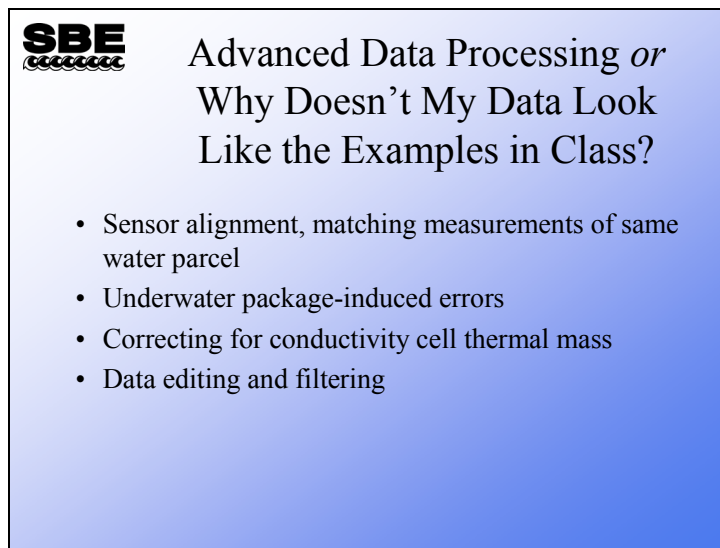


## **Module 9**

# **Advanced Data Processing**

## Overview



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Advanced Data Processing *or*  
Why Doesn't My Data Look  
Like the Examples in Class?

- Sensor alignment, matching measurements of same water parcel
- Underwater package-induced errors
- Correcting for conductivity cell thermal mass
- Data editing and filtering


This section of the course is the final topic in profiling. Some of it is fine tuning of your data to remove small artifacts of frequency counting, plumbing, and sensor physics. We will also discuss the removal of the fairly gross effects of ship heave. Understanding these topics will help explain most of the peculiar things that you might observe in your data if you look closely.

Finally, we will talk about some of the advanced plotting features in Seasoft.

When we finish this module you should be able to:

- Align your conductivity and temperature data relative to pressure.
- Filter your conductivity data so it matches the time response of your temperature data in an SBE 19*plus*.
- Align your dissolved oxygen data relative to pressure.
- Remove the effects of conductivity cell thermal mass from your data.
- Remove data artifacts caused by ship heave.

## Data Processing Steps: SBE 9*plus* / 11*plus*




Data Processing List:  
SBE 911*plus* with DO Sensor

- **Seasave:** Acquire raw data.
- **Data Conversion:** Convert raw data.
- **Filter:** Low-pass filter pressure with time constant = 0.15 seconds to increase pressure resolution for Loop Edit.
- **Align CTD:** Advance oxygen relative to pressure.
- **Cell Thermal Mass:** Perform conductivity cell thermal mass correction if salinity accuracies > 0.01 PSU desired in regions with steep gradients. Typical values  $\alpha = 0.03$  and  $1/\beta = 7.0$ .
- **Loop Edit:** Mark scans where CTD is moving less than minimum velocity or travelling backwards due to ship roll.
- **Derive:** Compute oxygen, salinity, density, and other parameters.
- **Bin Average:** Average data into desired pressure or depth bins.

This is an ordered list of the steps in acquisition and processing of CTD data gathered with the 911*plus*. This list has quite a few more steps than our earlier discussion of the basics. We will work our way through the list, first discussing the cause of the artifact that we are interested in applying some computational energy to, and then discussing the tool to apply it.

Note that the data is bin averaged before the major derived quantities are computed. Salinity, density, etc, are functions of T, C, and P; these are calculated on the final values of T, C, and P rather than the intermediate values. We'll talk a bit more about this at the end of the module.

## Data Processing Steps: SBE 19*plus*




**Data Processing List:**  
**SBE 19*plus* with DO Sensor**

- **Seasave or Seaterm:** Acquire raw data.
- **Data Conversion:** Convert raw data.
- **Filter:** Low-pass filter conductivity and temperature with time constant = 0.5 seconds to force them to have same response. Low-pass filter pressure with time constant = 1 second to increase resolution for Loop Edit.
- **Align CTD:** Advance temperature and oxygen relative to pressure.
- **Loop Edit:** Mark scans where CTD is moving less than minimum velocity or travelling backwards due to ship roll.
- **Derive:** Compute oxygen, salinity, density, and other parameters.
- **Bin Average:** Average data into desired pressure or depth bins.

The processing list for the 19*plus* is shorter because of the lower expectations of precision and the different acquisition electronics.

## Activity



### Activity: *Data Conversion*

- Use the file *C:/Data/Module9/AlignC/Faroe.dat*
  - For the configuration file, use *Faroe.con*
  - Convert the downcast only
  - **Use the secondary temperature and conductivity sensors**
  - Convert to quantities that stand alone:
    - Pressure, Digiquartz
    - Temperature,2 [ITS-90]
    - Conductivity,2 [S/m]
  - Do not calculate parameters that are functions of P,T,C
  - Name your file *Faroe.cnv*
- If you have time, do the same for *Miami.hex*
  - Look in your notes for details


We are preparing to operate on the data with an application that moves the T and C data streams relative to the pressure data stream. Calculation of parameters that are functions of T, C, and P is not useful at this stage. Further, it will complicate and confuse things to have them in the data set before we are ready for them.

