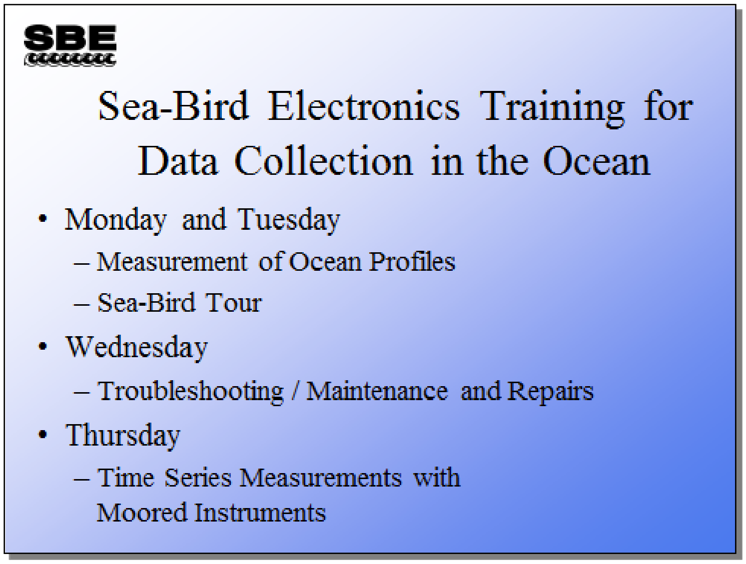
Module 0

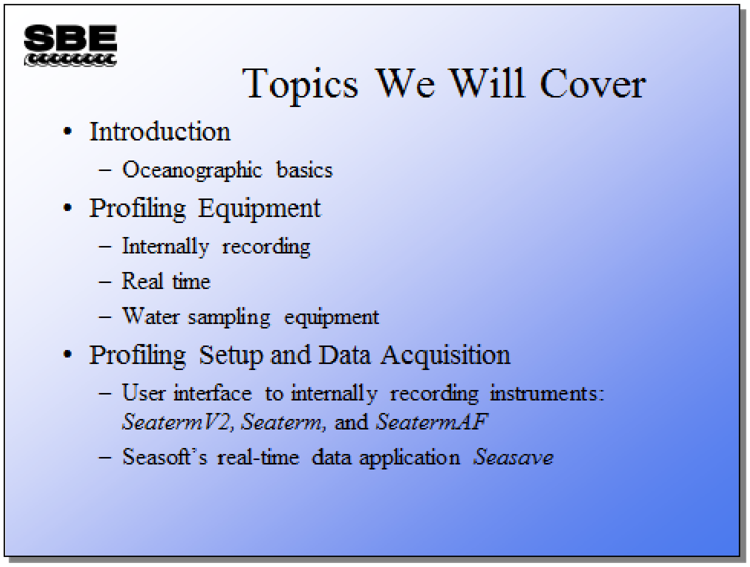
Introduction to Sea-Bird Electronics Training for Data Collection in the Ocean

SBE Training Introduction



Welcome to Sea-Bird Electronics training course. The next few slides will show you what we are going to cover in a little more detail.

Topics We Will Cover



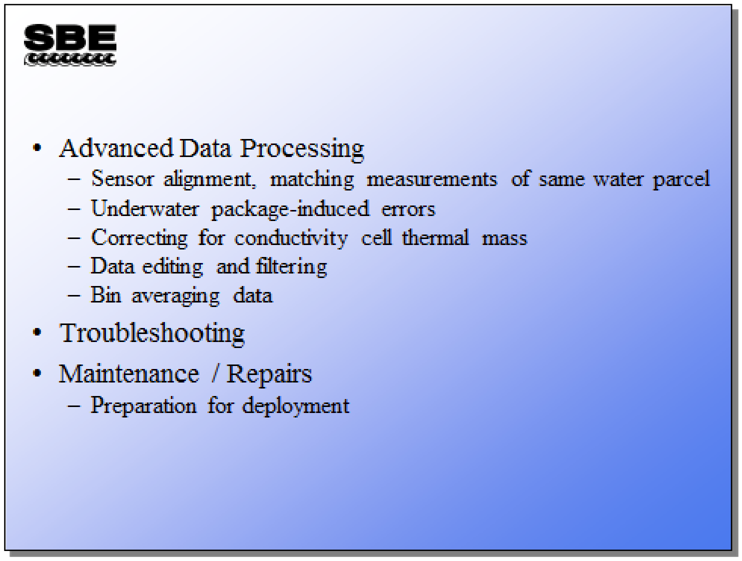
Topics We Will Cover (*continued*)

