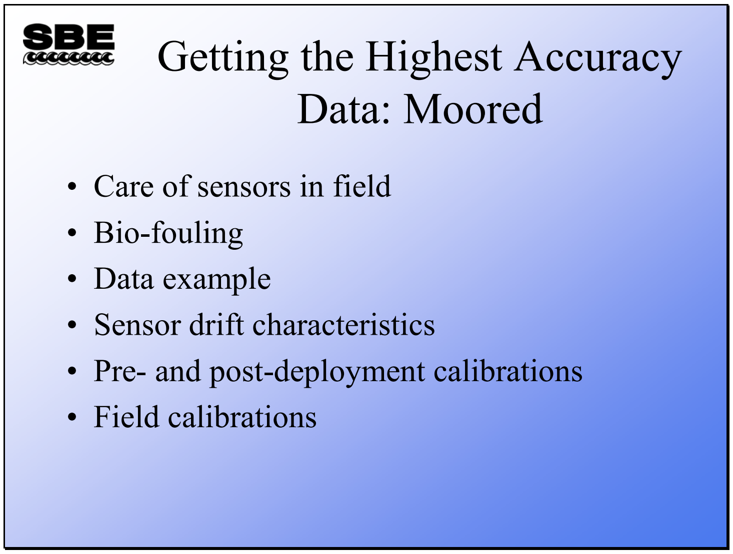
Module 12

Getting the Highest Accuracy Data from Moored Instruments

Overview

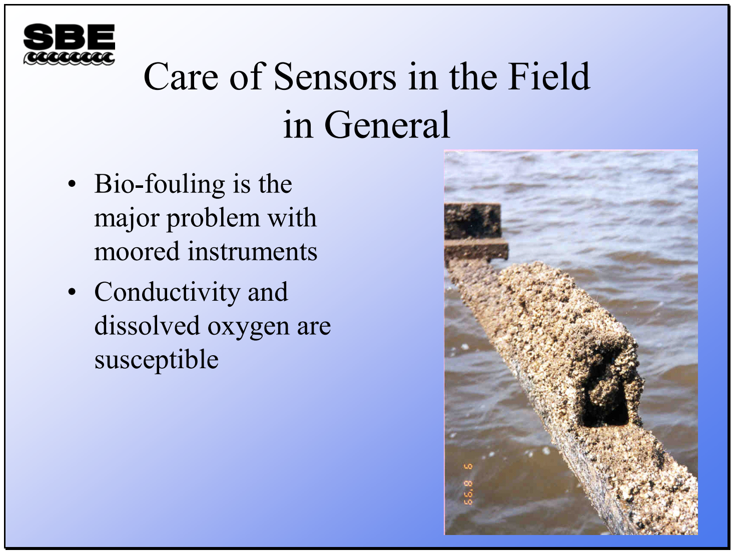


In the module we will discuss the means to get the highest accuracy in your moored measurements. This includes care of sensors in the field and understanding sensor drift characteristics. Moored instruments can exhibit unexpected drift in conductivity. Topics covered include pre- and post-deployment calibrations, field calibrations, and bio-fouling.

By the end of this module you should be able to:

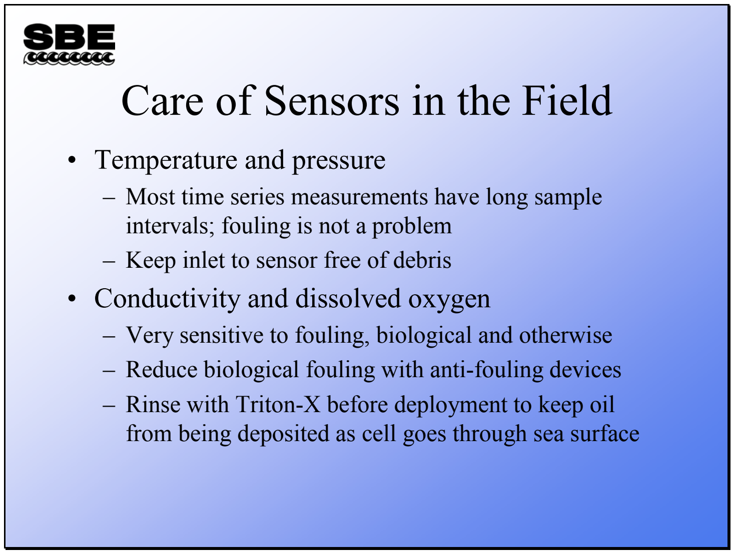
- Care for your moored sensors
- Know how to reduce bio-fouling
- Understand sensor drift
- Correct data for sensor drift with pre- and post-calibration
- Compare data from your mooring with data collected with a profiling instrument

