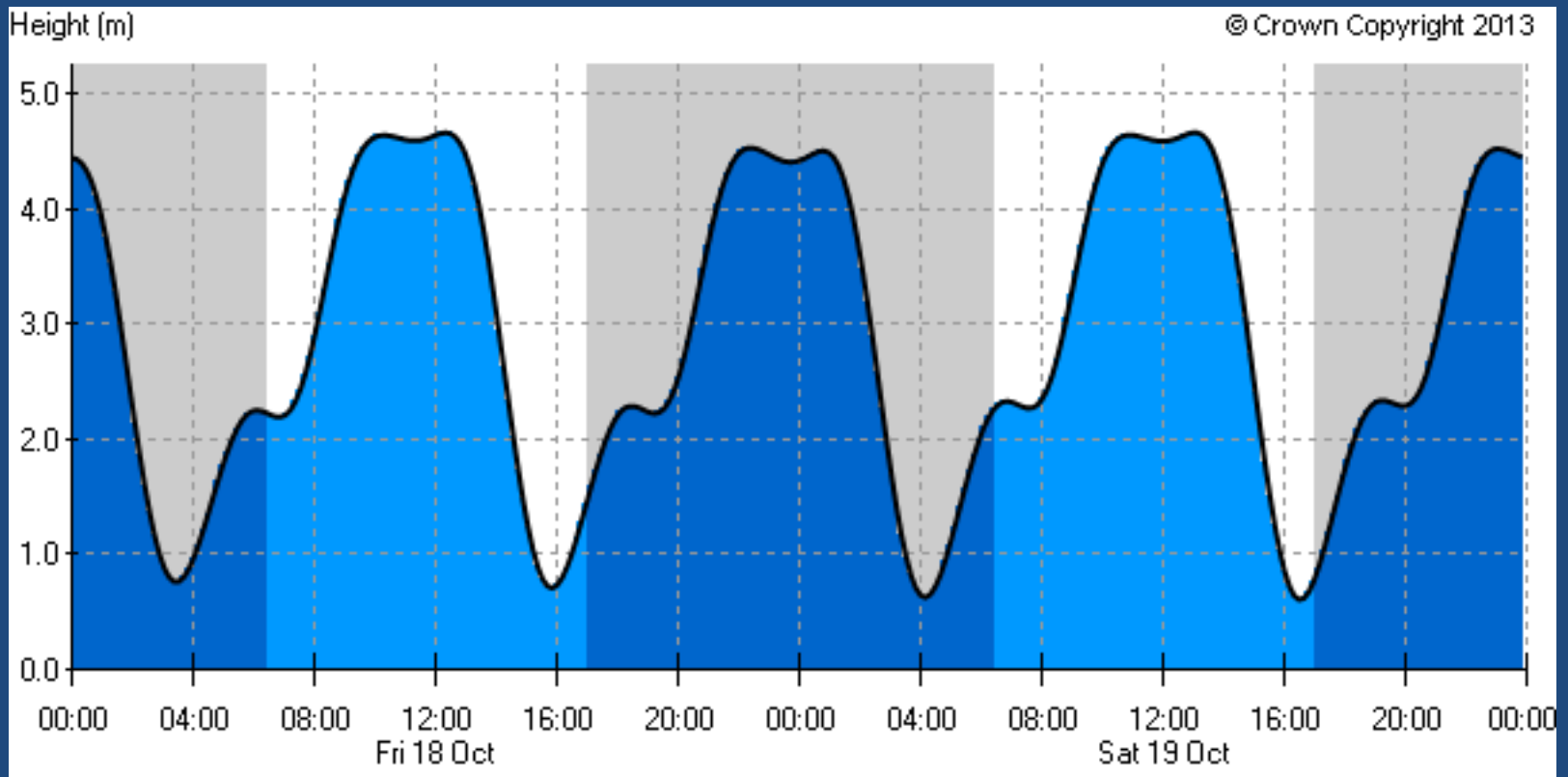


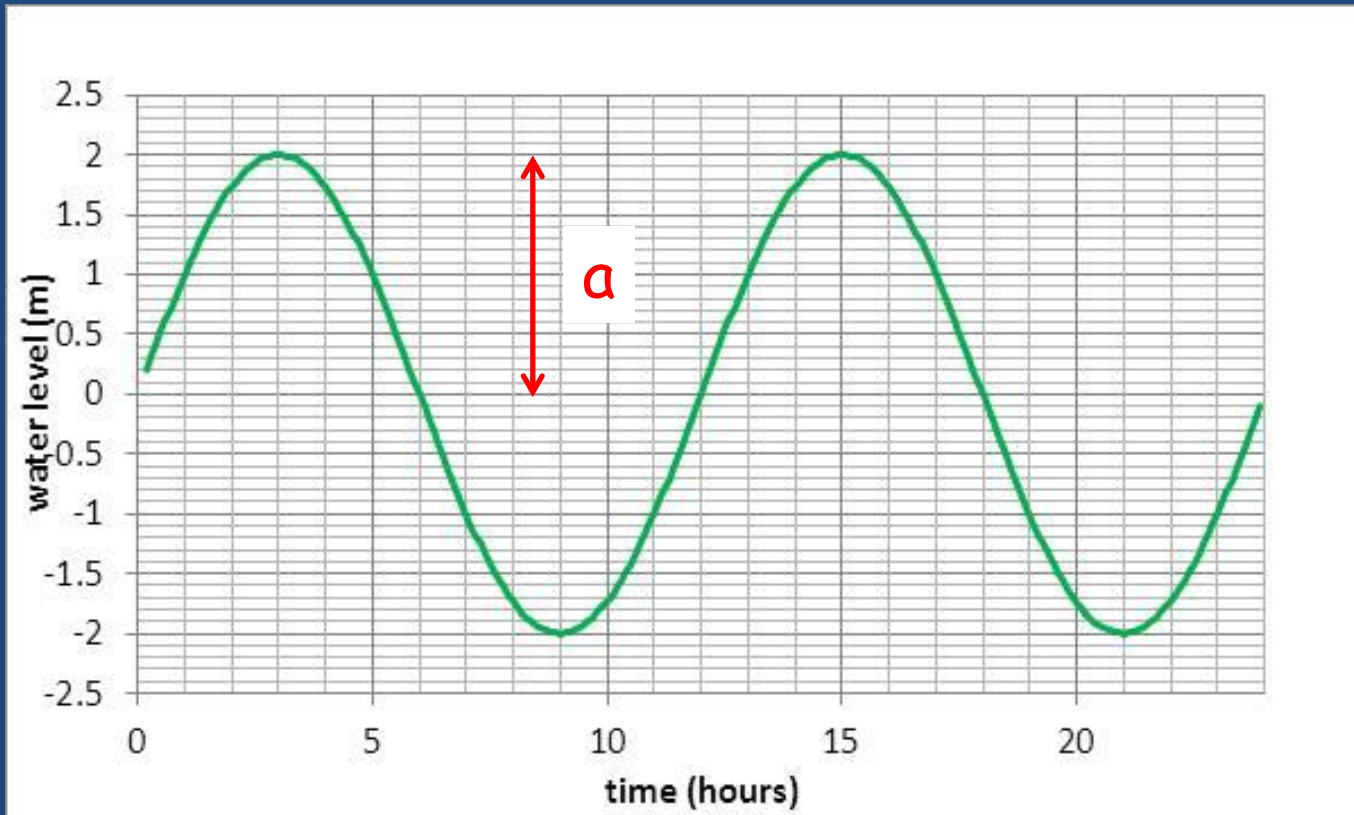
# SEICHES AND DOUBLE HIGH WATERS IN THE MENAI STRAIT