Topics We Will Cover (*continued*)

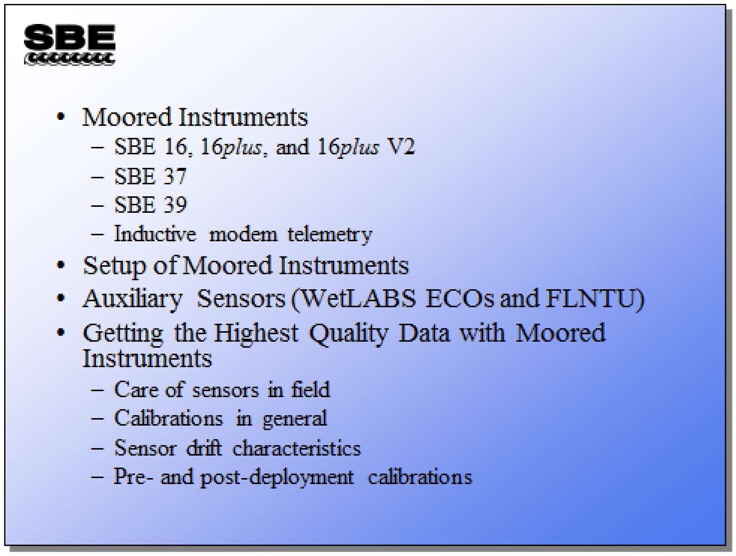
SBE

- Making Measurements in the Ocean
  - Sampling theory and sensor characteristics
  - Coordinating measurements in space and time
  - Comparison of sampling for different instruments
- Getting the Highest Accuracy Data
  - Care of sensors in field
  - Calibrations in general
  - Sensor drift characteristics
  - Pre- and post-deployment calibrations
  - Field calibrations

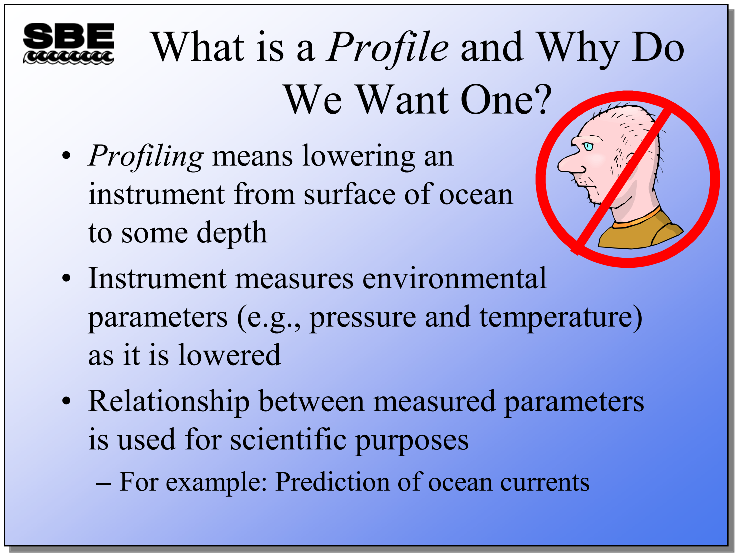
Topics We Will Cover (*continued*)



Topics We Will Cover (*continued*)



Introduction: Ocean Profiling



A profile is a set of data for one or more environmental measurements, such as temperature and salinity, taken at a regular interval over the ocean depth. In the beginning, there were few options for obtaining ocean data. The most common means were:

- Hydrocasts

  Oceanographers hung water samplers on a cable lowered into the ocean, then dropped a weight down the cable to close the sample bottle and capture a water sample, released another weight to trigger the next sample bottle, and so on. Once the samples were retrieved, discrete samples could be analyzed for temperature and salinity. Accuracy was poor by modern standards, and only 12 – 24 data points were obtained for the whole water column. They yearned for more data points.