Care of Sensors in the Field



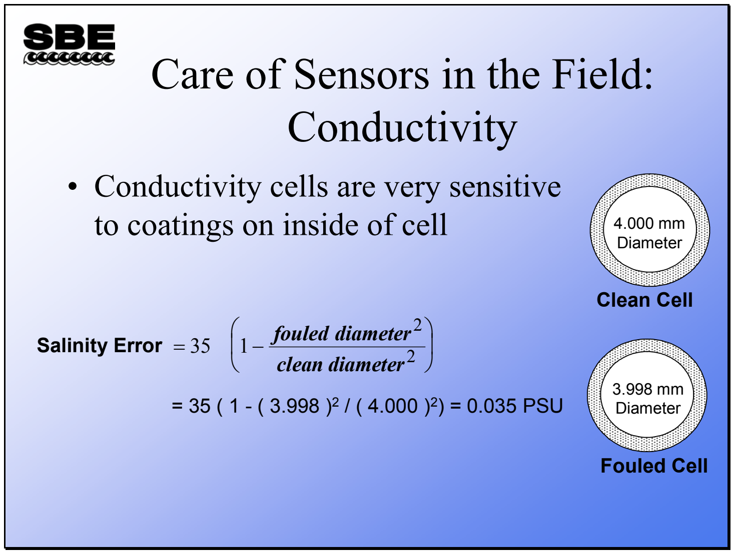
This SBE 37 is deployed in the tide waters of Georgia. Biological activity surges when the water temperature exceeds 20 °C. The researcher uses extra bio-fouling protection on each end of the conductivity cell and protects the pressure housing of the instrument with packing tape and silicon grease.

Care of Sensors in the Field



As we have discussed, thermometers are very robust. In moored applications, the sampling interval is much longer than the time constant of the thermometer, so except in extreme conditions fouling does not affect thermometers.

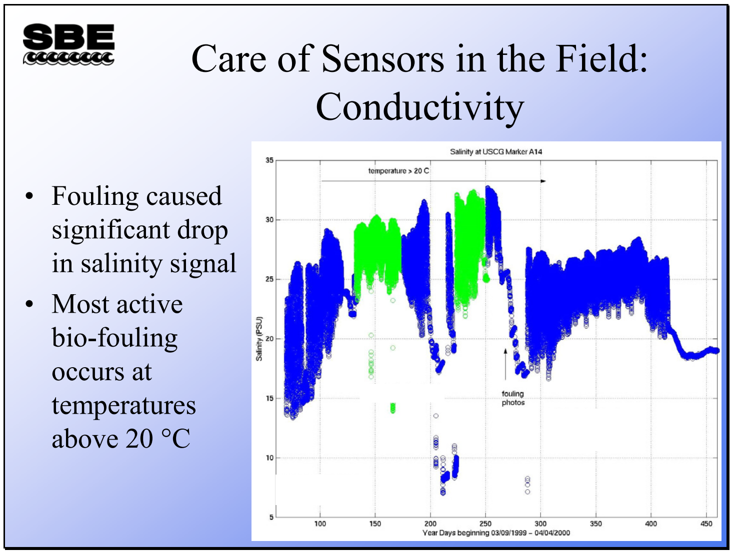
Care of Sensors in the Field: Conductivity



Conductivity sensors are another matter. Recall this slide from a previous discussion. A very thin coating can change the cell geometry, having a large effect on the conductivity measurement.

Care of Sensors in the Field: Conductivity (*continued*)

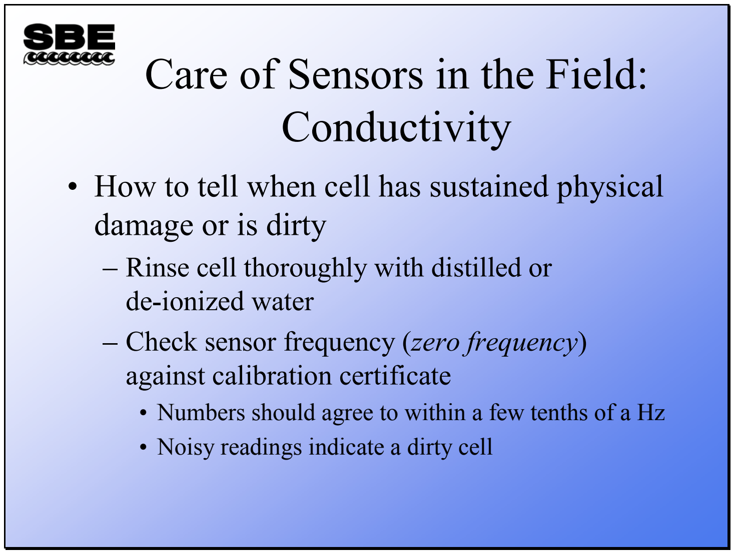
Care of Sensors in the Field: Conductivity (*continued*)



This plot is data collected at the site pictured on this module's second slide. Looking at the data set, it is obvious where fouling overwhelmed the instrument. At this site, it was not uncommon for larger animals to take up residence in the conductivity cell, resulting in a large disturbance in the data. Bio-fouling protection is meant to kill bacteria and larval animals that would settle inside the cell. Large animals (like a crab) will be killed, but more slowly, falling out of the cell after death.