D.G.Bowers, School of Ocean Sciences, April 2014



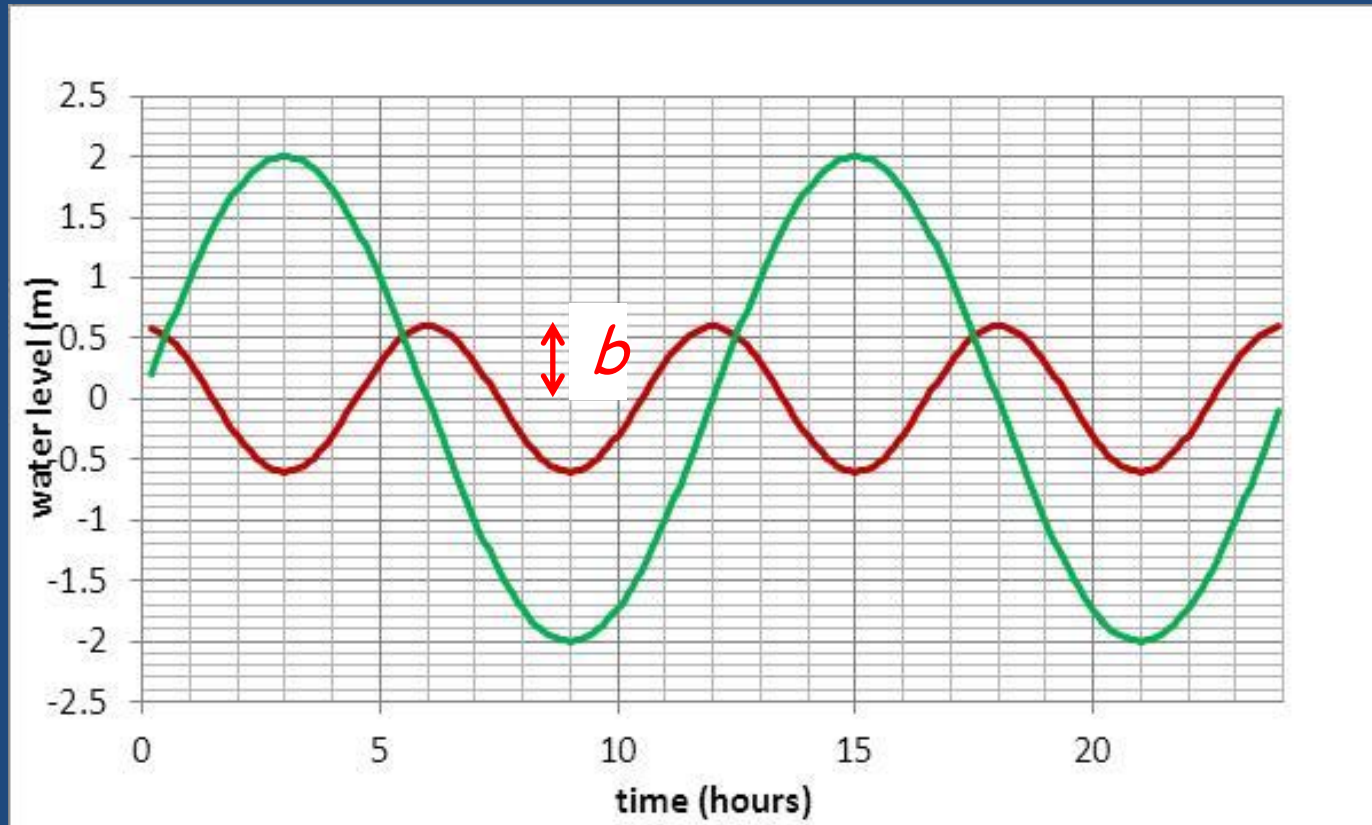
The tide at **Southampton** in **October** last year