If you have time, process the *19plus* data in

*C:\Data\Module9\AlignC\SBE19plus\Miami.hex*, using *Miami.con*. The *19plus* has no secondary sensors. Your *Data Conversion* setup is:

- Downcast only
- Convert... Pressure, Strain Gauge [db], Temperature [ITS-90], Conductivity [S/m]
- Name your file *Miami.cnv*

## Conductivity Time Constant



Conductivity Time Constant (Tau)

- Conductivity cell has a time constant that depends on pumping rate
- SBE *9plus* system's pump and TC duct constrain Tau of conductivity to match Tau of temperature
- SBE *19plus* is not as well matched and requires filtration
  - Best match is achieved by filtering both temperature and conductivity

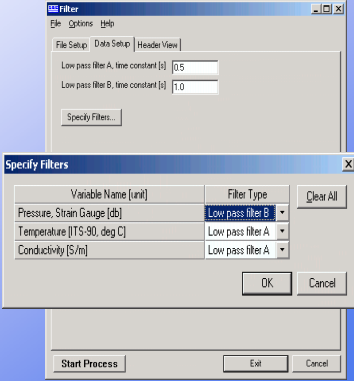
It is very desirable to match the time constants of the temperature and conductivity sensors. This improves salinity data in conditions of sharp gradients. The conductivity sensor has a time constant that depends on pumping rate; it can range from 10 milliseconds at a fast pumping rate to very large if no water is moving through the cell. For the *9plus* with a TC duct and standard plumbing, a pumping rate of 25 ml/s brings the conductivity sensor's time constant in line with the temperature sensor's time constant of ~70 ms. The *19plus* temperature sensor has a much slower time constant than its conductivity sensor, as we saw in the first part of the course. Because of the way the filtering algorithm operates, the best match of temperature and conductivity is obtained by filtering both channels with a filter having the same time constant as the temperature channel.

## Conductivity Time Constant (*continued*)

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### Filtering Converted Data

- SBE *9plus*
  - Filter A time constant  
0.15 seconds for pressure
- SBE 25
  - Filter A time constant  
0.5 seconds for pressure
- SBE *19plus*
  - Filter A time constant  
0.5 seconds for conductivity  
and temperature
  - Filter B time constant  
1.0 second for pressure

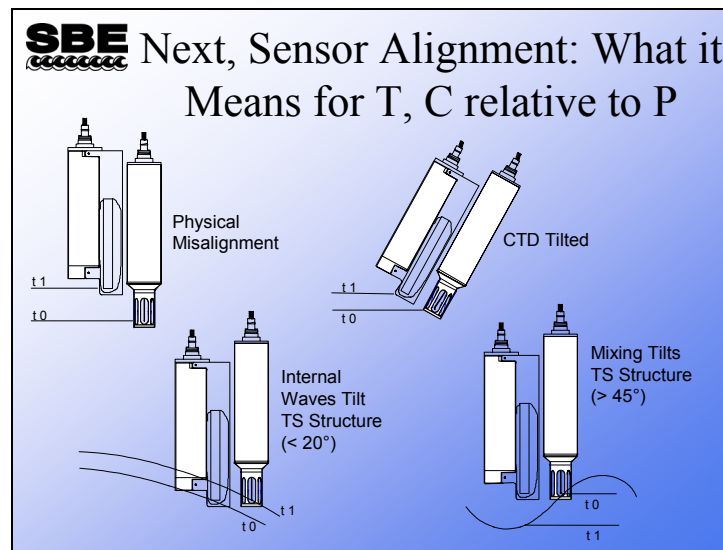


Variable Name [unit]	Filter Type
Pressure, Strain Gauge [db]	Low pass filter B
Temperature [ITS-90, deg C]	Low pass filter A
Conductivity [S/m]	Low pass filter A

Filtering is done for two reasons:

- To match the time constants of the temperature and conductivity sensors.
- To smooth the pressure signal to minimize digitization noise in preparation for removing *loops* in the data with *Loop Edit*. When smoothing pressure, use a filter that is approximately four times the sample rate:
  - SBE *9plus* – samples at 24 Hz (0.04167 sec),  $4 \times 0.04167 \approx 0.15$  sec
  - SBE 25 – samples at 8 Hz (0.125 sec),  $4 \times 0.125 = 0.5$  sec
  - SBE *19plus* – samples at 4 Hz (0.25 sec),  $4 \times 0.25 = 1$  sec

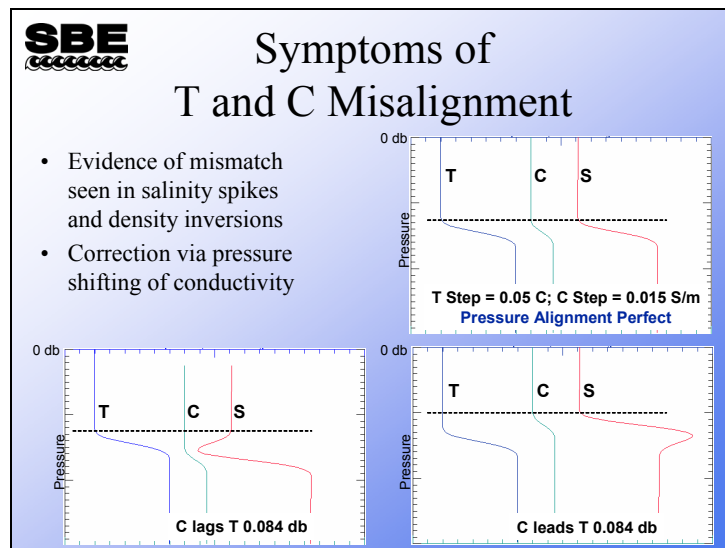
## Illustrating Sensor Misalignment



These illustrations show alignment problems for an instrument **not** using a TC duct (such as an SBE 19, which was typically sold without a TC duct). Here the temperature and conductivity sensors can *see* very different water.



## Demonstration of Misalignment Effects



Here is an artificial data set with a step change in temperature and conductivity.


Temperature is the blue trace, conductivity is the green, and salinity is the red.

- In the top plot, T and C are perfectly matched, yielding a plot of salinity that is as expected.
- In the bottom left plot, C lags by 0.084 decibars (this is 2 scans at the *9plus* data rate, at a typical 1 m/s lowering rate). You can see that a negative spike shows up in the salinity data.
- In the bottom right plot, C leads T by 0.084 decibars, yielding a positive spike in salinity.

This behavior can be present in any CTD system built by any manufacturer. It is caused by a mismatch of T and C measurements in relation to pressure. This is not a sensor artifact; any T and C pair using any technology will produce an error in salinity if a scan contains measurements from different water parcels.