We are grateful to Susan Elston at Skidaway Institute of Oceanography, Savannah, Georgia for sharing her photographs and data with us.

Care of Sensors in the Field: Conductivity (*continued*)

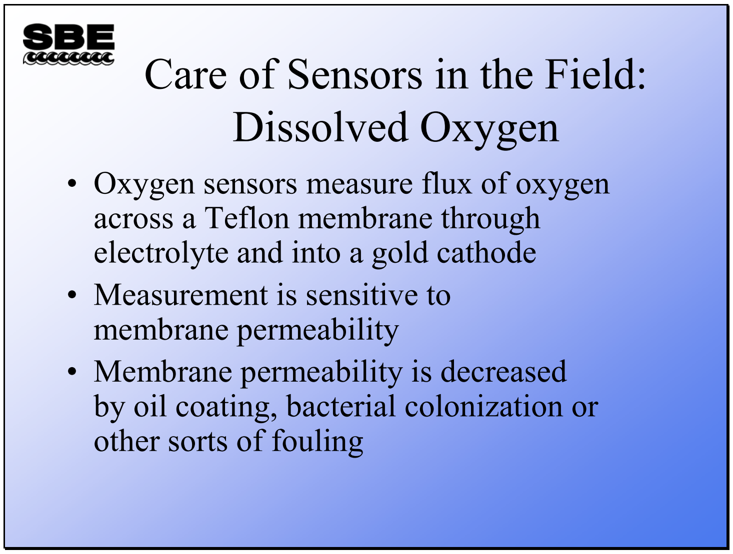


As we discussed in the previous module, checking the zero frequency of a conductivity cell is a great way to do a spot check on the health of the sensor.

If you are servicing moorings and do not intend to bring them in for calibration, a cleaning of the conductivity cell with hot 10% Triton-X solution is a good idea. If you suspect that the cell has been overrun by calcareous organisms, then a rinse with 10% HCl will help by removing any calcium carbonate that may have been deposited.

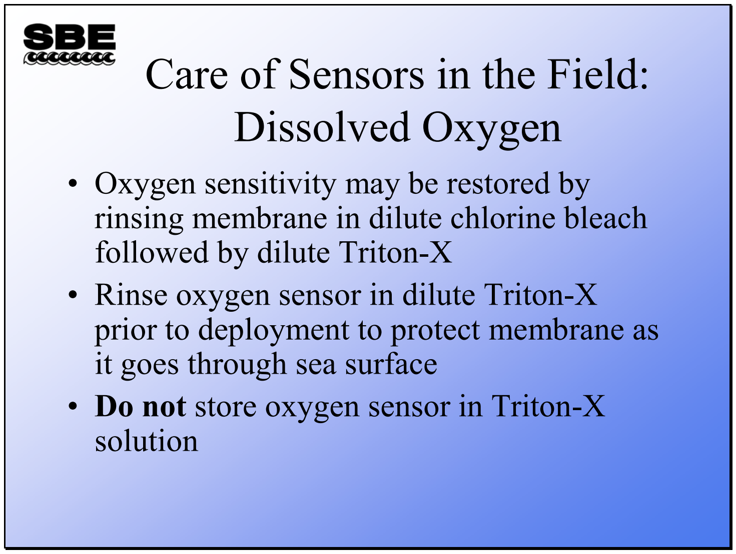
The conductivity cell is made of a glass tube, with cylindrical platinum foil electrodes within. **A brush through the cell risks dislodging the electrode and ruining the cell.** Further, the electrodes are coated with a finely divided metallic platinum known as platinum black. This coating is delicate and will be damaged by a brush.

Care of Sensors in the Field: Dissolved Oxygen



Oxygen sensors become less sensitive when then are fouled. One way to spot check your sensor is to place it in clean, quietly stirred water. You should get a reading near the oxygen saturation value for that temperature. Oxygen saturation is difficult to achieve; vigorous stirring will almost always over-saturate, and water that is changing temperature can be over- or under-saturated. Remember that the oxygen electrode depletes oxygen at its surface; it requires moving water to make an accurate reading.

Care of Sensors in the Field: Dissolved Oxygen (*continued*)



Clean your dissolved oxygen sensor with a 50:1 chlorine bleach solution (50 parts de-ionized water to 1 part chlorine bleach). Follow this with a wash with a 1% Triton-X solution. Repeat these 2 steps as necessary.