# CREATING A DOUBLE HIGH WATER



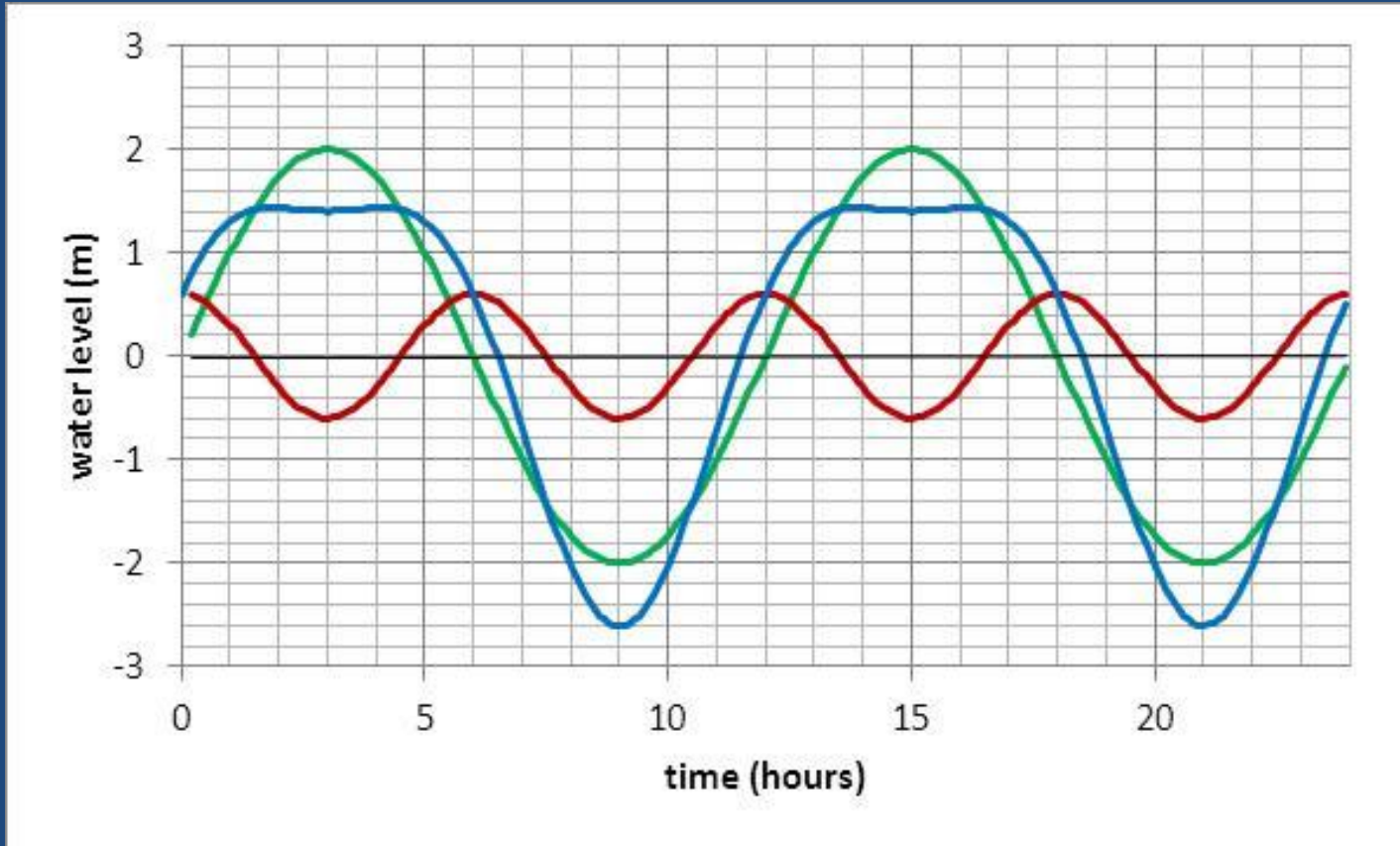
A semi-diurnal tide, amplitude  $a$

# ADDING A HIGHER HARMONIC - OR OVERTIDE



In this case, the overtide is quarter-diurnal, with amplitude  $b$  and just the right phase to produce double high waters

THE SUM, IN THIS CASE, PRODUCES A DOUBLE HW (JUST)