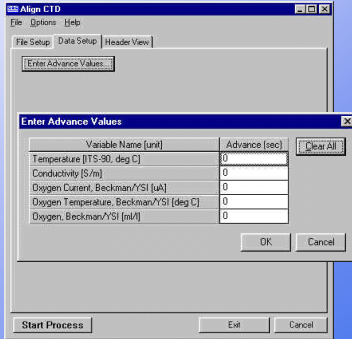
A note about the direction of the salinity spike: The direction of the salinity spike is also dependent on whether T and C are increasing or decreasing with increasing pressure. For the examples above, if T and C were decreasing rather increasing, the salinity spike would be in the opposite direction.

## Removing Misalignment



### Manipulating Data to Remove Misalignment

- An alignment is done automatically in the *11plus*
- Alignment can change from default due to changes in plumbing that increase or decrease pumping speed
- Use Align CTD module to match temperature and conductivity data streams



Because the *911plus* system is well characterized, an alignment of the data stream is done automatically in the *11plus* before data is transmitted to your computer. With the TC duct in place, an alignment of 1.75 data scans (or 0.073 seconds) is done on incoming data. A linear interpolation between scans is done to implement the alignment of a non-integer number of scans.

Misalignment that differs from the nominal values can arise from plumbing changes, which can influence pumping speed. A slower pumping speed increases a water parcel's residence time in the TC plumbing, and will require a larger shift in data scans. A faster pumping speed will decrease the residence time in the TC plumbing and require a smaller alignment value.

Note that the advance values are given in seconds and are relative to the pressure channel.

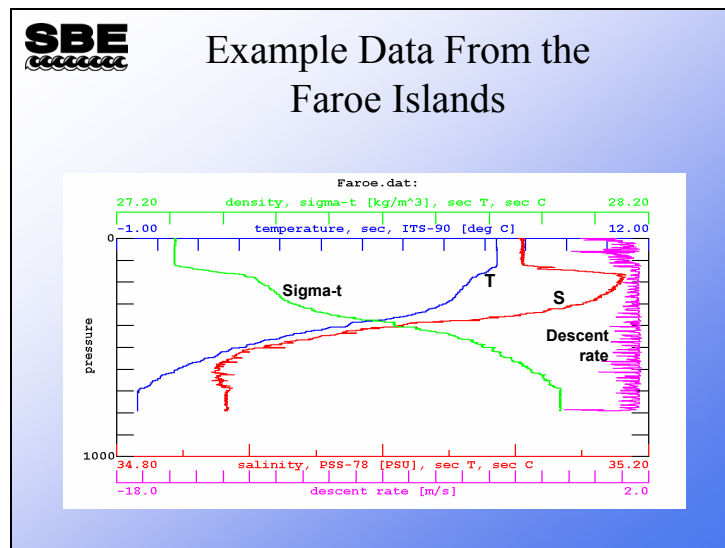
## Removing Misalignment (*continued*)



### How Do I Know How Much to Advance or Retard a Data Channel?

- By looking at your data
  - Find a spot in your data with a sharp salinity shift
  - Experiment with alignment values to minimize a salinity excursion, as shown previously

## Removing TC Misalignment: Example

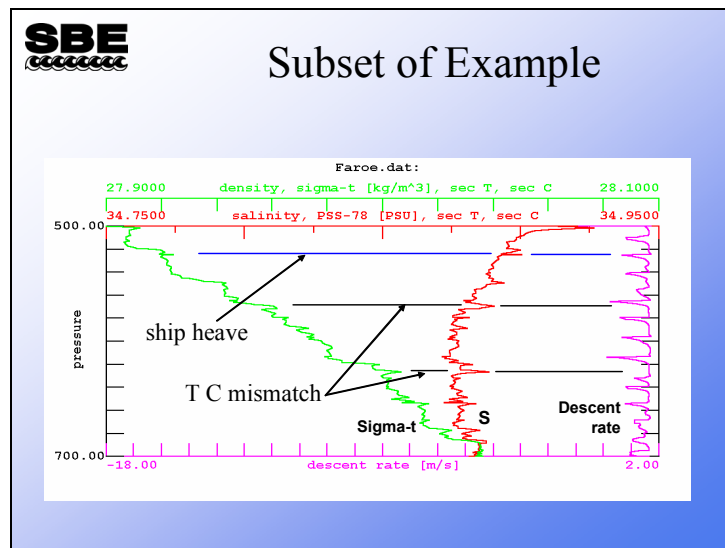


This data set was collected with the secondary T and C sensors of a 911*plus* off the Faroe Islands in 1995. Note the spiky salinity data and the density inversions. These arise from two phenomena: a mismatch between temperature and conductivity samples, and ship heave. The ship heave causes water to move from around the instrument package down to the sensors during deceleration.

We will enlarge part of the plot for a closer look, and do some experimenting with sensor alignment.


A note about sensor alignment in the 911*plus*: We mentioned earlier that the 11*plus* Deck Unit performs an automatic alignment of T and C. However, in old versions of the 11*plus*, the automatic alignment was done only on the output from the primary T and C sensors; for secondary sensors we must do the alignment in post-processing.

## Removing TC Misalignment: Example (*continued*)



It is important to plot descent rate as well as density and salinity, because ship heave can cause errors in your data set that are completely different from alignment errors. To align your data, plot a small subset of the data that has sharp changes in temperature and/or conductivity. Look for spikes in the salinity and density that do not correspond to rapid descent rate decreases, which are indicative of ship heave.

## Activity



### Activity: Align and Derive

- Use C:\Data\Module9\AlignC\Faroe.cnv you created in the last activity
- *Align CTD*:
  - Advance C relative to P 0.042, 0.084, and 0.126 seconds (1, 2, and 3 scans)
  - Name append *A1*, *A2*, and *A3*
- *Derive*:
  - Use Faroe.cnv, FaroeA1.cnv, FaroeA2.cnv, and FaroeA3.cnv
  - Calculate Salinity, 2[PSU] and Density 2, sigma-t Kg/m<sup>3</sup>
  - Name append *D*
- *Sea Plot*: compare results
  - Plot P vs S
  - Overlay plot with 0.025 offset for S
  - P: 500 to 700, S: 34.75 to 35.00,
  - Repeat, plotting P vs Sigma-T (27.9 to 28.1) with 0.025 offset for Sigma-T
- If you have time, do the same for 19*plus* data
  - Look in your notes for details

For this activity, start with the .cnv file you created in *Data Conversion* that contains temperature and conductivity. Do some advancing on the file with *Align CTD*. Then, use *Derive* to calculate salinity and density from the original .cnv file and each aligned file.