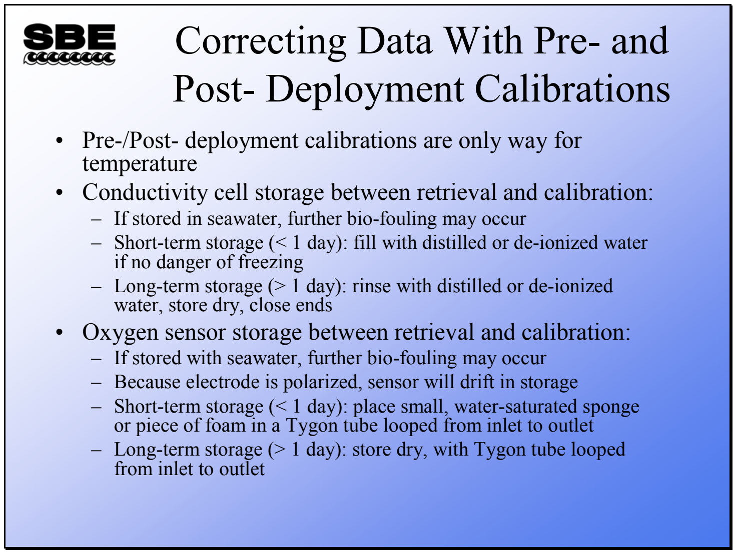
See Application Note 64 for details on oxygen sensor cleaning and storage.

Correcting Data

Sensor Drift

- Drift same as profiling instruments
- Pressure and temperature drift as offset
  - Typical temperature drift rates for SBE 16*plus*, 37, and 39 are 0.0002 °C/month
  - Typical pressure drifts are linear, with rates of 0.0015% - 0.004% full scale / month
- Conductivity and oxygen drift as slope
  - Conductivity drift rates are 0.0003 Siemens/meter/month
  - SBE 43 drift rate is 1 – 2% per month

Correcting Data



Conductivity cell:

- Short-term storage: If there is no danger of freezing, store the conductivity cell with distilled or de-ionized water in Tygon tubing looped around the cell. If there is danger of freezing, store the conductivity cell dry, with Tygon tubing looped around the cell.
- Long-term storage: Since conditions of transport and long-term storage are not always under the control of the user, we recommend storing the conductivity cell dry, with Tygon tubing looped around the cell ends. Dry storage eliminates the possibility of damage due to unforeseen freezing, as well as the possibility of bio-organism growth inside the cell.

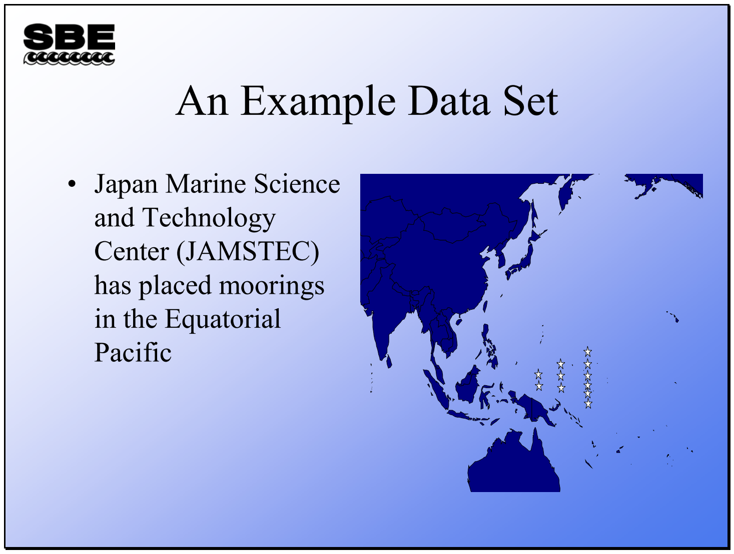
See Application Note 2D for details.

Oxygen sensor:

- Short-term storage: If there is no danger of freezing, place a small piece of clean sponge, *slightly dampened* with fresh, clean water, in the center of the tubing (not near the membrane). If there is danger of freezing, store the oxygen sensor dry, with Tygon tubing looped from inlet to outlet.
- Long-term storage: Since conditions of transport and long-term storage are not always under the control of the user, we recommend storing the oxygen sensor dry, with Tygon tubing looped from inlet to outlet. Dry storage eliminates the possibility of damage due to unforeseen freezing, as well as the possibility of bio-organism growth inside the cell.

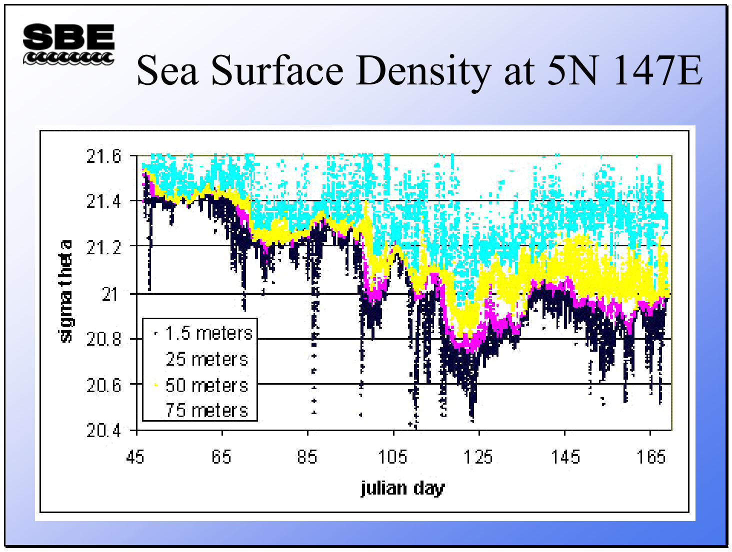
See Application Note 64 for details.