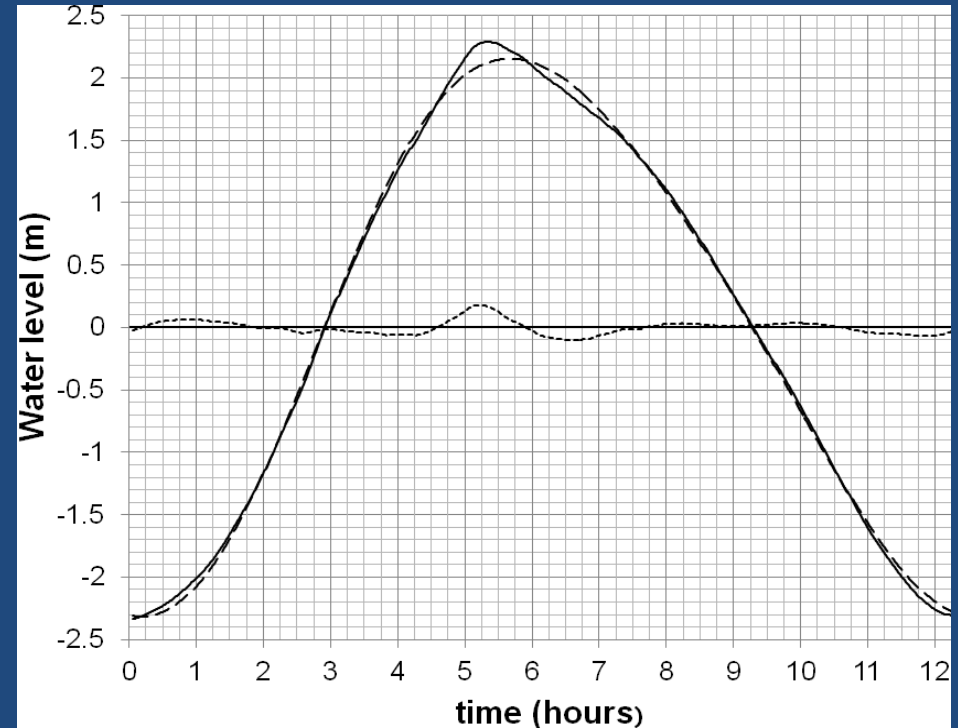
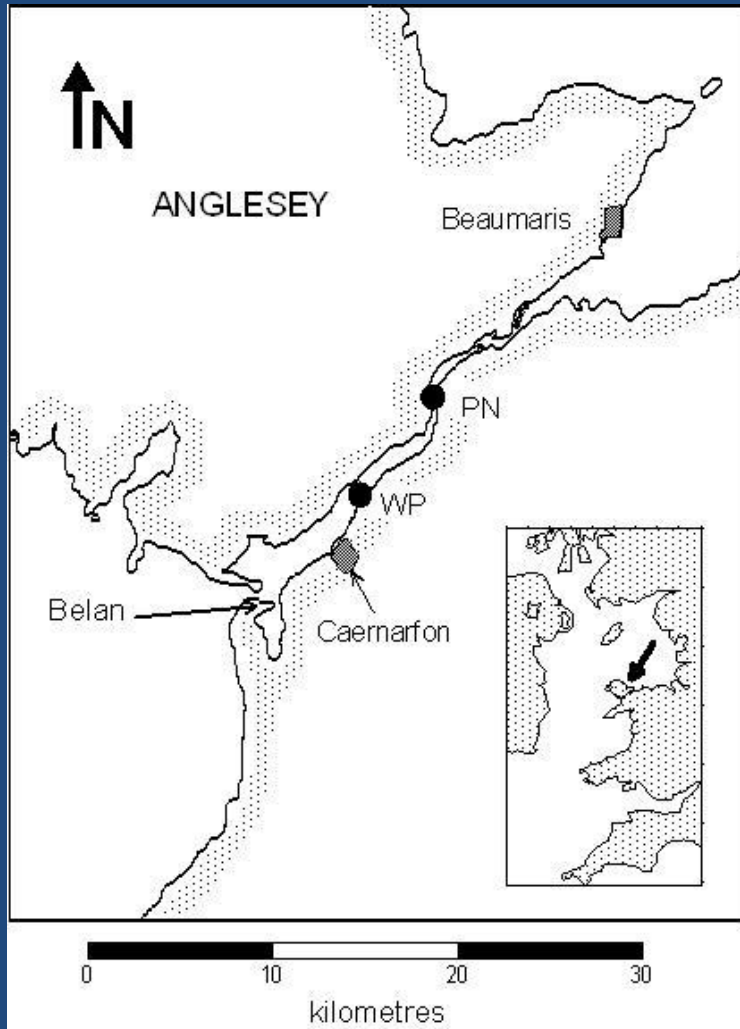


