Dispersion of heat in Southampton Water

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The mathematical procedure of Pearson and Pearson⁵ is attractive in its simplicity and yet generally compatible in accuracy of depiction with the rather coarse data customarily available for describing the complex physical conditions in estuaries.

45. In common with mathematical models generally it has the merit that, once the model is set up, it is a relatively straightforward matter to vary the values assigned to the input parameters and to ascertain the effects. Particularly appropriate to this kind of treatment are environmental problems where, for example, the long-term plans for a region envisage changes in effluent quantities and qualities and it is desired to predict what the general pollutional status will be in, say, the future 25 years. Such an estimate, albeit tentative, has been made recently for Southampton Water, again using salinity as the tracer for mixing.¹³

46. However, it is important to recognize the limitations of the simplified treatment, especially in respect of the assumption of complete mixing. Although the lower reaches of Southampton Water are fairly well mixed, there being only a small increase of salinity with depth below the surface, the upper reaches are stratified (segments 7 and 8 in particular) and probably more markedly so now as a result of the considerable change in configuration brought about by the new container berths.

47. The method is also very dependent on fairly reliable assessments of salinity gradient, which in the present instance is quite small in the lower reaches, as is apparent from the large values of F_i^* in Table 3. Unfortunately, salinity has not been monitored in Southampton Water and this means that, unlike the case with temperature, the long-term averages are not known, although the values assumed are no doubt, in the light of present knowledge, a fair representation. More recent data have shown that there is significant variation with river flow.¹⁴

48. As is evident in Table 3, there is a marked difference between the salinity value of segment 1 and that for the Solent outside, which has been taken as 35 parts per 1000—the same as that for the open sea. The conditions assumed for the seaward end affect the results and if the initial salinity difference were less, temperature estimates would be higher and conform more to measured values. On the basis of reliable and representative salinity values in this important entry region it would be possible to predict the flushing characteristics of the estuary (i.e. the proportion of new water which enters on each tide): a feature of obvious importance from the point of view of the heat balance. Recent indications are that about 30% is new water, but the proportion varies significantly with tidal range and river flow.

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We agree with Mr Webber that stratification and variable river flow could have an important bearing on variations of the temperature distribution in the upper part of

Southampton Water. In the lower part of the estuary, where these factors may be less important, the effects of uncertainties in the mean salinity of the Solent may well merit further study.

50. We considered a simple model based on mean salinity values, accepting the limitations implied by ignoring microstructure, to find out how useful such a simple treatment could be. In particular, lateral and vertical salinity gradients were neglected and replaced by average values. However, the reasonable agreement found between calculated and measured segment temperatures has shown that the method can be used with some confidence to predict the mean temperature distribution, particularly in estuaries where knowledge of salinity is too limited to afford a basis for greater sophistication.

51. As a Solent salinity of $S_0 = 3.5\%$ might be excessive in relation to a salinity of about 3.3% within the first segment, calculations were also made taking $S_0 = 3.4\%$. This reduced computed segment excess temperatures T_i by about 0.08 deg C on average, while raising natural excess temperatures θ_i (due to mixing of salt and fresh water) by about 0.03 deg C. Hence the overall excess temperatures $T_i + \theta_i$ were reduced, on average, by 0.05 deg C. From this we concluded that this model was probably rather insensitive to small errors in S_0 .

52. We understand that Mr Webber is obtaining and collating further data on the salinity variations within the estuary. It may then be possible for him to improve the results from this simple model by using more accurate estimates of mean salinities.

53. If accurate lateral and vertical salinity profiles are obtained for a number of vertical sections distributed along the estuary, a more complex computer based model might be used to simulate the situation more closely. The estuary could then be divided into a larger number of volume elements or cells, with mixing flows through their interfaces determined as before from salinity data.

54. We look forward to learning of Mr Webber's further results, but would stress that the simple model provides a useful estimation of heat or pollutant dispersal in any estuary for which limited salinity data are available.

References

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