You should end up with the following files:

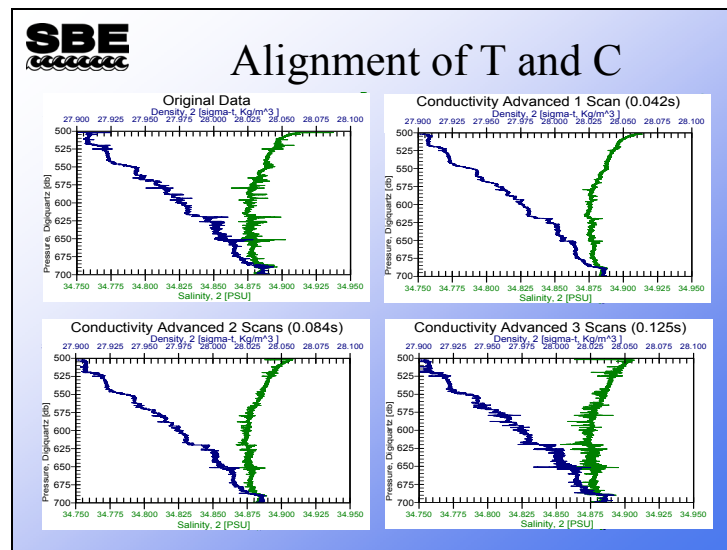
- FaroeD.cnv... Original data with salinity and density derived
- FaroeA1D.cnv... FaroeD.cnv with C advanced 1 scan = 0.042 seconds, with salinity and density derived
- FaroeA2D.cnv... FaroeD.cnv with C advanced 2 scans = 0.084 seconds, with salinity and density derived
- FaroeA3D.cnv... FaroeD.cnv with C advanced 3 scans = 0.126 seconds, with salinity and density derived

Check your results with an overlay plot in *Sea Plot*. De-select *Sort input files* in the Options menu, and then select the files in order: FaroeD.cnv, FaroeA1D.cnv, FaroeA2D.cnv, FaroeA3D.cnv.

If you have time, align the data in C:\Data\Module9\AlignC\SBE19plus\.

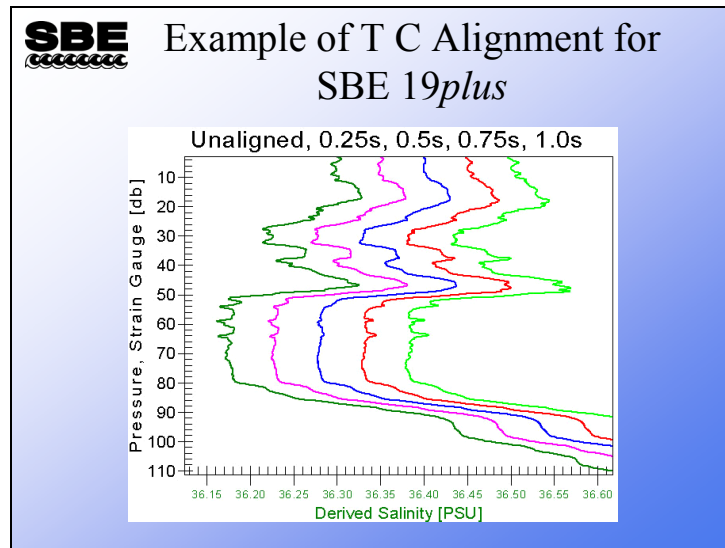
- First, filter the temperature and conductivity channels to match the sensor response, using the Filter module. On the *Data Setup* tab, set Low pass filter A to a time constant of 0.5 seconds. Click *Specify Filters...* and select *none* for pressure and *Low pass filter A* for temperature and conductivity.
- Next, advance temperature against pressure; try whole scan *values* of 0.25, 0.5, 0.75, and 1.0 seconds.
- Check your results with *Sea Plot*.

## Removing TC Misalignment: Example (*continued*)



This is from the Faroe data set. The data on the upper left is unaligned, raw data. The upper right has the conductivity channel advanced relative to pressure 0.42 seconds (1 scan); spiking shows considerable improvement. The plot on the lower left has conductivity advanced 0.084 seconds (2 scans) and shows some of the spikes going the other direction. The plot on the lower right has conductivity advanced 0.125 seconds (3 scans), and the spikes have reversed direction and are beginning to get longer. Note that you can align by a non-integer scan interval. In fact, the SBE 11*plus* performs an alignment for you of 1.75 scans (0.073 seconds).


## Removing TC Misalignment: Example (*continued*)



This is from the extra credit data set. The right most trace is the original unaligned data and the others, from left to right, are aligned from 1 to 4 scans. The optimal alignment value may lie between 0.25 and 0.5 seconds; it is left for the reader to experiment and find it.



## Removing Misalignment in Dissolved Oxygen



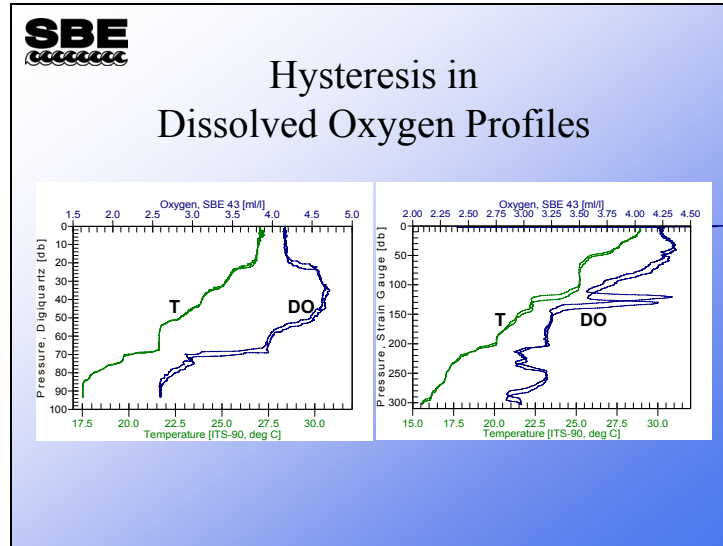
**SBE**  
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### Dissolved O<sub>2</sub> Alignment

