# Fucoid extent salinity measurement: <br> Change from mean to median 

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## Author: Best, M

## Recommendation

Due to tidal asymmetry in certain estuaries it is recommended to change from using average (mean) salinity to median ( $50 \%$ ile) salinity as the measure of central tendency for the fucoid extent tool.

## Background

The fucoid extent tool requires that we know the salinity that bathes the fucoid seaweed at the uppermost end of the estuary. This can be almost fresh water. Historically we have used the average salinity calculated from at least two spring/neap tidal cycles, ideally covering both a low freshwater flow period (tending to be higher salinity) and a high freshwater flow period (tending to be lower salinity). The average salinity acts as a surrogate for the amount of time the seaweed spends in potentially low salinity water.

However there are a number of water bodies where the tidal asymmetry leads to a rapidly changing salinity so that the average salinity does not reflect the true salinity regime faced by the Fucus plants. In estuaries (or estuarine arms) where the salinity changes very rapidly from low to high salinity (and vice versa) then it is possible get a mid salinity value as the average (e.g. a range from $0-28$ would generate an average salinity of about 14) which may not actually reflect the status of the estuary (i.e. the salinity of 14 would be moderate status and yet there is no pressure).

## Examples

Southampton water, in particular the Test tributary, is unusual. It is a shallow narrow winding estuary at the top, and a wide deep estuary below Redbridge. The salinity just upstream (north) the bridge is below 3 and then switches very quickly to a salinity of over 25 on each tide.


Salinity data was collected every 15 minutes over a spring neap tidal cycle from Southampton water (Test), Southampton water (Hamble) and another South East transitional water, the Adur. The data have been plotted below to demonstrate the variation in the salinities from these sites.

Salinity measurments Test, Hamble, Adur


The figure shows how much of the time the salinity in all of these estuaries is less than 5 ; however, they vary substantially in the proportion of the cycle which is high salinity. The Test rapidly drops from 25 to 5 salinity, while the Hamble (which is another arm of Southampton water) drops from 25 to 5 salinity in a more linear fashion. The Adur which is a different system show a steady but steep decline from 30 salinity to 5 and then a very slow decline to 0 salinity. These patterns have a strong influence on the mean salinity and hence the overall WFD classification. The premise of the tool is that fucoids will find low salinity stressful but can tolerate very low salinity conditions when there are no other pressures acting on them. The mean salinity would not indicate this here as the amount of time spent in high salinity is not accurately represented when there is a relatively rapid switch as in the Test. A median ( $50 \% \mathrm{ile}$ ) would more fully represent the mid salinity in these samples. The table below summarises the data for these points.

|  |  |  | Standard <br> deviation <br> of the |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Waterbody | Tributory | Mean | mean | Min | Max | median |
| Southampton water | Itchen | 10.58 | 11.10 | 0.19 | 29.96 | 2.61 |
| Southampton water | Test | 14.47 | 12.47 | 0.19 | 29.92 | 2.75 |
| Southampton water | Hamble | 8.62 | 9.04 | 0.01 | 26.58 | 3.41 |
| Adur estuary | Adur | 4.45 | 8.09 | 0.01 | 32.22 | 0.28 |

This illustrates an extreme situation over a single tide.
In practice continuous salinity results are gathered over 2 periods of at least two weeks in length. The salinity data is normalised to flow. However there is still a noticeable difference between the mean and median for many water bodies.


The data in the figure above have been ordered by the absolute difference between the mean and median salinity values, as a proportion of the larger of the two salinities. Those water bodies where the difference is greatest (approximately $60 \%$ difference) are at the left of the graph and those where there is very little difference are at the right (about $3 \%$ difference). There is only a class change in 3 or 4 cases.

## Conclusion

From the above it is clear that the median salinity is more representative of the typical salinity experienced by the Fucus plants, especially in estuaries where there is a significant tidal asymmetry. Moreover this amendment does not significantly alter most classifications. It is recommended that we use median salinity in all future classifications.

