WHY AREN'T ALL TIDES THE SAME HEIGHT?

My previous article explained why there are two high tides a day, when logic would dictate that there should be only one. I now want to explore the changes in the height of the tide, over the course of the month, and over the course of a year.

In order to understand the pattern of the tides, it is first necessary to understand the phases of the moon. Figure 1 shows the positions of the sun and the moon at three times during the month. When the moon is on the same side of the earth as the sun, the dark side of the moon faces the earth, and only a thin crescent of the moon's disk is visible. This is a 'new moon', which is mainly visible during the daytime. At the time of the full moon, the sun and the moon are on opposite sides of the earth, so that the whole disk of the moon is sunlit, when seen from the earth. The full moon is highest in the sky in the middle of the night. Between the full moon and the new moon, the moon is around the 'side' of the earth, and a 'quarter' moon is visible—the 'first quarter' occurs after the new moon, and the 'last quarter' after the full moon. In both cases, the moon is lit from the side, so that half of the disk is illuminated. The moon is at its highest around dusk (first quarter) or dawn (last quarter).

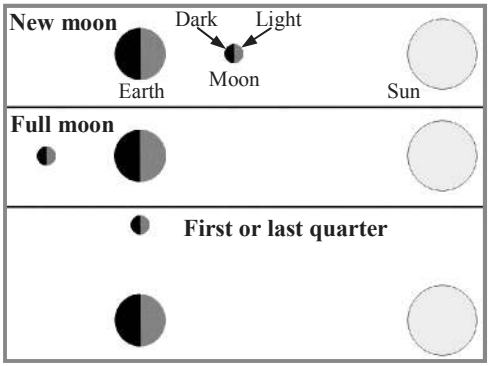

Fig 1: Relative positions of the moon, earth and sun at new moon, full moon and first and last quarters

The main factor producing the tides is the moon's 'tidal force', which is the difference between the moon's gravity on the side of the earth facing the moon and the moon's gravity on the opposite side of the earth. The sun's tidal force is much weaker than the moon's (because the sun is much further away), but it also exerts a 'pull', which modifies the effect of the moon's tidal force. At the time of the new moon, the sun's tidal force acts in the same direction as the moon's, causing the tides to be higher. At the time of the full moon, the sun is opposite the moon in the sky, and its tidal force adds to the 'centrifugal force' of the earth's rotation (described in the previous article), again causing the tides to be higher. Both these times of higher tides are called 'springs'. This is nothing to do with the season of the year—the word 'spring' is used as in a 'jump' or 'leap'. At the times of the first and last quarters, the sun's tidal force pulls 'sideways', compared with that of the moon, and it

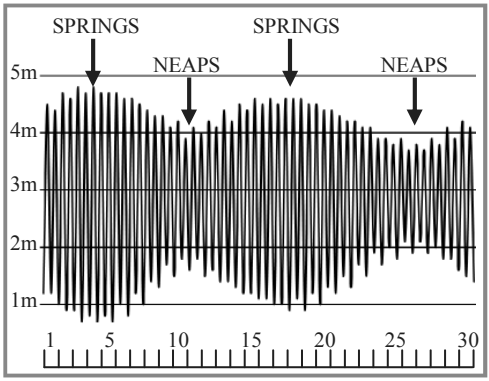

Fig. 2: The rise and fall of the tide at Portsmouth during November 2009

actually reduces, rather than increases, the height of the tide. These lower-than-average tides are known as 'neaps'—the Old English word for 'low'. In the course of a month, there are two spring tides and two neap tides. Figure 2 shows the rise and fall of the tide at Portsmouth during a single month (November 2009). The difference in height between the springs and neaps is clearly visible, but it is also apparent that not all spring (or neap) tides are the same height. This is because of the changing height of the sun in the sky.

Because the earth's axis is tilted relative

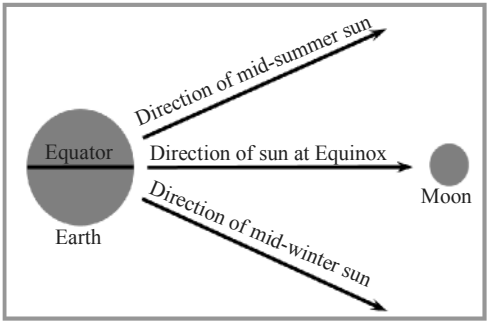

Fig 3: The sun and moon are in line at the equinox; the alignment is poorest at mid-summer and mid-winter

to its orbit, the sun changes its height in the sky over the course of a year. At the latitude of Bosham, the height of the sun above the horizon is 62° at the summer solstice (21 June) and only 16° at the winter solstice (21 December). The sun is exactly opposite the equator at the times of the vernal equinox (20 March) and the autumnal equinox (22/23 September). The highest tides occur when the tidal forces of the sun and moon act in the same direction. Since the moon orbits the earth roughly in line with the equator, the sun and moon are in closest alignment when the sun is also over the equator, which occurs at the equinoxes (Figure 3). Thus, the highest tides of the year occur around the time of

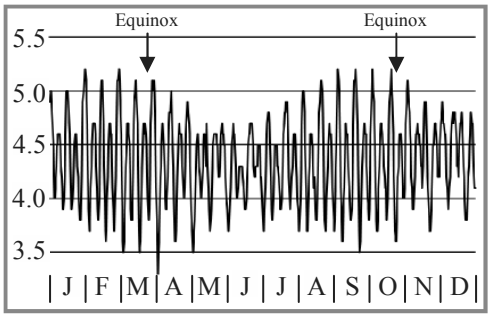

Fig 4: Heights of successive <u>high</u> tides at Bosham during 2010

the equinoxes, and are called (surprisingly enough) equinoctial tides! Figure 4 shows the height of the high tides at Bosham during 2010. The highest tides are in February/March and September/October. There is clearly no exact correspondence between the height of the tides and the dates of the equinoxes, although a general trend can be seen—the highest tides are in the spring and autumn, with lower tides in the summer and winter. The correspondence is not exact because of other factors which affect the height of the tides, including the distance between the moon and the earth, and the distance between the earth and the sun. The third article in this series will examine why the high and low tides occur at the times that they do.

(*Revised February 2015*)