- Sensor time constants ~ 2 - 6 seconds, depending on temperature
- Plumbing delay ~ 2 seconds
- Delays add for ~ 4 seconds total
- Hysteresis in DO profiles is caused by plumbing delays, temperature mismatch, and sensor response time
- Newer sensor, SBE 43, minimizes these problems

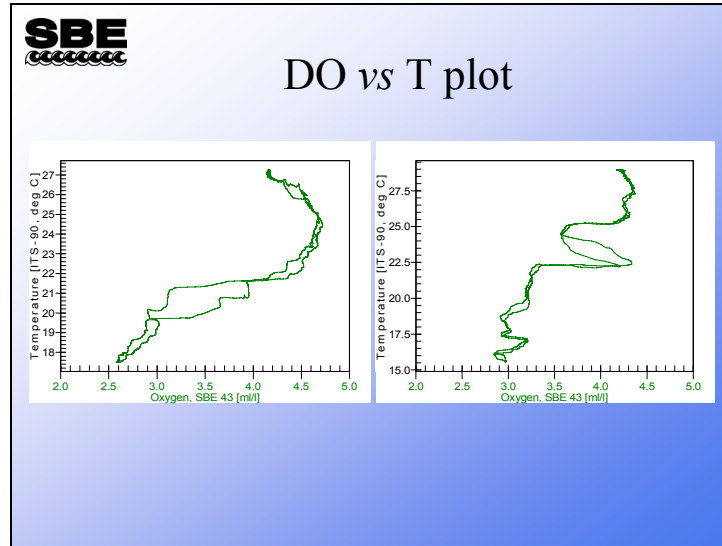
Aligning oxygen current and temperature in relation to pressure can improve hysteresis in dissolved oxygen profiles. The SBE 43 has a faster time constant and shows improvement in hysteresis over the Beckman- or YSI-type of sensor.

## Removing Misalignment in Dissolved Oxygen (continued)



While hysteresis is easily observed in pressure *vs.* oxygen profiles, it is also easy to confuse hydrographic phenomenon with hysteresis. The plot on the right shows hysteresis in both temperature and oxygen; the peak in oxygen has a sharp gradient in temperature associated with it. The cast was taken near the Gulf Stream, and it is likely that the ship drifted during the cast. The CTD downcast probably moved through the hydrographic feature at a different depth than the upcast. A hydrographic phenomenon should not be removed with data manipulation.

## Removing Misalignment in Dissolved Oxygen (continued)



Viewing hysteresis in  $DO - T$  space is an effective way of eliminating the confusion of hysteresis and hydrographic phenomenon.

## Activity



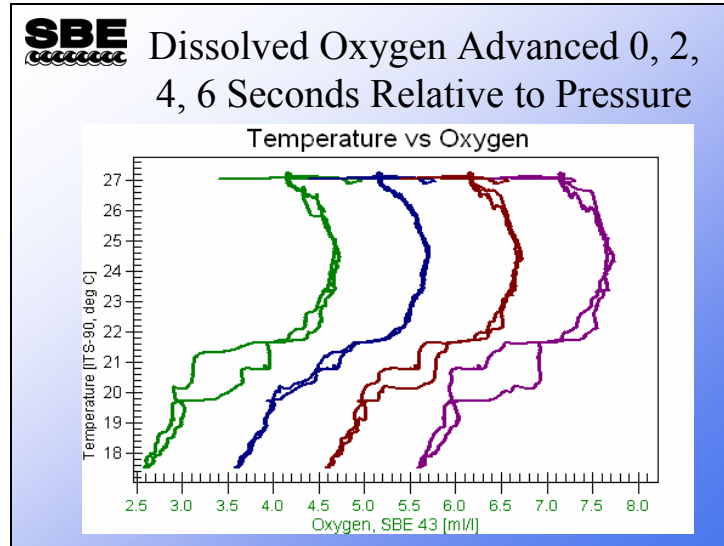
### Activity: Align DO Data

- Use C:\Data\Module9\AlignDO\GulfMex.dat
- *Data Conversion*: P, T, S, Oxygen Voltage SBE 43
  - Upcast and downcast, file name GulfMex.cnv
- *Align CTD*: advance Oxygen Voltage SBE 43 relative to pressure 2, 4, and 6 seconds
  - Name append *A2*, *A4*, and *A6*
- *Derive*: Oxygen, SBE 43 in ml/l for **all** .cnv
  - Name append *D*
  - Accept default 2.0 second window size for oxygen
- *Sea Plot*: Plot T vs Oxygen, compare results
- If you have time, align oxygen data in C:\Data\Module9\AlignDO\SBE19plus\


You should end up with the following files:

- GulfMexD.cnv                      original data, not advanced
- GulfMexA2D.cnv                  dissolved oxygen advanced 2 seconds
- GulfMexA4D.cnv                  dissolved oxygen advanced 4 seconds
- GulfMexA6D.cnv                  dissolved oxygen advanced 6 seconds

## Removing Misalignment in Dissolved Oxygen (continued)



## Conductivity Cell Thermal Mass

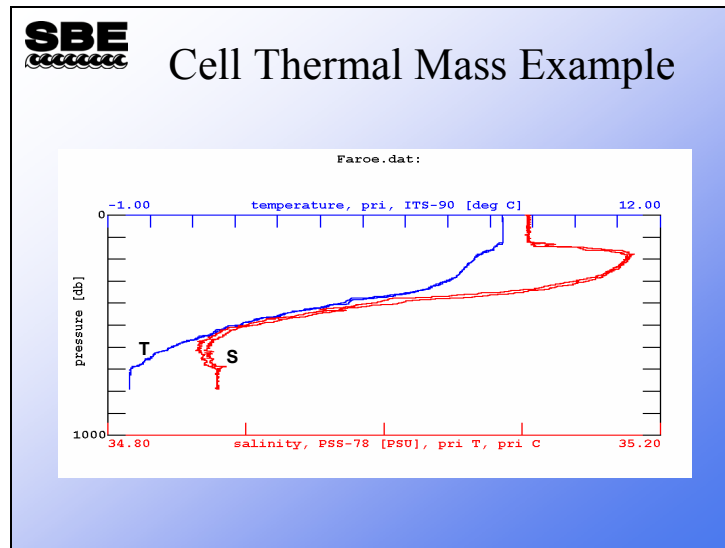


Effect of Conductivity  
Cell Thermal Mass

- Glass conductivity cell stores heat
- A warm cell warms water moving through it
- A cold cell cools water moving through it
- This causes water in cell to be a different temperature than thermometer measured a moment earlier