The condition for a double high water (Doodson) is

$$\frac{b}{a} > \frac{1}{n^2}$$

However, this condition is not met at Southampton

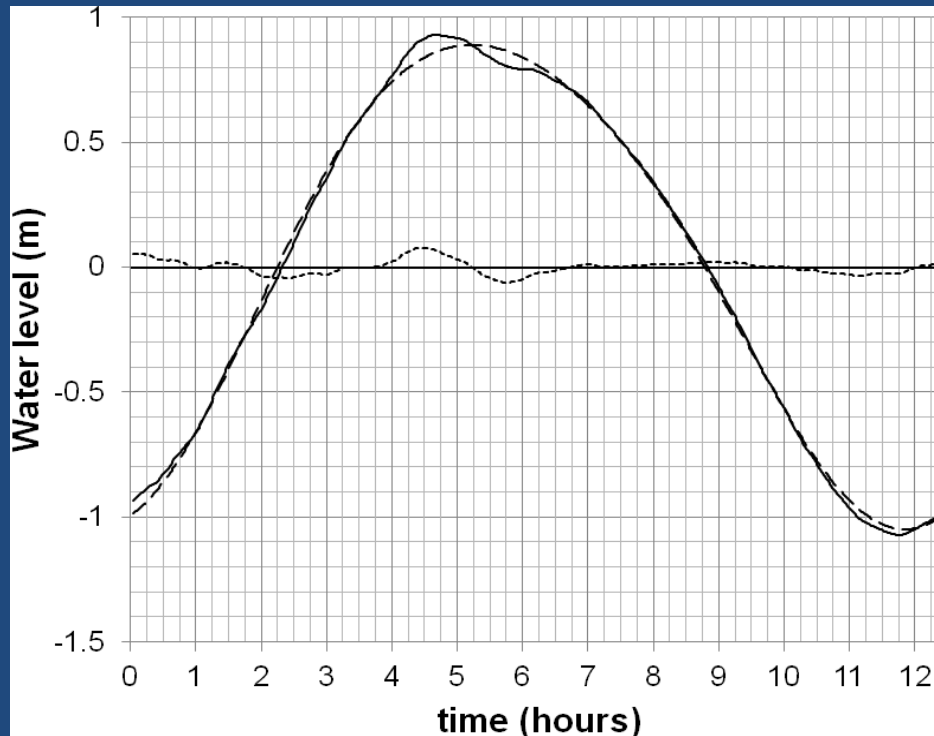
# OBSERVATIONS IN THE MENAI STRAIT



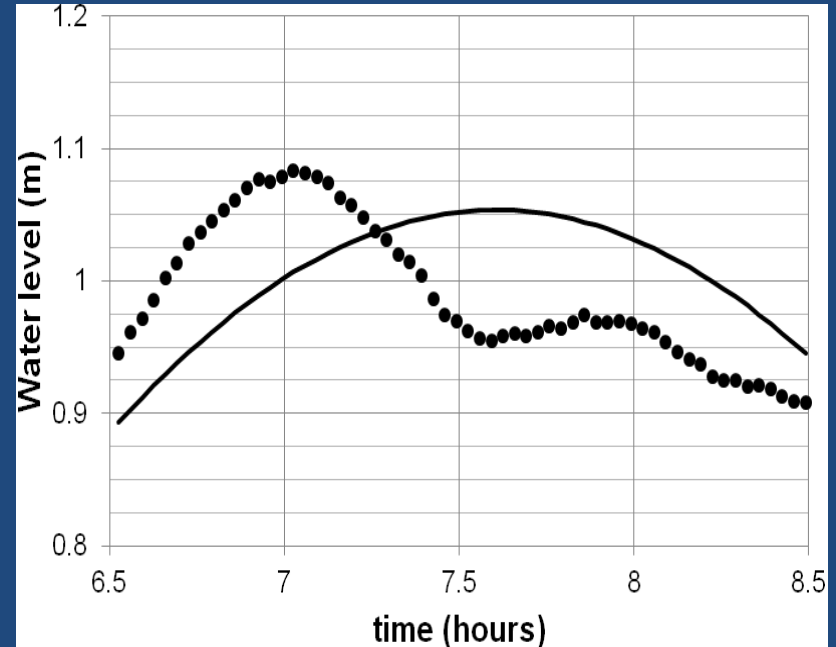
After removing the tide there is a damped oscillation, or a *transient*, with a period of about 2.5 hours

Observations shown are for August 18<sup>th</sup> 2011 at Plas Newydd

Sometimes the transient is vigorous enough to produce a tidal *stand* and, occasionally, a double high tide



24/8/11



2/3/12

The effect of the transient is most marked at *neap* tides, when the tidal range is small

# CREATING TRANSIENTS

Transients are produced by a *sudden change* in forcing

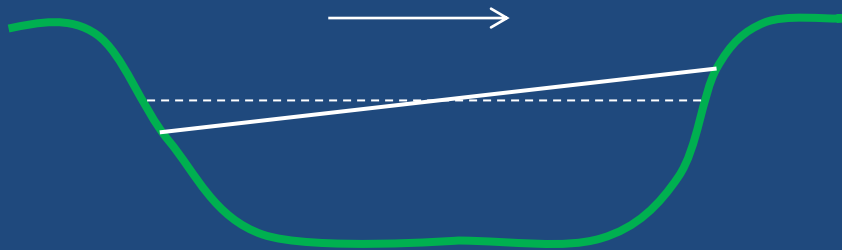


The oscillation has the *natural period* of the object and is *damped* by friction

