

Methods note · Sea ice and ocean

When conductivity does not mean saltier water

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Fictional author and institute · Editorial demonstration, not peer reviewed

ABSTRACT

A conductivity change is not a direct measurement of changing salt content because temperature, pressure, units, and seawater composition affect its interpretation. This methods note follows the documented TEOS-10 calculation chain from conductivity to Practical Salinity and Absolute Salinity, then to thermodynamic interpretation. A published Gibbs SeaWater demonstration supplies two nearly equal conductivities with substantially different calculated salinities, making the importance of context explicit. Hypothetical archive and mooring cases show how a convention change can create an artificial step and why validated freshening does not uniquely identify its source. No field deployment or calibration is analysed. The note identifies the variable definitions, original inputs, processing versions, and quality information needed before a profile can support claims about water masses, density, or freshwater pathways.

Keywords: conductivity · Practical Salinity · Absolute Salinity · TEOS-10 · seawater density

A source-based editorial text, not a report of original Still North research. Examples and imagery are illustrative.

A conductivity trace rises as a sensor passes into warmer water. Has the ocean become saltier? Not necessarily. Conductivity responds to temperature and pressure as well as dissolved ions. The salinity value commonly stored in an oceanographic archive is already a calculation from several measurements, while the salinity used in modern thermodynamic calculations may be a different, derived variable. Interpreting either requires following that calculation chain.

This methods note uses the TEOS-10 manual, its Gibbs SeaWater reference functions, and the published Absolute Salinity algorithm to distinguish measurement, scale conversion, and physical interpretation. It presents one worked numerical comparison drawn from a documented software example, alongside hypothetical decision cases. It does not analyse a field deployment, provide a sensor calibration, or infer a freshwater source from a single profile.

Start with what the instrument measures

A conductivity-temperature-depth package measures quantities from which seawater properties are estimated. Conductivity describes the ability of the sample to carry an electrical current. Temperature changes ion mobility, while pressure affects the relationship as well. Comparing raw conductivity at two temperatures is therefore not equivalent to comparing dissolved salt content. A derived salinity estimate needs the corresponding temperature and pressure, with compatible timing and units.

The official `gsw_SP_from_C` reference makes that dependence explicit: conductivity, in-situ temperature, and sea pressure are inputs. Its conductivity unit is mS/cm, not S/m. One S/m equals ten mS/cm, so passing the numerical value from one unit as though it belonged to the other is a factor-of-ten input error. The pressure input is sea

pressure in decibars, not an unlabelled depth in metres or absolute pressure in pascals.

Practical Salinity is a scale, not a mass fraction

Practical Salinity, conventionally written SP, is defined through conductivity relationships on the Practical Salinity Scale of 1978. It is dimensionless. Calling an SP value 'grams of salt per kilogram' confuses a useful conductivity-based scale with a mass-fraction quantity. Historical labels such as PSU are widespread, but an archive should identify the actual scale rather than relying on a familiar suffix to explain it.

The GSW documentation also states a validity distinction that matters near freshwater inputs: the original PSS-78 relationship applies over a specified salinity range, and the implementation uses an additional low-salinity formulation when required. A numerical output does not prove that an arbitrary river, concentrated brine, or unusual industrial solution has ordinary seawater composition. The instrument response, selected conversion, and intended fluid domain must all be appropriate before physical interpretation begins.

A worked example that reverses the raw comparison

The GSW reference provides a six-level demonstration. Two of its rows illustrate why conductivity alone is not an ordering of salinity. One input conductivity is 34.5487 mS/cm at 28.7856°C and 10 dbar; the resulting SP is approximately 20.0099. Another is 34.5600 mS/cm at 4.4036°C and 1,000 dbar; the resulting SP is approximately 36.4003. These are published software demonstration inputs and outputs, not Still North observations or an Arctic profile.