- Bathythermograph

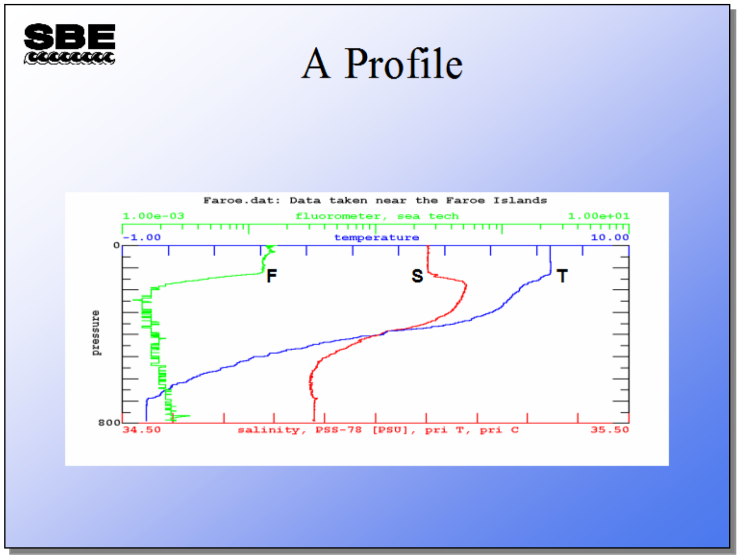
  The bathythermograph was towed from a ship as it was lowered on a cable. It scratched a trace of the temperature versus depth on a coated glass slide. This provided more points, but only for temperature and only for relatively shallow depths. People still yearned for more data.

- Modern sensors and profiling equipment

  Equipment that could make measurements and telemeter these measurements from the end of a conducting cable back to the ship was invented; now there were more points, and life was good. However, there was room for improvement. There has been steady refinement in profiling equipment, data is telemetered digitally, sensors are improved, water sampling equipment is attached to the measurement package, and samplers capture their water on command from the computer on the ship. There are sensors available to measure a wider variety of parameters.

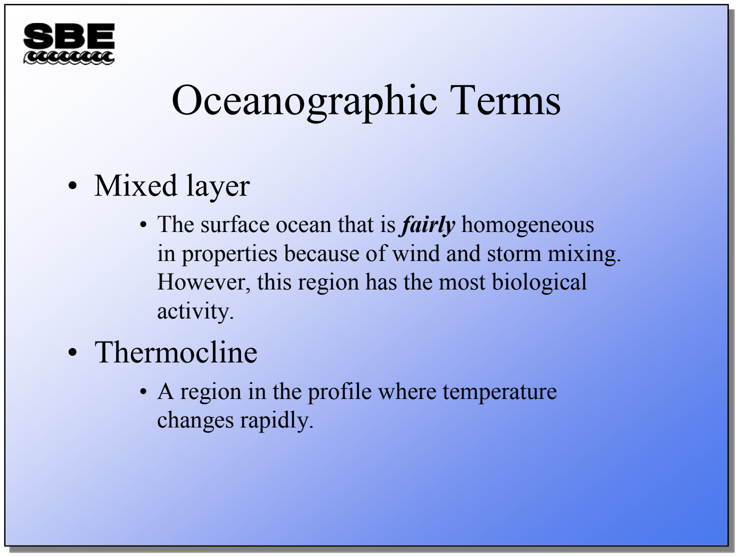
What do we do with our profile? We estimate deep ocean currents based on density profiles. We look for sharp density changes to investigate the interesting chemical and biological processes that go on there. We look for the boundaries of surface ocean currents. We look for the movements of different water masses near shore that indicate upwelling or currents that move sediment along the shore. We measure a sound velocity profile so we can refine our acoustic investigation of the ocean bottom. We discover the depth at which a basin becomes anoxic. We are only limited by our imagination.

Introduction: Ocean Profiling



This profile was collected with an SBE 911*plus* system near the Faroe Islands.