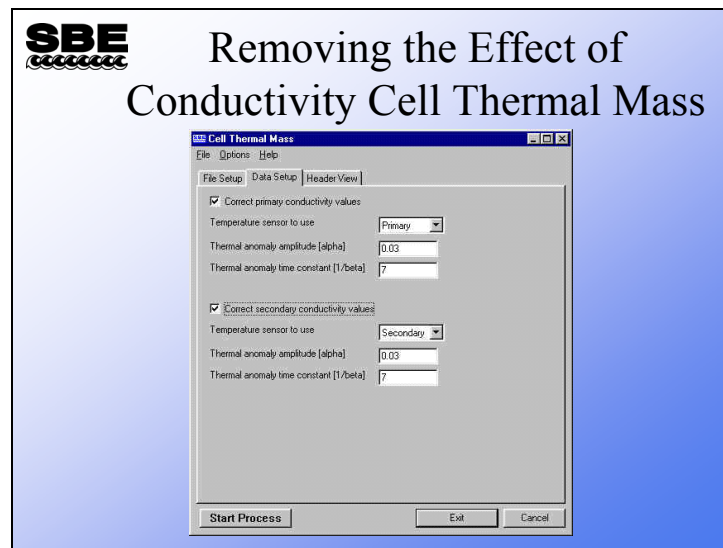
The conductivity measurement has temperature dependence. The conductivity cell itself is constructed of glass and plastic, and as such has a thermal mass. When the cell goes from warm water into cold, the water that passes through the cell is slightly warmed as it transits the cell. Conversely, when the cell comes up from cold water into warmer water, the water that passes through the cell is cooled slightly. This heat transfer can be modeled and corrected.

## Conductivity Cell Thermal Mass (*continued*)



The feature that looks like salinity hysteresis is actually caused by the effect of cell thermal mass.

## Compensating for Conductivity Cell Thermal Mass



SBE Data Processing has a *Cell Thermal Mass* module. The thermal mass correction is made with the equation shown below, which is a function of amplitude ( $\alpha$ ) and time constant ( $1 / \beta$ ). Like many of the sensor-related phenomena we have considered, the heat transfer within the cell has a time constant.

Thermal mass correction:

$$\text{Corrected Conductivity} = C + ctm$$

Where:

$C$  = uncorrected conductivity

$$ctm = -1.0 \times b \times \text{previous } ctm + a \times \left( \frac{dc}{dt} \right) \times dt$$

$dt$  = temperature - previous temperature


$$a = 2 \times \frac{\alpha}{\text{sample interval} \times \beta + 2}$$

$$b = 1 - \left( 2 \times \frac{a}{\alpha} \right)$$

$$\frac{dc}{dt} = 0.1 \times (1 + 0.006 \times [\text{temperature} - 20])$$



## Activity



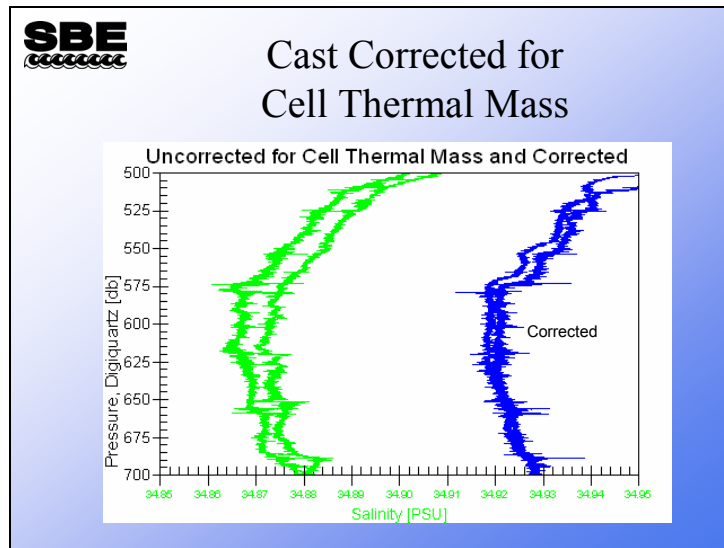
**Activity: Conductivity for Cell Thermal Mass**

- File is C:\Data\Module9\CellTM\Faroe.dat
- *Data Conversion:*
  - Downcast and upcast
  - Time, Elapsed.. Seconds
  - Pressure, Digiquartz..db
  - Temperature..ITS-90..deg C
  - Conductivity.. S/m
- *Cell Thermal Mass:* use defaults
  - Name Append C
- *Derive:* salinity for original and corrected
- *Sea Plot:*
  - Compare results over 500 – 700 db pressure range
  - Overlay plot of pressure vs salinity


You should have files named:

- Faroe.cnv           for original data
- FaroeC.cnv         for corrected data

## Activity (*continued*)



## Filtering Pressure to Remove Digitization Effects



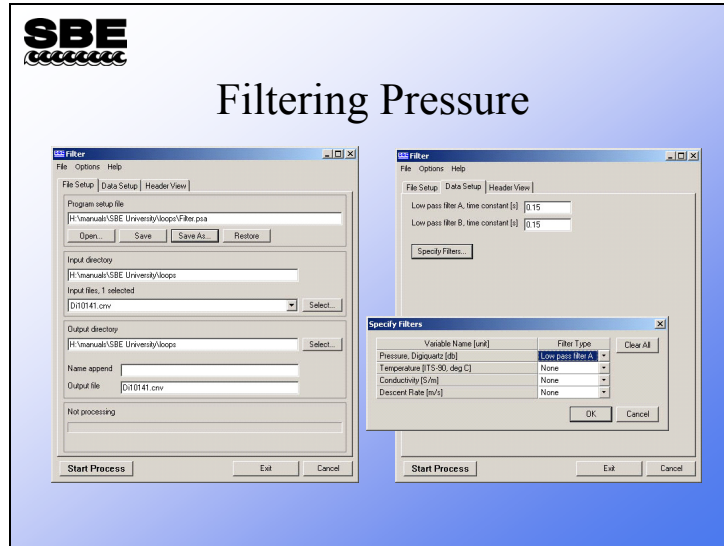
**SBE**  
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### Filtering Pressure

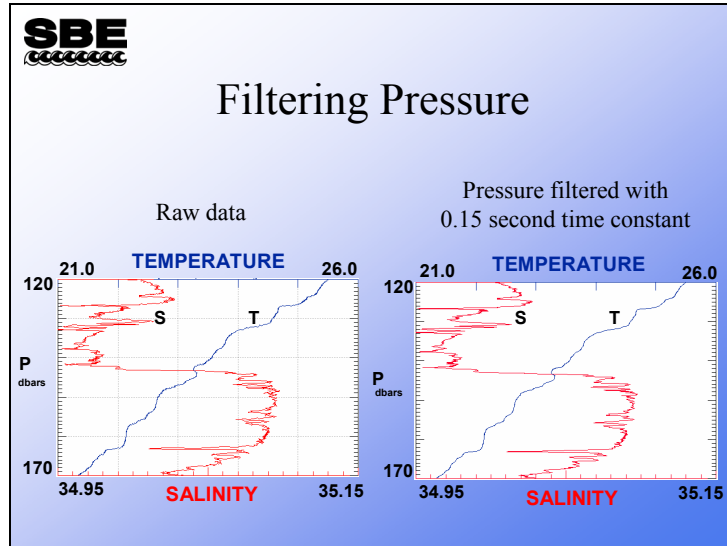
- Filtering pressure data removes the digitization noise
- Filter pressure data if:
  - You are going to use *Loop Edit* to remove data artifacts, and/or
  - You are interested in fine scale in a *9plus*

In measuring the pressure sensor signal, there is a digitization error that may be removed by filtering the signal with a low-pass filter. This has the effect of improving the resolution of the pressure signal by smoothing the digitization jitter.

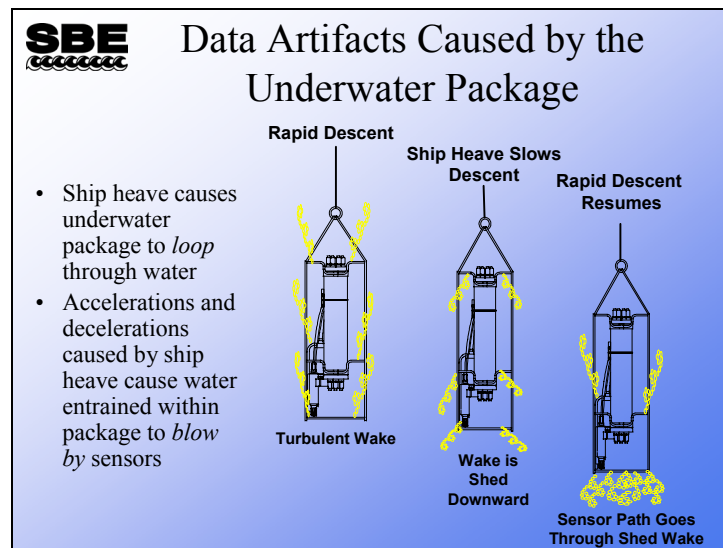
## Filtering Pressure to Remove Digitization Effects (continued)



## Filtering Pressure to Remove Digitization Effects (continued)



## Data Artifacts Induced by Ship Heave

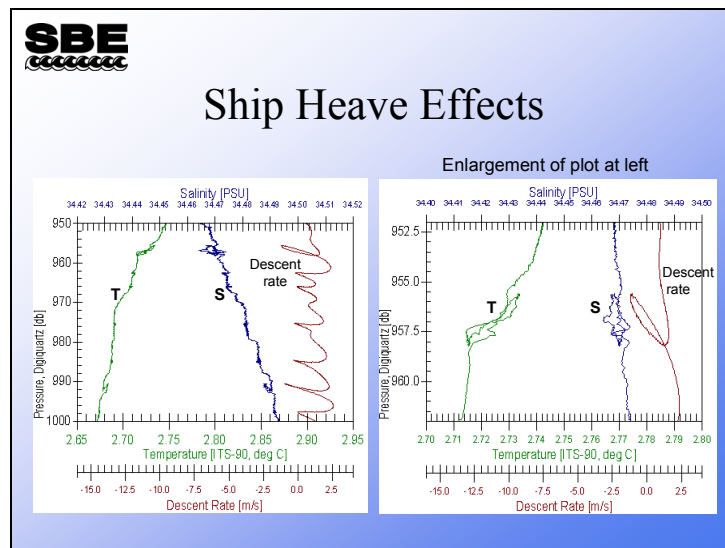


Ship heave is the rocking motion of the ship. Most CTD deployments are made with a small boom or an A-frame that leans out from the ship, giving some distance between the sea cable and the side of the ship. Ship rocking has the effect of pulling up on the sea cable when the ship rocks in one direction and slackening the sea cable when it rocks in the other. This heaving action causes the underwater package to decelerate when the sea cable is pulled up and accelerate when it goes slack. Most instrument packages have sufficient cross section that the deceleration effect is more pronounced than the acceleration.

As the instrument decelerates, water that is entrained within the package can continue downward past the sensors. This water is of different temperature and conductivity than the water at the bottom of the package, and it causes a sampling error.


Further, in cases of radical ship heave, the instrument package can have a trajectory through the water column that describes loops. It goes without saying that this sort of behavior causes sampling errors.