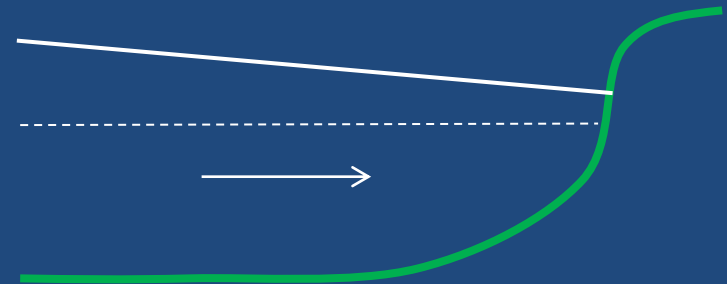
# CREATING TRANSIENTS IN WATER

Transients are produced by a *sudden change* in forcing

a) by the wind



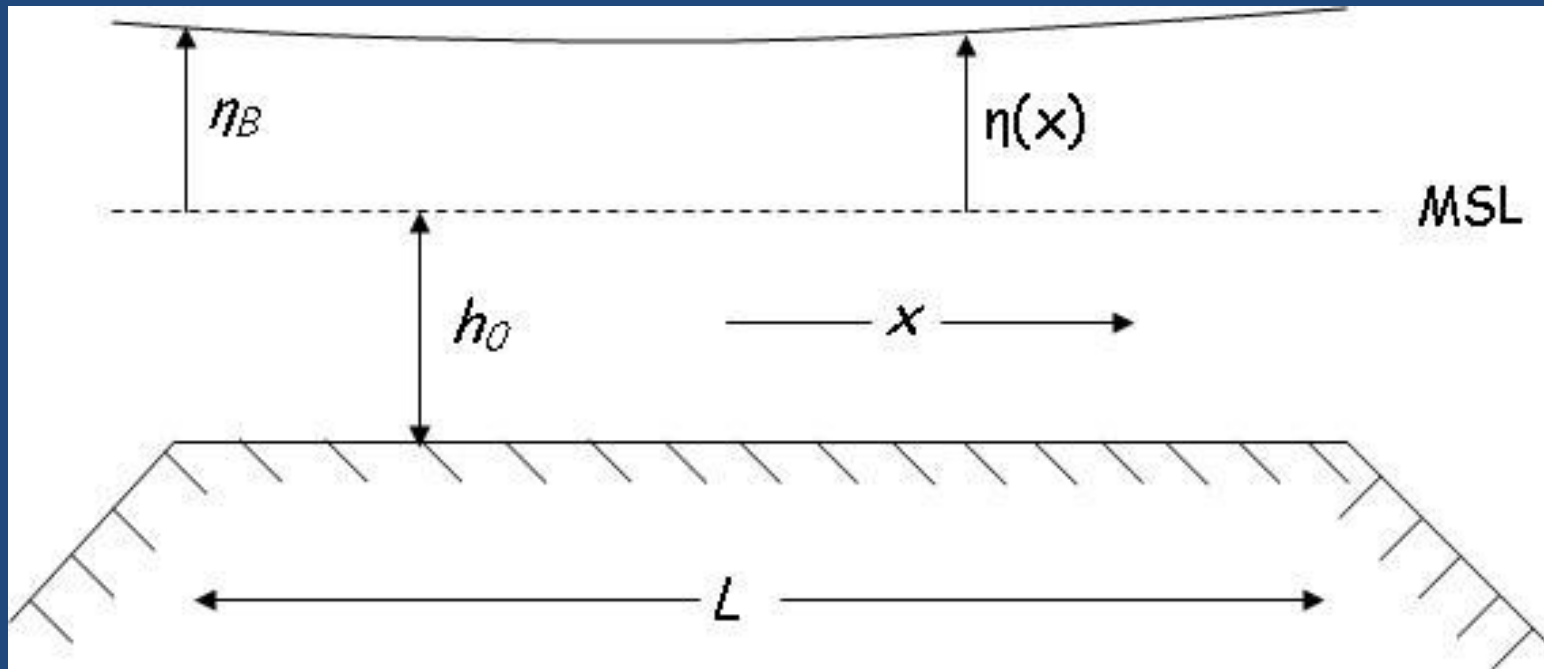
b) by the tide



The transient period depends on the dimensions of the lake; the simplest mode is an oscillation (called a *seiche*) with a node in the centre of the lake

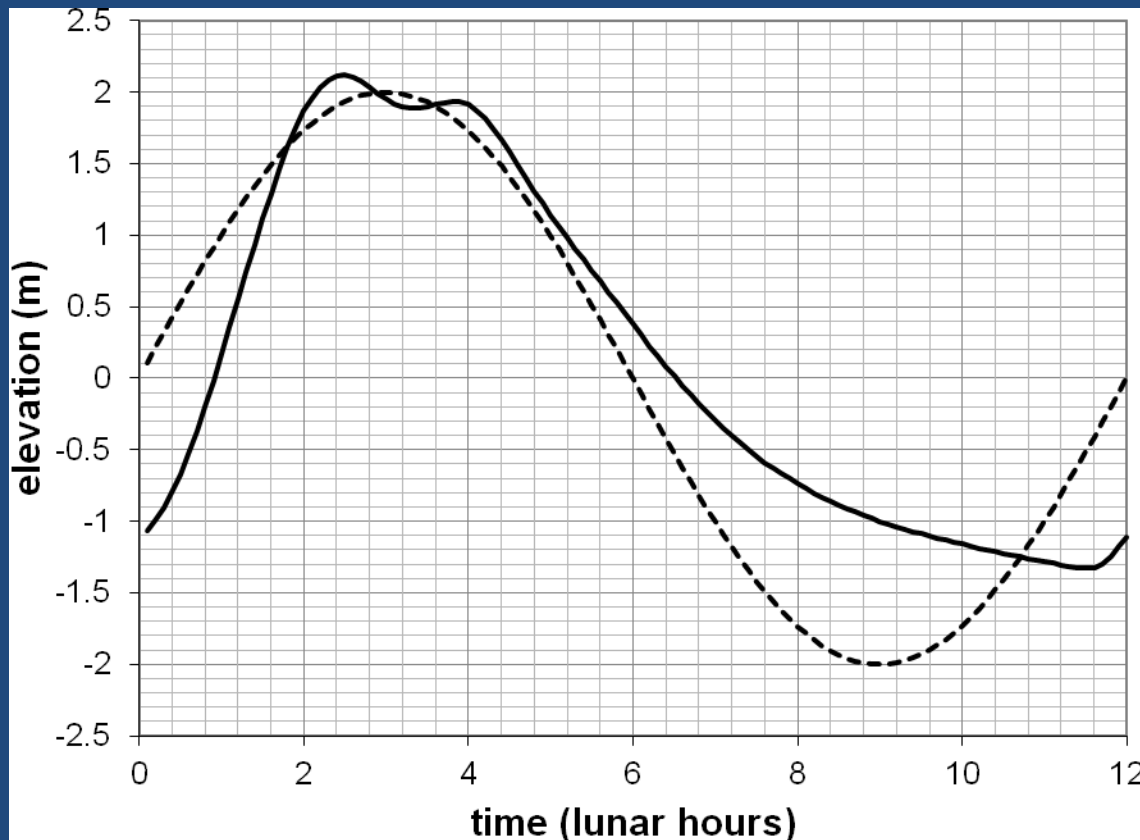
The simplest mode is an oscillation with a node at the entrance to the water body

# A 1-D STRAIT MODEL OF THE TRANSIENT MOTION



solve the equations of motion and continuity. Quadratic friction is proportional to a bottom drag coefficient  $c_D$

# TIDAL CURVES AT END AND MIDDLE OF STRAIT



For a single node in the centre of the strait the period is given by Merian's formula