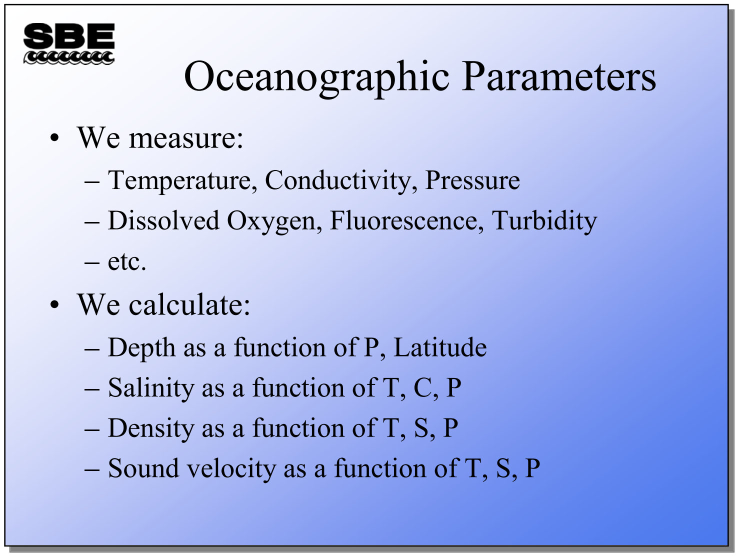
Introduction: Oceanographic Terms



The ocean is often spoken of as a two-layer system: a mixed or surface layer and a deep layer. The mixed layer or surface layer is as it sounds, at the surface of the ocean and well mixed by wind and waves. The deep layer is separated from the surface by a region of rapidly changing temperature referred to as the thermocline. Because density is a strong function of temperature, the water in this area also changes sharply in density. The change in density makes it difficult for water in the deep ocean to mix with water in the surface ocean, effectively separating the deep layer from the mixed layer.

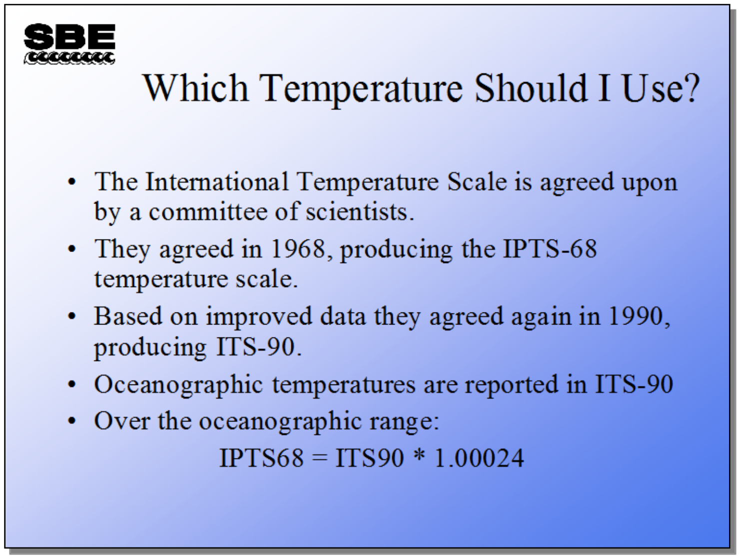
Definitions of many other oceanographic terms and parameters are available in the Glossary that is at the back of your binder.

Introduction: Oceanographic Parameters



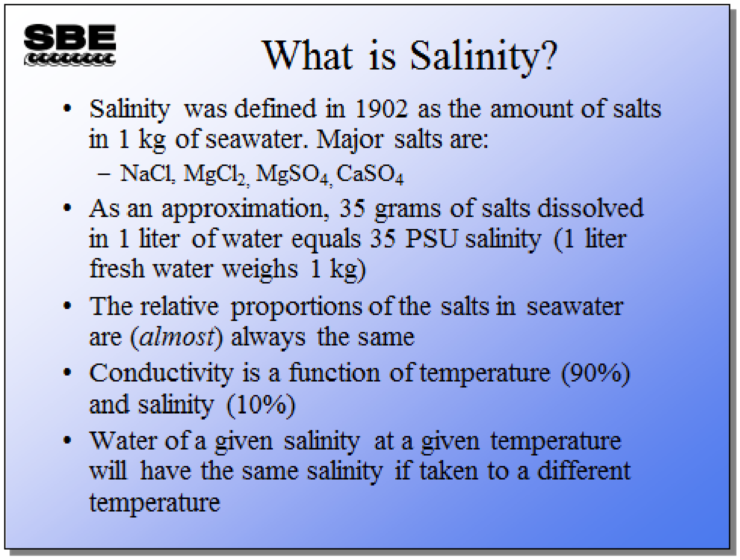
We measure physical quantities with Sea-Bird instruments. These quantities are then used to calculate the many parameters that are found in the analysis of oceanographic data. Because the calculated parameters rely on accurate measurement of the physical quantities, a small error in the original measurement can result in a large error in data analysis.