The conductivities differ by only about 0.0113 mS/cm, yet the derived salinities differ substantially because

Documented example row	Conductivity	Temperature	Sea pressure	Calculated SP
Warm, shallow input	34.5487 mS/cm	28.7856°C	10 dbar	20.0099
Cooler, deeper input	34.5600 mS/cm	4.4036°C	1,000 dbar	36.4003

the temperature and pressure contexts differ. This is not evidence that pressure alone explains the contrast, nor a suggested approximation for Arctic water. It is a reproducible demonstration that a near-equal conductivity does not imply near-equal salinity. Use the documented calculation, not a general linear correction invented from these two rows.

Absolute Salinity adds another explicit step
TEOS-10 represents thermodynamic properties using Absolute Salinity, SA, commonly expressed in g/kg. For standard-composition seawater, Reference Salinity is proportional to SP, with the conversion factor 35.16504/35. For SP = 35, Reference Salinity is therefore 35.16504 g/kg. The difference between those numerical values is a scale conversion, not a measured freshening or salinification. Plotting the two conventions as though they were one time series would create an artificial step.

McDougall and colleagues explain why a composition anomaly is then needed to estimate SA more accurately. Dissolved constituents do not everywhere occur in identical proportions, and conductivity does not capture every constituent's density effect equally. Their global algorithm uses available density measurements and approximate relationships with silicate to estimate an anomaly. It is an informed spatial estimate, not a direct laboratory determination of every sample's composition.

The SA conversion function accordingly requires pressure, longitude, and latitude as well as SP. Preserve those inputs and the software version. A plausible output at a coastal coordinate does not validate the coordinate or resolve local composition anomalies: the documented land flag is deliberately coarse. Coastal and freshwater-influenced applications require particular attention to the conversion's assumptions and any independent information on composition.

Temperature also has more than one useful meaning

In-situ temperature is the measured temperature at the sample's pressure. Potential temperature describes a reference-pressure transformation under stated thermodynamic conditions. Conservative Temperature, used in TEOS-10, is related to potential enthalpy and supports consistent heat accounting. These variables answer different questions. A difference between in-situ temperatures at widely separated depths is not automatically a difference in heat acquired from the environment.

Similarly, density at the sample's pressure includes compressibility effects. Assessing stratification by simply comparing two in-situ density numbers from different pressures can mislead. Use an appropriate thermodynamic stability calculation or consistently referenced density diagnostic, with its pressure reference named. In cold waters, salinity differences can strongly influence density, but the relative temperature and salinity contri-

butions must be calculated for the actual conditions rather than imposed as a universal slogan.

What a freshening result would need
Consider a hypothetical mooring whose processed SP falls between successive months. First ask whether the sensor sampled the same depth and water mass, whether conductivity and temperature channels were aligned, and whether biofouling, drift, or a processing change is documented. Next examine circulation, vertical structure, and nearby measurements. A validated salinity decline establishes a change in water properties at the sampled place and support; it does not uniquely identify river water, precipitation, ice melt, or advection as the source.

A second hypothetical case involves joining an older SP archive to a later SA export. The appropriate action is not subtracting a guessed constant from the newer data. Recover the variable definitions and original inputs, then make a consistent comparison using documented conversions. Keep the original measurements and processing lineage. The TEOS-10 manual explicitly supports retaining Practical Salinity in observational databases while deriving thermodynamic quantities for analysis, helping avoid precisely this confusion.

Limits and the reporting minimum
This note has not run a seawater toolbox or characterised calibration uncertainty. Its reproduced software example shows the logic of conversion, not the performance of a particular sensor. A genuine uncertainty estimate must include the instrument, calibration history, channel alignment, pressure assignment, processing choices, and suitability of the thermodynamic description. Adding decimal places after a conversion cannot recover information missing from those inputs.

Report conductivity units, temperature scale and variable, salinity convention, pressure definition, location, calculation version, and quality flags with the result. That may appear more demanding than a single column labelled salt. In practice, it is the smallest record that lets another reader distinguish a physical ocean change from a change in units or definitions. Once that distinction is secure, a salinity profile becomes a much stronger basis for asking where the water came from and what it can do.

References

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