Correcting Data Example

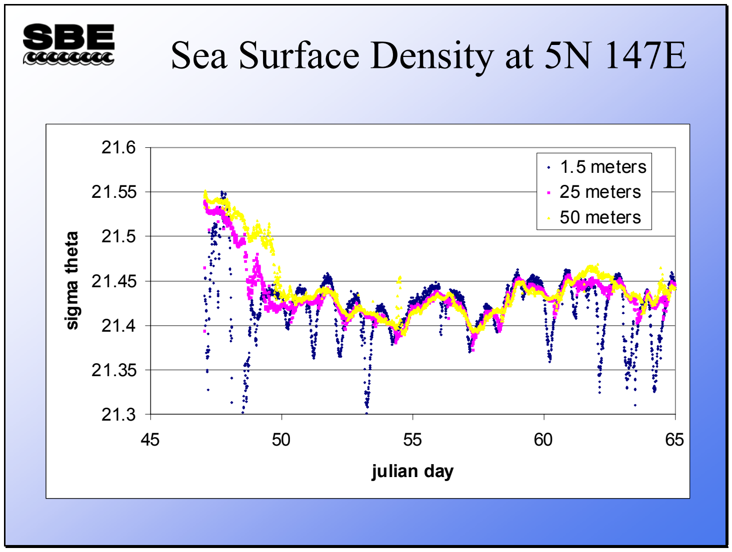


We are going to look at the results of a mooring program carried out by the Japan Marine Science and Technology Center, JAMSTEC. This agency has a mission similar to NOAA in the US. JAMSTEC has placed moorings in the Eastern Equatorial Pacific, which use inductive telemetry to report data in real time via the ARGOS satellite system. The mooring program started in 1998 and continues today.

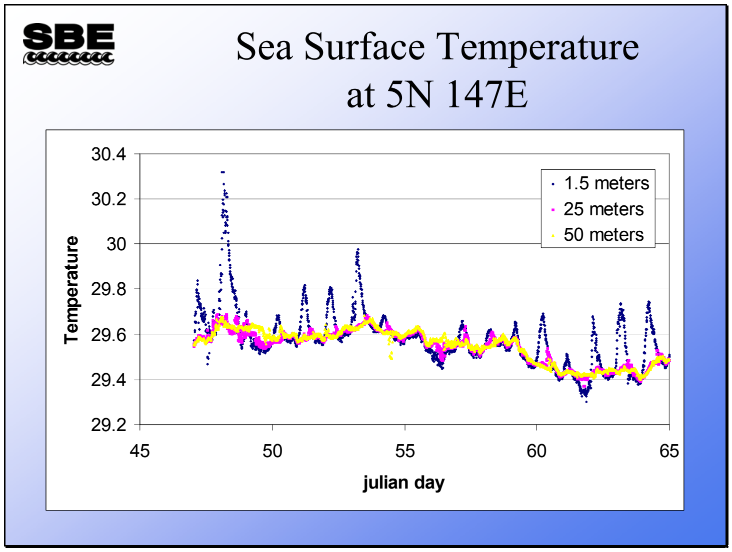
Correcting Data: Example (*continued*)



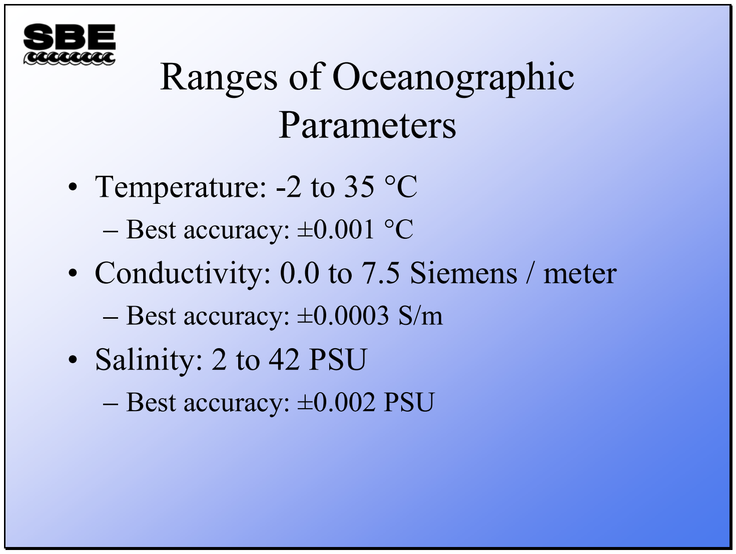
Correcting Data: Example (*continued*)



Correcting Data: Example (*continued*)