Introduction: Oceanographic Parameters (*continued*)



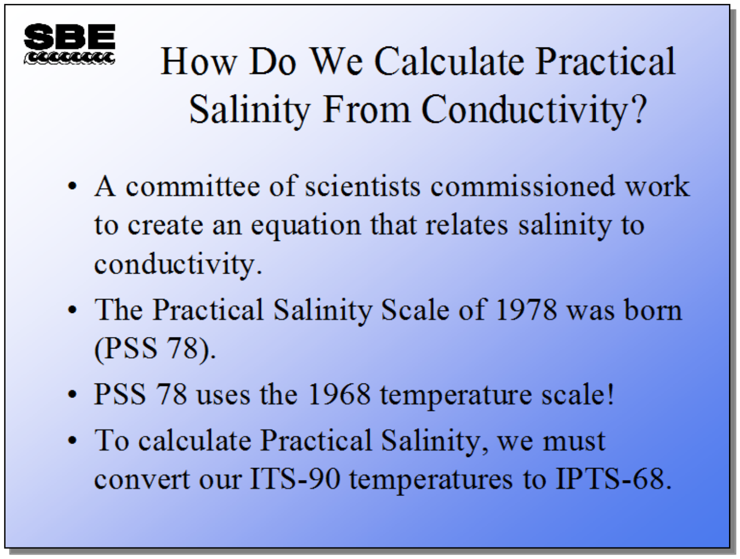
The calculation of the parameters mentioned on the previous slide is made with equations of the physical parameters. These equations were derived by gathering data in a laboratory relating T, P, and C to the parameter of interest, and statistically fitting the data to high order polynomials. The coefficients of the polynomials were determined using the 1968 temperature scale. So, to use these high-order polynomials, we must convert to the 1968 temperature scale for these calculations.

Introduction: Oceanographic Parameters (*continued*)



The basis of the PSU calculations is the assumption that the relative proportion of each salt in seawater remains constant all over the ocean. This means that if we compare a kg of seawater at 35.000 PSU with a kg of seawater at 20.000 PSU, only the proportion of water in each is different. This does not hold true in areas of freshwater influence, such as river estuaries, or at high Latitudes when the ice is melting. Similarly it does not hold true in brines, either those formed by evaporation of seawater or from dissolution of salt domes or formed via volcanic influence.

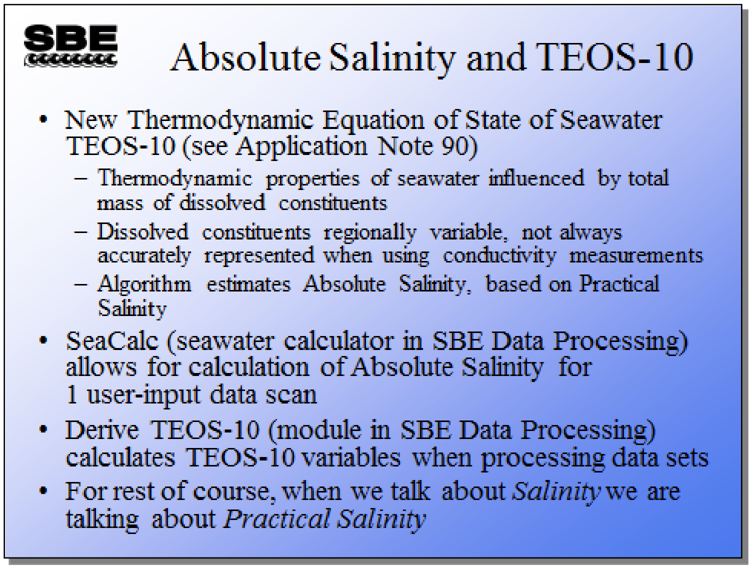
Introduction: Oceanographic Parameters (*continued*)



Salinity is calculated from several polynomials that characterize seawater's thermodynamic behavior in terms of conductivity, temperature, and pressure. The calculation is based on the ratio of the seawater sample conductivity to the conductivity of standard seawater. The polynomials were determined by statistically fitting the coefficients of these equations to laboratory results. The Practical Salinity Scale of 1978 is only valid when used with the temperature scale of 1968 over a temperature range of -2 °C to 35 °C, and it is only valid for seawater that has salinity between 2 and 42 practical salinity units (PSU).

Note that Sea-Bird calibrates temperature sensors using the ITS-90 scale. In our real-time data acquisition software and data processing software, the ITS-90 temperatures are automatically converted to IPTS-68 temperatures before input to the salinity equation.

