Frequency range and marine fouling

Datawell - Oceanographic Instruments

Introduction

At some locations at sea, the growth of biofouling can be so impressive, that one cannot help wondering whether this would not affect buoy performance. The reassuring conclusion of this note is that the effect of biofouling on *heave* measurements is virtually non-existent, except for a small decrease of upper wave frequency.

For soft ('non-calcareous') biofouling such as seaweed (see Figure 1 a), this can be sensed from the fact that the specific weight of marine growth does not significantly differ from that of sea water, and that the soft fouling moves as easily with the waves as the water particles or indeed the buoy itself. Hard ('calcareous') fouling such as barnacles and zebra mussels (see Figure 1 b, c) however do have a subtle effect on measurements, in slightly increasing the effective diameter (D) of the instrument. Since the upper limit of wave frequencies that a buoy can measure is proportional to $D^{-1/2}$, every percent increase of (virtual) diameter reduces the upper frequency by 0.5 percent. This decrease with fouling is indeed observed during an instrument test period at the North Sea, and the observations are shared in this note.

Figure 1 (a): Examples of marine fouling of different type and way of attachment. (a) Soft seaweed, off the coast of California. Courtesy of Scripps Institute

The 2012 sea trial results

A Datawell DWR4 0.9m buoy with ACM was deployed in the North Sea, 1 km off the pier of IJmuiden during the summer of 2012 (March to August). The sea trial was aimed to test the Acoustic Current Meter (ACM), especially during a period of intensive marine fouling growth, and it yielded both wave and current data.

The upper frequency limit for each heave spectrum is defined as the frequency value up to where the power law $S \sim f^{-n}$ for the spectrum holds (see Figure 2). It is determined as the abscissa of the point of intersection of two linear fits in the log-log plot of the power spectral density, one at frequencies below 0.78 Hz, the other at frequencies above this value. The results were averaged over a day and plotted in Fig.3 (left). It is seen that the cut-off frequency is more or less constant until mid-July (and equal to the one determined for 0.9 m buoy [1]), after which it rapidly decreases.

Figure 1 (b) Mussels, Off the Belgian coast. The buoy is completely hidden from view by a 'sleeve' of fouling.

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The ACM is equipped with 3 ultrasonic transducers. The relative signal strength (RSSI) of each transducer is strongly dependent on the amount of fouling covering the active part of transducer. From Figure 3 (right), it is seen that the decrease of the cut-off frequency over time coincides very well with the decrease of the RSSI, i.e. with the increase of bio fouling.

Figure 1 (c) Off the coast of California. The underwater part is encrusted by hard fouling. Courtesy of Scripps Institute (2010).

Conclusions

The performed data analysis shows a subtle sensitivity of the sensor's high frequency response to the amount of fouling encrusting the buoy hull. Similar results were observed at other locations, e.g. off the Pacific coast of California, in the period 2012-2013.

[1] "Experimental investigation of the high frequency response of 0.4, 0.7 and 0.9 m diameter buoys", Datawell Technical Note T.03.01. Here the cut-off frequency of the free floating buoys was determined to be 1.00, 0.88 and 0.78 Hz respectively. Here we can

see the trend: the bigger the buoy the lower is the cut-off frequency.