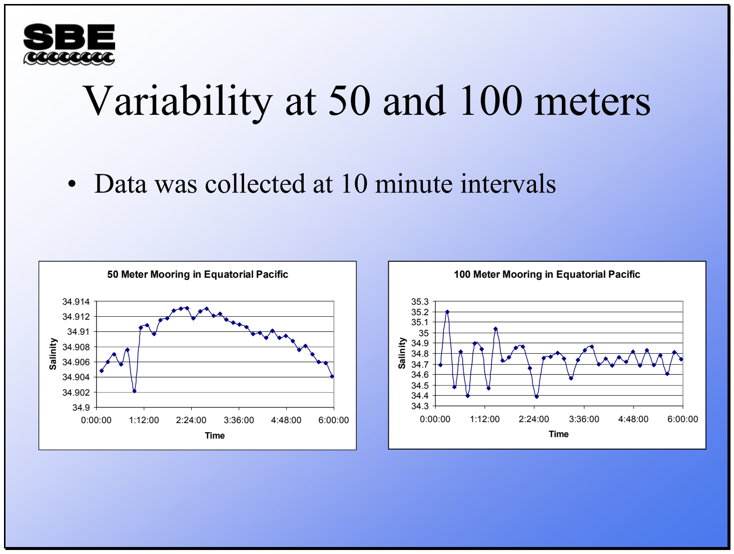


Correcting Data: Review



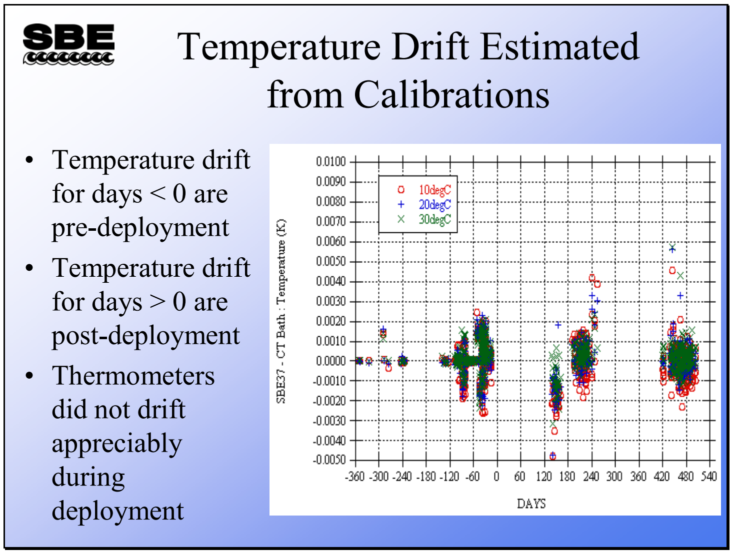
We saw this slide in module 0 in the introduction to oceanographic concepts. These ranges and accuracies will provide a bench mark to evaluate the data that follows.

Correcting Data: Review



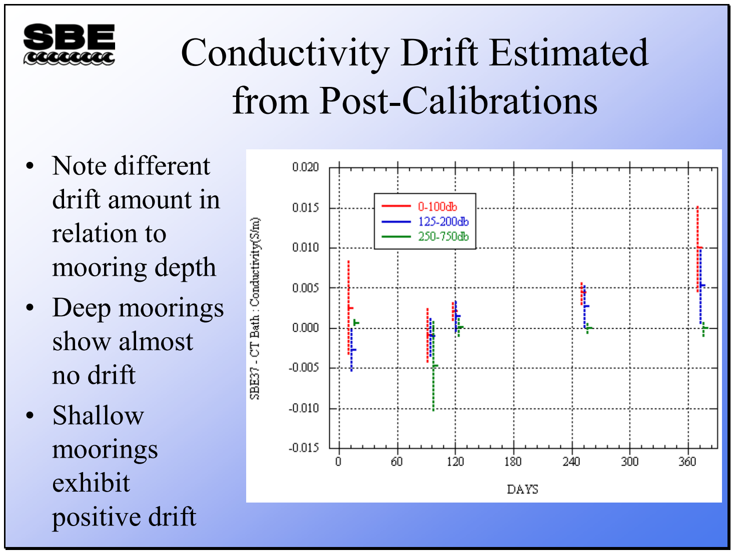
We are going to be comparing data collected by moored instruments with data collected in a CTD profile. It is important to keep in mind that even though the mooring is fixed in place, the ocean moves around it. There can be substantial variability over a fairly small time interval. Most of the time there is little hope of having the CTD in place at the moment the moored instrument is taking a measurement.

Correcting Data: Example (*continued*)



JAMSTEC has installed calibration equipment that allows them to monitor the drift of their sensors before they are deployed. The plot above shows drift of their temperature sensors before and after deployment at three temperatures. As you can see from the plot, with a few exceptions the thermometers are very stable: ±0.002 ºC is within the initial accuracy specified for the SBE 37.