Introduction: Oceanographic Parameters (*continued*)



IAPSO recommends that only Practical Salinity be stored in data repositories:

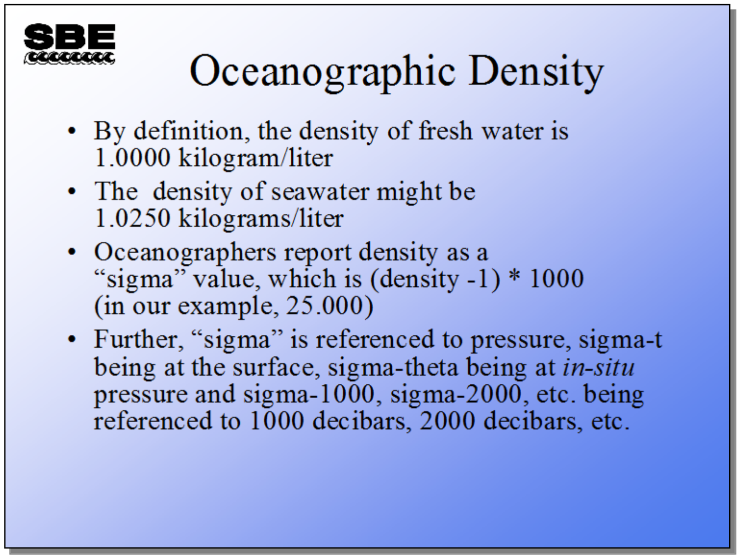
- Absolute Salinity derived from a combination of C, T, P as well as other measurements and corrections that are not yet well established.
- Important to not create confusion in national data bases with a change in reporting of salinity.
- Algorithm for determining Absolute Salinity is immature, and will likely change.

In 2013, Sea-Bird released SBE Data processing version 7.23.1, which includes:

- SeaCalc III (seawater calculator module that computes a number of derived variables from one user-input data scan), , and
- Derive TEOS-10, which allows you to calculate most relevant TEOS-10 variables when processing data sets.

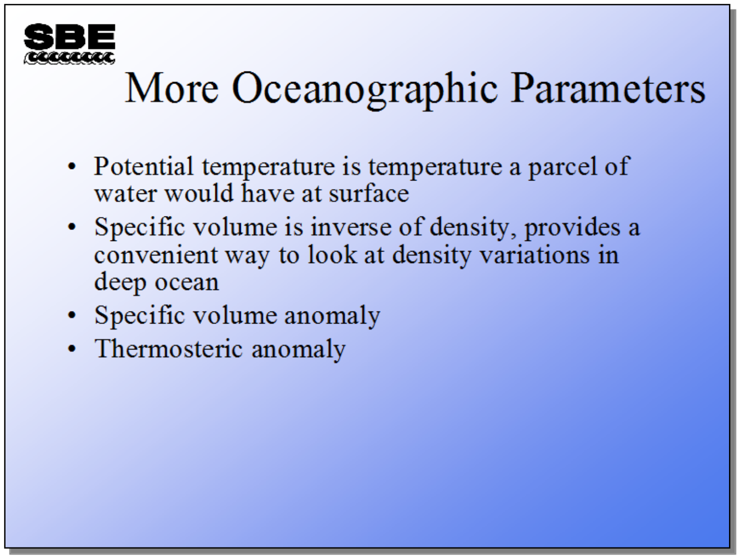
Application Note 90 on our website (www.seabird.com/application_notes/AN90.htm) provides more details.

Introduction: Oceanographic Parameters (*continued*)



