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Limnology and Oceanography, Volume 27, Issue 2 (Mar., 1982), 387-389.

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Limnology and Oceanography

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major constituent composition of the river. This does not seem to be a problem in the Delaware. In other rivers it might cause a discrepancy at low salinities, but this must be demonstrated. If this were indeed the case, chlorinity titrations would then give a more accurate estimate of the chloride content. However, conductivity might give a better estimate of the total dissolved solids. In a case where river ions contribute significantly to conductivity, the total solids content—not the chlorinity—might be more desirable to know. In such a situation, chloride content will not represent the oceanic contribution to the total dissolved solids.

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Limnol. Oceanogr., 27(2), 1982, 387–389
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The practical salinity scale 1978: A reply to comments by T. R. Parsons

During its meeting in Sidney, British Columbia, in September 1980 the UNESCO/ICES/SCOR/IAPSO Joint Panel on Oceanographic Tables and Standards made its final deliberations on the proposed “Practical salinity scale 1978 and the international equation of state of seawater 1980.” A full report on this meeting is available (UNESCO 1981*a*) and the sponsoring organizations have endorsed this work in principle. Parsons (1982) has raised an important point as to the “reality” of the salinity definition, when seawater is strongly diluted by river water or runoff, such as in estuaries. I here present some relevant excerpts from the joint panel’s report, explaining first the need for these new definitions, as well as the various caveats to the application of the equations, particularly in situations when deviations from the mean composition of seawater can be substantial.

A new equation of state was considered desirable because recently acquired data indicated slight discrepancies with the Knudsen–Ekman equation of state of seawater. There is a systematic difference in the specific volume of the order of $8.7 \times 10^{-6} \text{ cm}^3 \cdot \text{g}^{-1}$ in the Knudsen equation for atmospheric pressure, but this difference increases to $33 \times 10^{-6} \text{ cm}^3 \cdot \text{g}^{-1}$ at 500 bars and $89 \times 10^{-6} \text{ cm}^3 \cdot \text{g}^{-1}$ at 1,000 bars pressure in the Ekman equation for elevated pressures (Grasshoff 1976).

A new salinity scale was considered necessary so that all oceanographers using conductivity-temperature-depth instruments would be able to report their observations in a consistent manner. The existing international tables (UNESCO 1966), giving salinity as a function of conductivity ratio, do not go below 10°C, which makes them unsuited for use in most CTD applications. Salinity calcula-

tions have, therefore, been based on the data of Brown and Allentoft (1966) or a combination of their data with the international tables. The two data sets are incompatible because they are derived from experiments on seawaters that did and did not vary in ionic composition as a function of salinity, and they are based on different "definitions" of salinity. In one case a constant times chlorinity was used, in the other the weight ratio obtained by evaporating a 35‰ seawater or diluting it with distilled water. Water of 35‰ from any ocean was defined in turn as having a conductivity ratio of unity with IAPSO Standard Seawater. In addition errors in the data have been detected in the vicinity of 0°C. CTD data reduction equations produced in various attempts to resolve these conflicts yield salinities differing by up to 0.01‰ in coastal waters. With in situ experimental resolutions of $\pm 0.002\%$ salinity available, it is essential that the existing algorithms be replaced by a single equation and that the chlorinity-salinity-conductivity ratio ambiguity which exists when ionic ratios change be resolved (Lewis 1980).

During the course of the work of the joint panel (UNESCO 1976, 1979), it became clear that there was a need for a reproducible electrical conductivity standard. A precisely specified solution of potassium chloride was chosen as this standard (Dauphinee 1980). A concentration of potassium chloride was taken that would yield a conductivity ratio of unity at 15°C with respect to a North Atlantic seawater of 35‰ salinity on the old salinity scale (equivalent to a chlorinity of 19.3740‰) so as to ensure continuity at that salinity with the previous scale. Whereas the existing salinity scale was based on a conductivity-chlorinity relation using natural seawater, the new scale is different in that the standard seawater used was diluted by weight with distilled water or evaporated to obtain other salinity values. This procedure was followed to ensure the constancy of composition of this seawater over the salinity range of interest. The salinities obtained

on this new scale will henceforth be referred to as "practical salinities" and will be reported as dimensionless quantities. New oceanographic tables for the computation of practical salinity have been prepared (UNESCO 1981*b*).

It should be emphasized that although a solution of potassium chloride was chosen as a reproducible electrical conductivity standard, oceanographers are urged to continue to use standard seawater—supplied by the Standard Seawater Service (Institute of Oceanographic Sciences, Wormley, Godalming, United Kingdom)—as a reference water and to not attempt to produce their own potassium chloride solution.

The definition of practical salinity and of the new international equation of state of seawater as well as the algorithms necessary for calculating practical salinity from the conductivity ratio at all temperatures and pressures over the range of oceanographic interest are detailed in the joint panel report (UNESCO 1981*a*); below I re-emphasize some of the limitations of the equations.

The practical salinity scale and the international equation of state of seawater are meant for use in all oceanic waters. However, the equations should be used with caution in waters that have a chemical composition different from standard seawater. Salinities determined by laboratory salinometers operated at widely different temperatures may differ measurably due to possible changes in the temperature dependence of the conductivity ratio with the changing composition of chemicals. In such waters, densities derived with the methods described here, i.e. based on practical salinity measurements and the international equation of state, may deviate measurably from the true densities (Millero et al. 1976*a,b*, 1978; Millero and Kremling 1976; Poisson et al. 1980). However, it is important to note that in water masses different in composition from standard seawater the *differences* in densities derived by the new equations involve only very small errors (Lewis and Perkin 1978). Corrections to the calculated densities can be

made from direct density measurements or from calculations involving the use of partial molal volume data and conductivity data if the chemical composition is known (Brewer and Bradshaw 1975; Poisson and Chanu 1976, 1980; Poisson 1978; Millero et al. 1978; Poisson et al. 1979).

During the meeting of the joint panel in September 1980 it was emphasized that estuarine chemists would prefer to use chlorinity as a conservative mixing tracer, and for these reasons future standard seawater samples will be labeled not only with conductivity information but also with a precise value of the chlorinity of the sample.

The concerns raised by Parsons (1982) do have merit, especially in the estuarine, low salinity environment. The joint panel is acutely aware of this as is evident from the above discussion. Of course, neither practical salinity nor chlorinity is a true measure of the salt content of such waters.

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