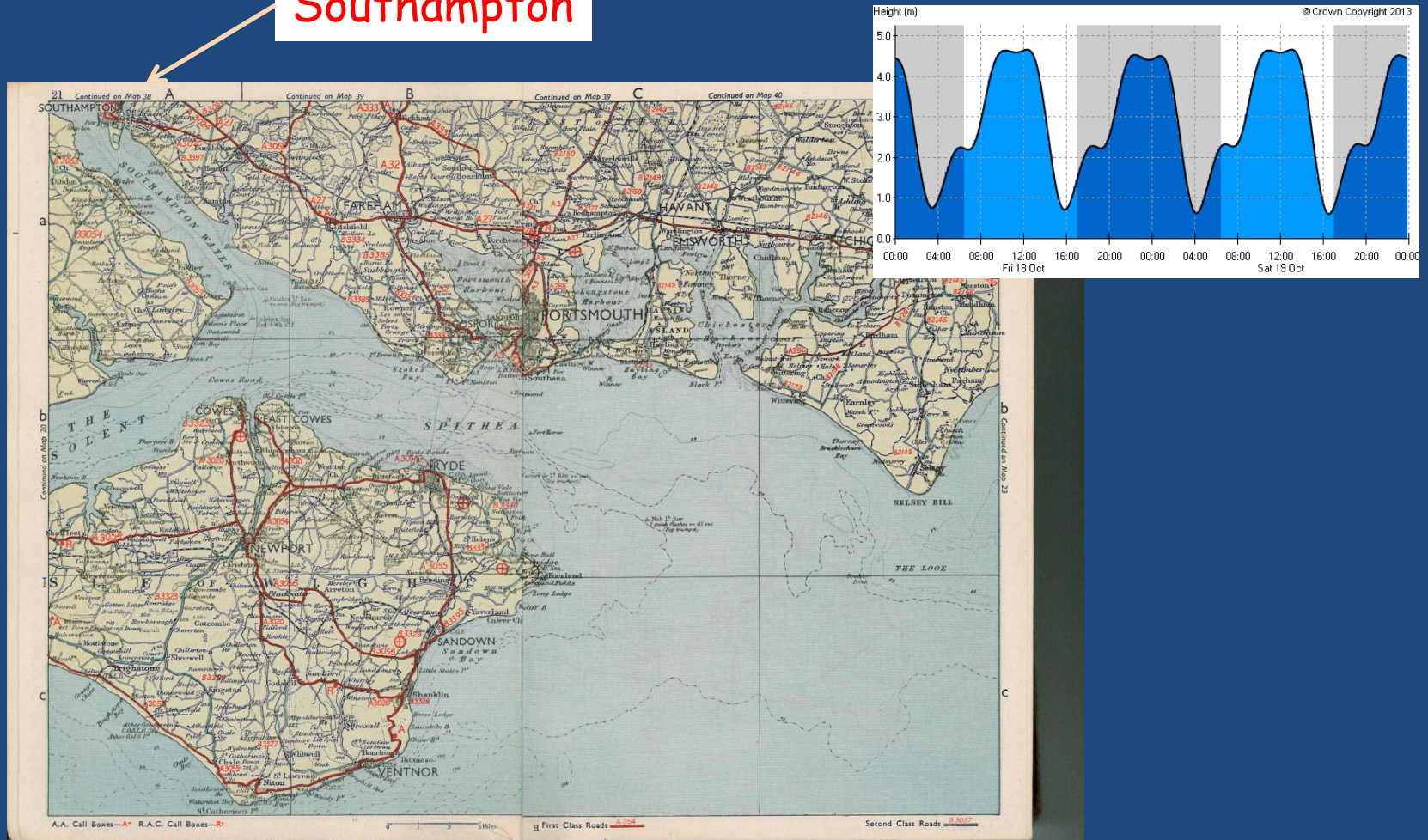
$$T = \frac{2L}{\sqrt{gh_0}}$$

- Modelled water level outside the strait
- \_\_\_\_\_ Modelled water level in centre of strait

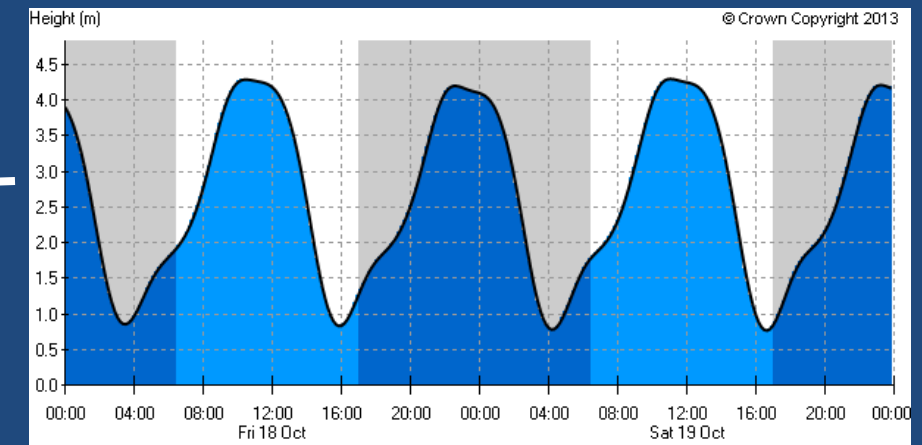
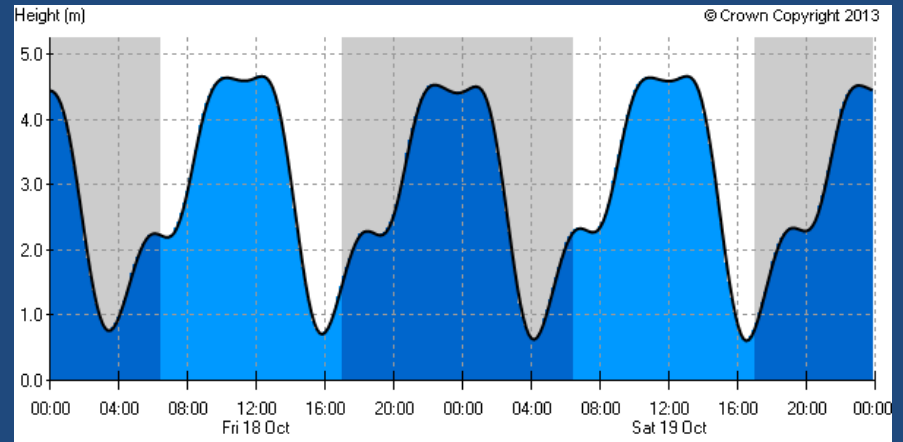
$$L=22\text{km}, h_0=2\text{m}, c_D=0.0015, a=2\text{m}$$