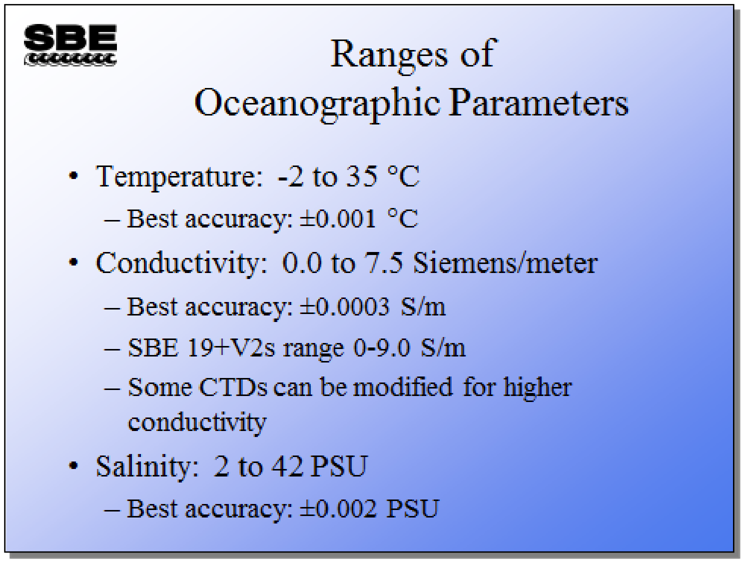
Parameter	Units	Definition	Additional Information
ρ (t, s, p)	kg/m^3	Density as a function of temperature, salinity, and pressure	• Relationship with T and S nonlinear (more so for T) • Less sensitive to T at low T
σ (t, s, p)	-	Sigma = ρ (t, s, p) - 1000	• Used because variations in oceanic density are very small • Includes pressure effect on density • Pressure effect on T and S not accounted for • Most variations in density due to direct effects of pressure; however, dynamically important changes are not due to pressure, so this parameter is less commonly used
σ_t (t, s, 0)	-	Sigma-t = ρ (t, s, 0) - 1000	• Sigma at atmospheric pressure
σ_θ (θ, s, 0)	-	Sigma-theta = ρ (θ, s, 0) - 1000	• Removes effect on density caused by adiabatic cooling / heating • Removes pressure effect on density

Introduction: Oceanographic Parameters (*continued*)



Parameter	Units	Definition	Additional Information
θ	deg C	Potential temperature = Temperature of sample brought adiabatically to surface (no heat exchange with surrounding water as raised)	• Temperature parcel of water would have at surface • Used to compare waters at significantly different depths, and used for describing vertical motions over large depth ranges
α (t, s, p)	m^3/kg	Specific volume = 1/ ρ (t, s, p)	• Convenient way to look at density variations in deep ocean
α (0, 35, p)	m^3/kg	1/ ρ (0, 35, p)	• Specific volume of arbitrary seawater standard (0 deg C, 35 PSU) at depth of sample
δ	m^3/kg	Specific volume anomaly = α (t, s, p) - α (0, 35, p) = $\delta_s + \delta_t + \delta_{s,t} + \delta_{s,p} + \delta_{t,p} + \delta_{s,t,p}$	• Sum of 6 anomalies of specific volume due to t, s, p
$\Delta_{s,t}$	m^3/kg	Thermosteric anomaly = $\delta_s + \delta_t + \delta_{s,t}$	• Accounts for most of the density effect due to t, s • $\delta_{s,t,p}$ is quite small, so is usually ignored

Introduction: Oceanographic Parameters (*continued*)



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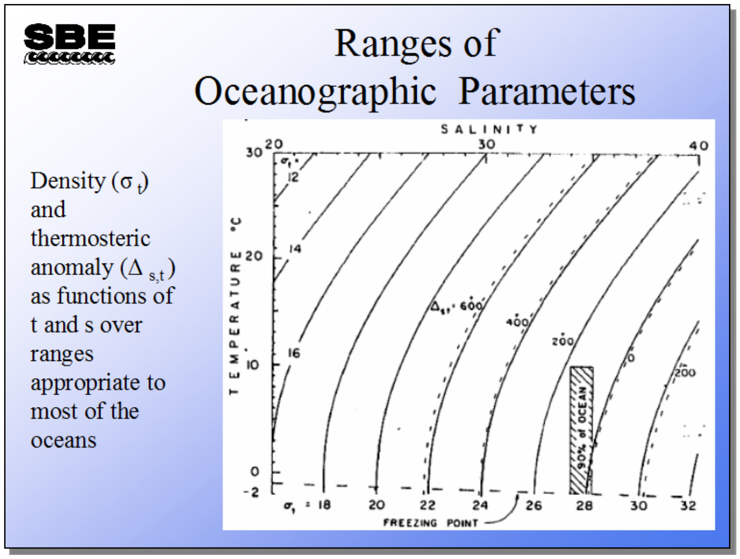

Approximately 90% of the world ocean has temperature and salinity values within the shaded rectangle.

Graph is from Introductory Dynamical Oceanography, Pond & Pickard, 1983, 2nd Edition.