Measuring Ocean Salinity in the Laboratory

Introduction

Salinity is one of the most measured parameters in oceanography. The importance of high quality salinity data has long been recognised in open ocean studies and more recently in coastal and estuarine processes. Many of the data are collected using in-situ instrumentation but the measurement of salinity in the laboratory also remains an important and widely used technique. This article describes the methodology used in the high precision, accurate measurement of Practical Salinity in the laboratory.

Why do we Measure Salinity?

In recent years salinity data has provided important information in the study of climate change. Large transects of the ocean using Conductivity, Temperature and Depth (CTD) profiles have helped to improve the understanding of ocean circulation and water mass movements which are critical factors in the influence of global weather. Improving our knowledge of sea surface salinity also leads to a better estimation of the global hydrological cycle and will aid in the prediction of possible climate change events such as the reversal of the North Atlantic Deep Flow.

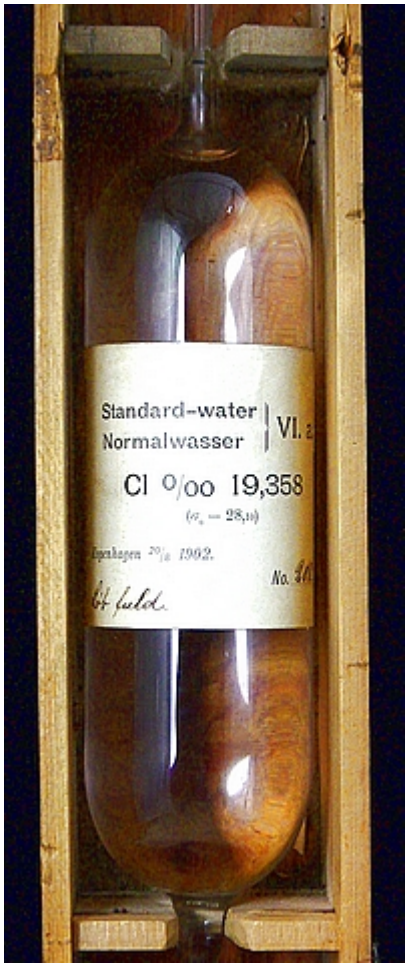
Salinity measurement continues to play an important role in other aspects of oceanography. The passage of sound in seawater is dependent on the density and hence the salinity of that water. Activities involving SONAR devices rely, at some stage, on an accurate measurement of salinity in order to obtain meaningful data. Such applications include seabed mapping, submarine detection and bathymetry.

It should be remembered that salinity data are also important in coastal and estuarine waters. Being a natural parameter, which changes significantly with every tidal cycle, salinity can play a useful role in assessing the dynamics of a coastal or estuarine location. Such applications are used, for example, to predict the fate of effluents from industry or sediments during dredging operations.

Salinity also plays an important role in biological processes affecting algal blooms, fish movements, shellfish productivity and aquaculture.

Early Work on Salinity Measurement

Early work in measuring the saltiness of the sea involved techniques utilizing weighing after evaporation (Boyle,1693; see Birch, 1965), solvent extraction (Lavoisier, 1772) and precipitation (Bergman, 1784). It was Forchhammer (1865) who introduced the term salinity and the concept of measuring one parameter, chloride (in reality total halide), from which the salinity could be calculated. This work was supported further by Dittmar (1884) who analysed over 75 samples from the Challenger Expedition to establish the theory of 'Constant Composition of Seawater'. Further work by Knudsen et al(1902) resulted in a new definition which stated that Salinity was "The total amount of solid material in grams contained in one kilogram of seawater when all of the carbonate has been converted to oxide, all the bromine and iodine replaced by chlorine and all the organic material oxidised".



It was at this time that Knudsen introduced the Standard Seawater Service to supply (natural) seawater standards to workers measuring salinity. This innovative forethought has led to the high degree of comparability in salinity data from workers world-wide for over a century (Culkin and Smed, 1979). This service is currently operated, in the UK, by Ocean Scientific International Ltd. who supply IAPSO Standard Seawater to salinity workers in over 75 countries world-wide, who depend on the reliability of this common standard (Culkin and Ridout, 1997).

These methods remained dominant until the 1950s when conductivity was introduced as a practical means to measure salinity. A conductivity based salinometer was developed for the International Ice Patrol that was capable of measuring salinity to better than 0.01 ppt (Emery and Thomson, 1998). It contained six thermostatically controlled conductivity cells and was claimed to have reached a precision of 0.003 ppt. (Cox, 1963). Various salinometers were developed during the 1950s and 1960s (eg Hamon; 1955;) and new relationships were produced for conductivity and salinity (Culkin,1979, Millero et al.,1977; Poisson et al, 1978).

Practical Salinity

In 1978 the break with chlorinity was sealed with the introduction of a new conductivity-based definition by the Joint Panel on Oceanographic Tables and Standards (JPOTS). This new definition, which is current today, states that ' a seawater of salinity 35 has a conductivity ratio of unity with of 32.4356 grams of Potassium Chloride in 1 kilogram of solution at 15 C and 1 atmosphere'. The standard concentration of KCL was derived from measurements carried out on one batch of Standard Seawater, weight diluted and evaporated (Lewis,1980; see Unesco Technical Papers No. 37, 1981). Also included were measurements of absolute conductivity carried out at the Institute of Oceanographic Sciences, Wormley, UK (Culkin and Smith, 1980).

The introduction of the Practical Salinity Scale 1978 (PSS78) resulted in some significant operational changes. One change has been the abolition of units due to the adoption of a scale. Previous methods had resulted in concentration units such as parts per thousand (ppt) being used but these were no longer valid. The correct way to report Practical Salinity is as a number (eg the sample had a salinity of 35) possibly with reference to PSS78. However the move away from units has proved so difficult for some to accept that a new unit, the Practical Salinity Unit (PSU), has been unofficially introduced. In true terms of the PSS78 the PSU is not valid but it is widely used and often not rejected by journal editors.

Modern Salinometers

The first version of the modern conductive salinometer was developed by Dauphinee in 1975 who produced a 4 electrode (platinum) cell located in a temperature controlled bath. This gave rise to the widely accepted 'industry standard' salinometers (Autosal and Portasal), produced by Guildline Instruments Ltd., which achieve a quoted accuracy of +-0.002 in Practical Salinity. This proved to be important in the World Ocean Circulation Experiment (WOCE) during the 1990s which produced the largest set ever high precision salinity data from the world oceans. This level of accuracy is now widely accepted as the desirable goal for all salinity data from the open ocean.

Data Quality

The quality and comparability of the millions of salinity data points accumulated over the past century depend largely on the widespread use of a single source calibration standard, IAPSO Standard Seawater (SSW). As approved by the International Association for the Physical Sciences of the Ocean (IAPSO), SSW is now used as a reference standard in the measurement of the electrical conductivity (and hence salinity) of seawater. The label value of the standard shows the Conductivity Ratio at 15 degrees C (K15) which is used to calibrate the salinometer. The expanded uncertainty of the K15 value was found to be 1×10–5, based on a coverage factor of 2 (Bacon et al, 2007 in press) which is equivalent to 0.0003 in salinity. This allows meaningful measurements to be made with an accuracy of +- 0,002 in salinity which is of particular importance when tracking micro-scale differences in ocean salinity in, for example, ocean circulation studies.

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