# APPLICATION TO SOUTHAMPTON'S TIDES

Southampton



# The double high tide appears as you travel up Southampton water

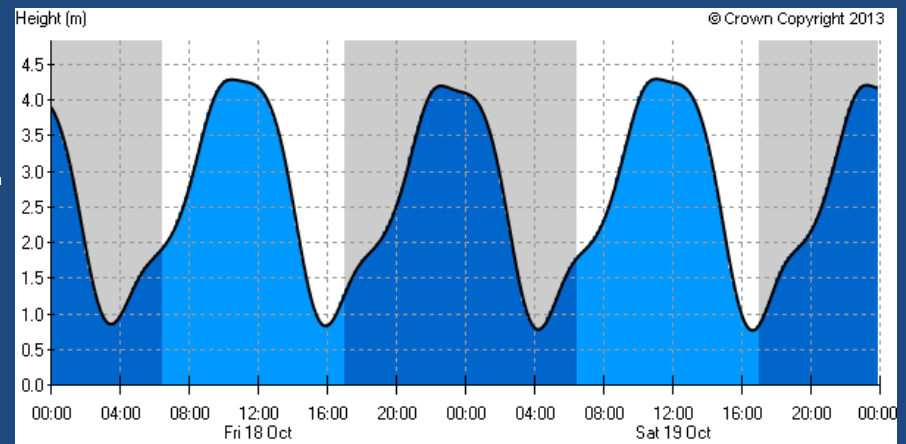


There is no double high tide at the entrance to Southampton water

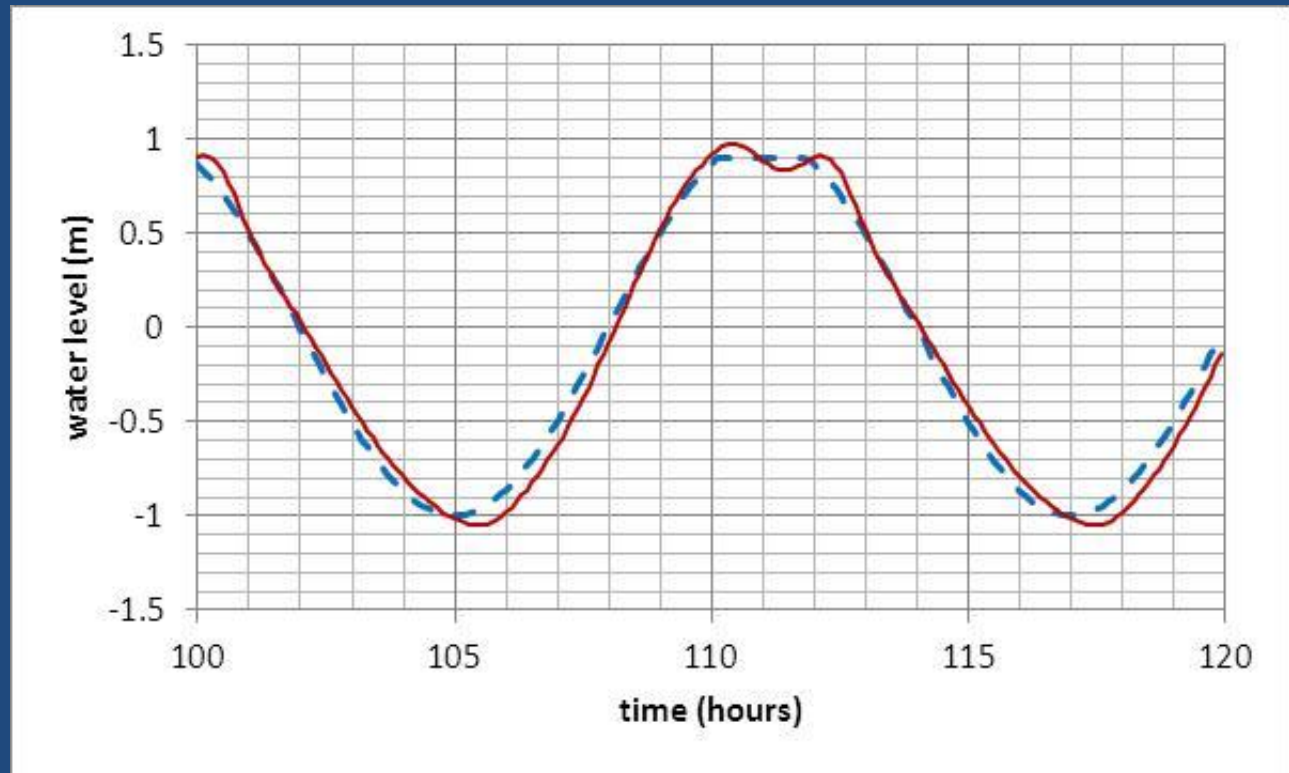
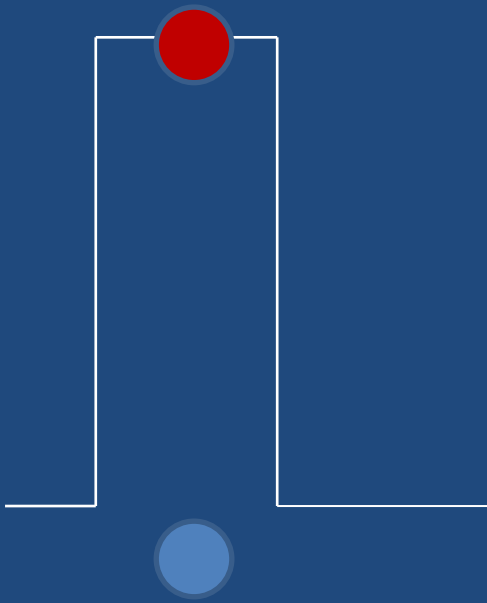
# THE COWBOY APPROACHING THE SALOON BAR DOOR..



The tide at the entrance does represent a rapid change in forcing...



Producing a transient in Southampton Water with a flat-topped forcing tide is actually quite easy



Forcing a Gulf with a flat topped tide

$$L=12\text{km}, h_0=6\text{m}, c_D=0.002, a=2\text{m}$$

# CONCLUSIONS

1. The most famous double high water in the world, at Southampton, can be predicted for tide tables but is not properly understood.
2. Observations in the Menai Strait show that the sudden change in forcing around high water can produce a temporary oscillation - a transient - with a period equal to the seiche period of the strait.
3. The transient affects the tide curve around high water and on occasion produces a double high tide in the centre of the strait.
4. The mechanism is a plausible one for explaining the double tides at Southampton and deserves investigation.