Correcting Data: Example (*continued*)

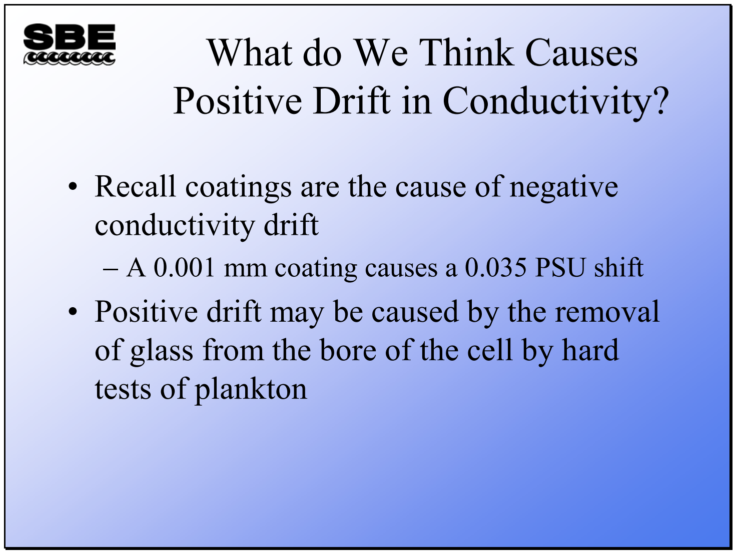


In this plot the drift is estimated at a conductivity value of 6 S/m, and instruments are lumped by mooring depth. Instruments moored in deep water show almost no drift. Those within the surface layer show a positive drift that increases with time. Drift in conductivity sensors is caused by a change in the cell characteristics - either a change in the cell dimensions or electrode characteristics. Note the large error bars on the plot; conductivity drift often has an episodic nature owing to cell fouling due to handling or deployment. The mooring recovered at 90 days has larger error bars and the only negative drift shown. This reinforces the idea that there may have been some incident at or before deployment responsible for the observed drift.

Conductivity: Positive Drift

We have no substantiated ideas regarding positive drift, although it has been observed by researchers in various parts of the world. Anecdotally, when positive drift is observed, it occurs in the instruments in the surface part of the mooring. Also, it seems to occur in areas of high productivity and in areas with strong surface currents.

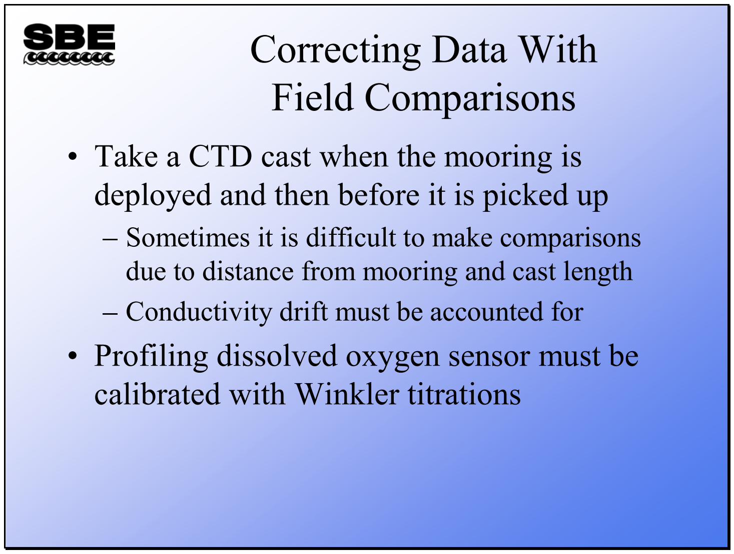
Conductivity: Positive Drift (*continued*)



One possibility is that the hard parts of phytoplankton may abrade the glass of the cell as they pass through. This causes the cross-sectional area of the cell to increase. The conductivity measurement depends on the cell volume; an increase in cross-sectional area will cause the volume to increase. If a cell is calibrated with a starting volume V and the volume is increased at a later time to (V+ΔV), the conductivity value calculated with the original coefficients will produce a calculated conductivity that is high of correct.

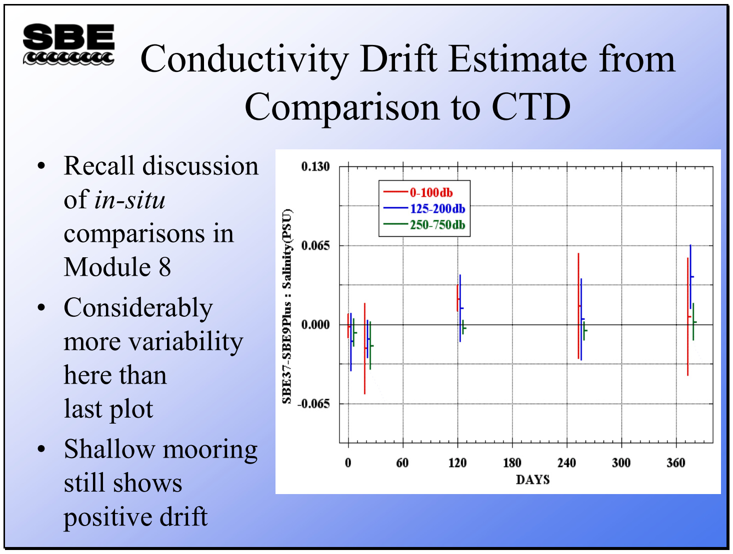
You might think that we could measure the volume of the cell and observe the change in volume. The diameter increase that would produce the errors we are seeing are in the micron range. This change in volume could not be measured gravimetrically. Further, the cross-section of the original cell is not uniform throughout its length, and the abrasion is probably not uniform either, so a comparison of cross-section is not viable.

