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COMMENT

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The new physical definition of salinity: Biologists beware

For reasons associated with the needs of physical oceanographers, there has been a gradual replacement of the method for the determination of salinity from that involving chlorinity to a definition based wholly on conductivity (e.g. Cox et al. 1967). The most recent practical definition of salinity (Perkin and Lewis 1980) is based on the conductivity of a sample of seawater in comparison with that of a standard solution of potassium chloride (KCl), in which the mass fraction of KCl is 32.4356×10^{-3} , the temperature is 15°C, and the pressure is one standard atmosphere. For physical oceanographers this is an important improvement in the salinity standard, but for biologists it is equally important to recognize that the continuing trend away from a chemically based definition not only may be less useful but may also mislead, when compared to earlier definitions based on the chloride content of seawater (Knudsen et al. 1902). In other words the newer definitions of salinity based on conductivity are no longer a measure of how much seawater contributes to a mixture of seawater and freshwater. This particularly becomes a problem for biological oceanographers who work in estuarine environments; a simple example will suffice to explain this comment.

If on the practical salinity scale a sample of Baltic water is 5.000 (a dimensionless number: Perkin and Lewis 1980) it may have neither the same chemical composition nor the same density as a sample of Amazon estuarine water, which could also have a salinity of 5.000. This means that conservative and nonconservative properties of the two samples may differ, while independently the concentration of these dissolved substances

may yield similar salinities. Properties which are most likely to be affected are the concentrations of calcium, magnesium, carbonate, nutrient salts, pH, oxygen, and organic matter, as well as such physical properties as osmotic pressure and density. For example the concentration of nonconservative substances, such as nutrient salts, may affect salinity in the third decimal place under all circumstances and certainly in the second decimal place in all estuarine environments. The effect becomes relatively smaller at high salinities. However in coastal areas, at low salinities, both the concentration of nonconservative dissolved substances and any differences in the ratio of conservative ions in the source river waters can cause appreciable differences in the properties of two seawater samples having identical salinities. The chemical composition of seawater, particularly with reference to dissolved organics and other nonconservative and conservative substances, including many inorganic compounds, is of utmost importance in understanding the biology of different water masses. I suggest that the reporting of two similar salinities, as given in the example above, may be misleading in implying a similarity between the two waters. The question posed by this comment is whether the problem of conductivity measurements as a representation of salinity is large enough in some estuarine environments to affect salinity values to an extent greater than that already stated above (i.e. the second decimal place, as measured by nutrient changes alone)?

It may be better to report the chloride content of two samples as an approximate indication of the degree to which each

was mixed with seawater (i.e. source water, having a known concentration of chloride). For this reason I suggest that biologists should report the chlorinity of coastal seawater samples (or more precisely the halide content), not in relation to salinity but as indicative of the salt water content of their samples. Eventually a useful comparative biological description of seawater, particularly in coastal environments, might be obtained by analogy with agricultural practices. For example the notation 27-14-0 gives the nutrient content in terms of nitrogen, phosphorus, and potassium of an agricultural fertilizer. A similar technique could be applied to a seawater sample to give, say, halogen, total nitrogen, and pH values, which would be more biologically

informative than salinity reported to three decimal places.

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The physical definition of salinity: A chemical evaluation¹

The concern of Parsons (1982) is justified in that definitions of salinity based on electrical conductivity are strictly valid only for open ocean salinities and that extrapolations to estuarine waters are often made without sufficient concern for physical chemical principles. However, it may be possible to push the conductimetric measurement of salinity in estuaries closer toward infinite dilution than he suggests.

Millero has investigated the physical chemistry of estuarine water and made theoretical (Millero 1975) and experimental (Millero et al. 1976) comparisons between river waters and diluted seawater. By diluting standard seawater to equivalent total solid concentrations of various average river waters, he com-

pared densities in the seawater range of 0-35‰, with the lowest concentration samples equivalent to 0, 0.7, and 1.4‰ salinity. Agreement between river water and diluted seawater was ± 3 ppm density ($\text{g}\cdot\text{cm}^{-3}$) which is equivalent to $\pm 0.003 \sigma_t$. He concluded that the densities (and other physical chemical properties) of seawater diluted with pure water could be used in rivers and estuaries (Millero 1975). He showed that natural waters and seawater diluted with pure water having the same concentrations of dissolved solids have nearly equal conductivities.

Therefore, on the basis of theory and laboratory experiments, the conductimetric measurement of salinity in estuaries should be accurate to salinities $< 5\text{‰}$. However, an important consideration arises in mathematical translations between conductivity and salinity and between salinity and chlorinity.

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