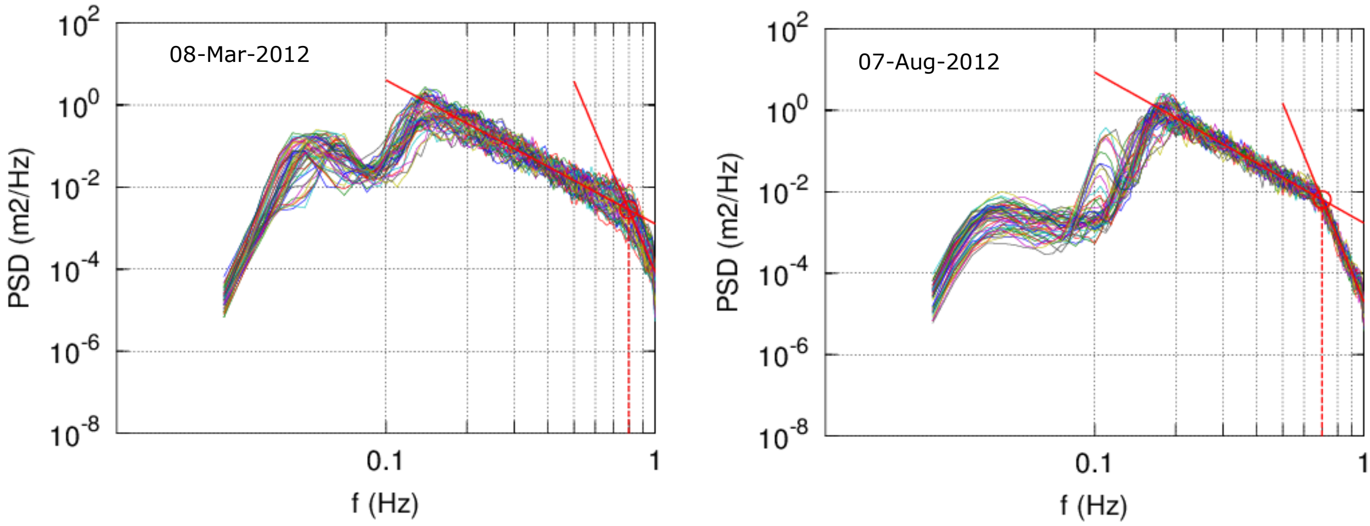

Figure 2: Logarithmic plots of heave spectra within one day in the beginning (without fouling) and in the end (with fouling) of the sea trial. The red solid lines are the results of numerical linear fit and serve as guidance for an eye to identify a kink (cut-off frequency).

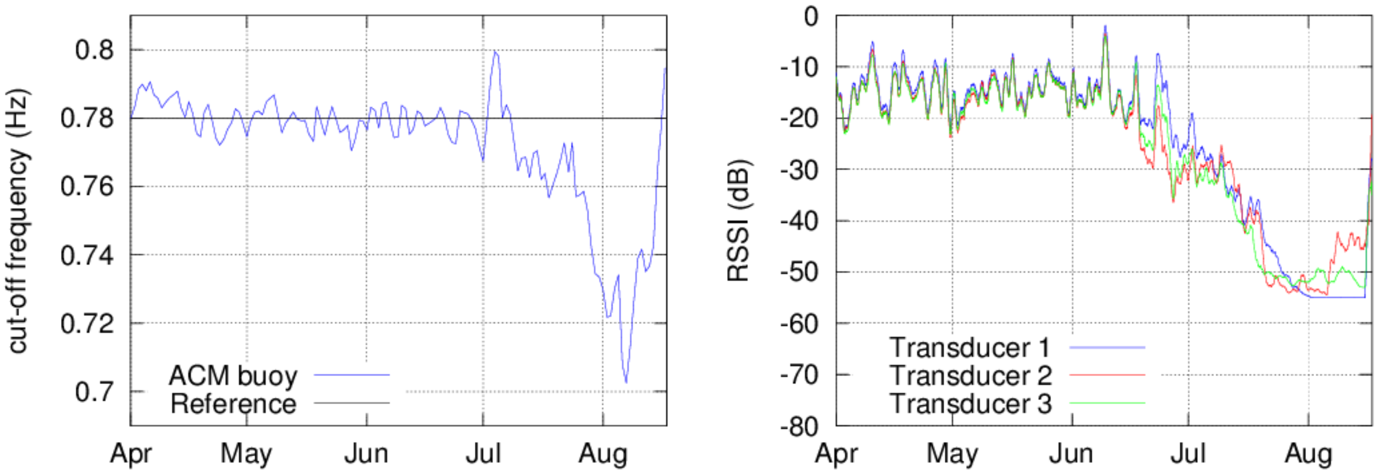

Figure 3: Left: cut-off frequency calculated per day during the sea trial. The reference level corresponds to the previously determined value of 0.78 Hz for 0.9 m. buoy. Right: RSSI of all 3 transducers during the sea trial.