Correcting Data



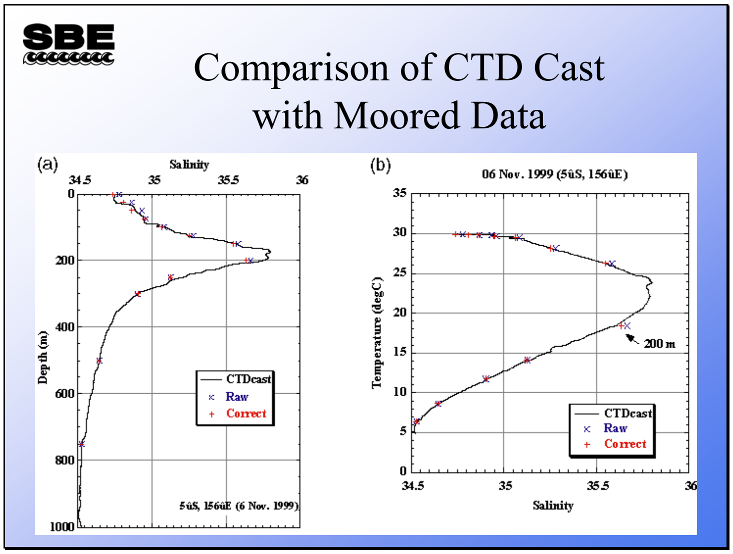
Sea-Bird does not supply software to correct time series data. These corrections are similar to those done on a cast basis for profiled data. An incremental offset is applied to temperature data, assuming the offset drift is linear and monotonic throughout the deployment. For conductivity, an incremental slope is applied to the time series, again assuming that the slope change is linear and monotonic throughout the deployment period.

Correcting Data: Example



Here is a salinity comparison of CTD profiles with mooring data; the data is presented as moored SBE 37 minus SBE 9*plus* CTD. The scale of this plot is much larger than in the plot we looked at on page 20, because the difference in salinity values is much higher. Note that the deep comparisons show little difference, but the variability is quite high in the surface layer. Recall our earlier discussion of calibration by *in-situ* sampling and the plots from the Hawaii Ocean Time Series data.

Correcting Data: Example (*continued*)



Here is a plot of a CTD cast with the mooring data overplotted on it. Raw and corrected values are shown. Although the scale is rather coarse, the correction improved the agreement between the instruments.

Correcting Data: Example (*continued*)

***In-situ* Comparison Statistics: Mooring – CTD (all in PSU)**

	Raw	Corrected by Calibration
Mean	0.0152	-0.0148
Median	0.0168	-0.0069
Standard Deviation	0.0397	0.0422

Here are the statistics from the analysis of seventy SBE 37s deployed for various intervals from 13 days to over a year. It is instructive to note that the mean and median for the raw data are very similar. The data correction process shifted the mean to a negative value, but did not improve its magnitude. The median however was improved, so the data analysis was successful for most instruments. The large mean and standard deviation are likely due as much to surface variability as to measurement errors.

Plots and statistics taken from:

Matsumoto et. al.,(2001) The time drift of temperature and conductivity sensors of TRITON buoy and the correction of conductivity data. JAMSTECR, 44

Activity

Activity: Converting and Plotting Time Series Data

- Use *Seaterm* to convert the data in C:\Data\Module12\Pacific.asc into the *.cnv* format
  - Reference pressure is 50 decibars
- Use *Derive* to add Salinity and Sigma-t
  - Use name append *D*
  - Use any .con file!
- Plot with *Sea Plot*
  - Single X (Julian days), multiple Y (Salinity and Sigma-T)
  - Uncheck the reverse axis box on the X axis
  - Start with the auto range and re-plot as appropriate

A note about .con files and data from SBE 37 MicroCATs:

The SBE 37 is not user-configurable (i.e., it cannot interface with auxiliary sensors), and it outputs converted data in engineering units (using calibration coefficients programmed into the instrument). Therefore, it does not have a .con file (remember that the .con file defines what sensor data is in the data stream and also defines the calibration coefficients). But, SBE Data Processing was originally written to process data from instruments that do have a .con file, and the Derive module therefore requires the selection of a .con file before it will allow you to select the variables to be derived. You can select any .con file; the selection will have no impact on the results.