## Data Artifacts Induced by Ship Heave (*continued*)



These two plots show the effect of ship heave. Both plots show descent rate in brown. The plot on the left shows that each time the descent rate drops, the temperature and salinity traces are disturbed. The plot on the right is an enlargement of a portion of the left plot, showing the loop trajectory that was mentioned previously.

## Removing Data Artifacts Induced by Ship Heave



### Removing Package-Induced Data Artifacts

- Data errors introduced this way must be deleted; there is no *fix*
- *Loop Edit* removes loops caused by ship heave
- *Wild Edit* removes data that fall outside of user-specified limits

The error caused by ship heave comes from the instrument package disturbing the water that it is trying to sample. Because of this, there is no numerical solution for the problem. SBE Data Processing has two editing modules that remove the offending data. As winch technology improves, we can expect to see vessels equipped with motion compensation capability, which will greatly reduce this problem.

*Loop Edit* marks data collected when the CTD loops through the water or decelerates sharply. *Wild Edit* marks data that falls outside of user-specified limits, given as standard deviations of a window of data.

Data that is marked by these modules can be omitted in subsequent processing steps.



## Removing Data Artifacts Induced by Ship Heave (continued)

**SBE** **Removing Package-Induced Data Artifacts**

The screenshot displays two dialog boxes from the SBE software interface. The 'Loop Edit' dialog box on the left has the following settings: Minimum velocity type set to 'Fixed minimum velocity', Minimum CTD velocity (m/s) set to 0.25, Window size (s) set to 100, Percent of mean speed set to 50, and the checkbox 'Exclude scans marked bad' is checked. The 'Wild Edit' dialog box on the right has the following settings: Standard deviations for pass one set to 2, Standard deviations for pass two set to 20, Scans per block set to 100, Keep data within this distance of the mean set to 0, and the checkbox 'Exclude scans marked bad' is checked. A 'Variables in test.csv' dialog box is also visible, listing variables with checkboxes for 'Wild Edit': Pressure, Digiquartz (db) [X], Temperature, 1 (ITS-90, deg C) [X], Temperature, 2 (ITS-90, deg C) [X], Conductivity, 1 (S/m) [X], and Conductivity, 2 (S/m) [X].

**Loop Edit**

File Options Help

File Setup Data Setup Header View

Minimum velocity type: Fixed minimum velocity

Minimum CTD velocity (m/s): 0.25

Window size (s): 100

Percent of mean speed: 50

Exclude scans marked bad

Start Process Exit Cancel

**Wild Edit**

File Options Help

File Setup Data Setup Header View

Standard deviations for pass one: 2

Standard deviations for pass two: 20

Scans per block: 100

Keep data within this distance of the mean: 0

Exclude scans marked bad


Select Wild Edit Variables...

**Variables in test.csv**

Variable Name (unit)	Wild Edit	Select All
Pressure, Digiquartz (db)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Temperature, 1 (ITS-90, deg C)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Temperature, 2 (ITS-90, deg C)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Conductivity, 1 (S/m)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Conductivity, 2 (S/m)	<input checked="" type="checkbox"/>	<input type="checkbox"/>

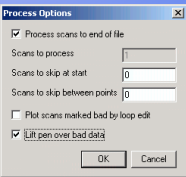
Start Process Exit Cancel

## Activity



### Activity: Remove the Loops from an Example Data Set

- Use the file C:\Data\Module9\Loop\AArctic.dat
- *Data Conversion:*
  - Downcast only
  - Time, pressure, temperature, salinity, descent rate
- *Filter:* Pressure
  - Time constant 0.15 s
  - Use the same file name, AArctic.cnv
- *Loop Edit:* Uncheck *Remove surface soak* and *Exclude scans marked bad*
  - Percent mean speed, 300 second window, 20% mean speed, name append *P*
  - Fixed minimum velocity, 0.25 m/s, name append *F*
- *Sea Plot:* compare results
  - Click *Plot Setup* tab
  - Click *Process options* button
  - Check *Lift pen over bad data*



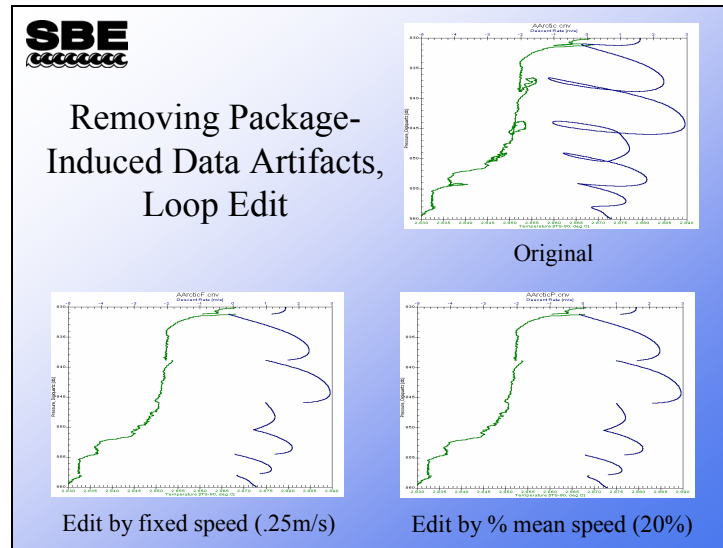
You should have the following files after processing AArctic.cnv in Loop Edit:

- AArcticP.cnv      for percent of mean speed
- AArcticF.cnv      for fixed velocity

When you plot your data, choose pressure for the y axis. Choose descent rate and temperature for the x axes. Suggested ranges are:


- Pressure: 830 to 860 decibars
- Temperature: 2.83 to 2.89 °C
- Descent rate: -5 to 3 m/sec

## Removing Data Artifacts Induced by Ship Heave (continued)



Here is the example of loopy data that we showed earlier. The bottom two plots have been edited by the two means available. Both plots show very similar results. The bottom left plot is made by editing out data that drop below a fixed speed, in this case 0.25m/s. The bottom right plot is made by editing data that drops below 20% of the mean speed calculated over a 5-minute window; this method gives you a bit more flexibility.

## Data Processing Tips



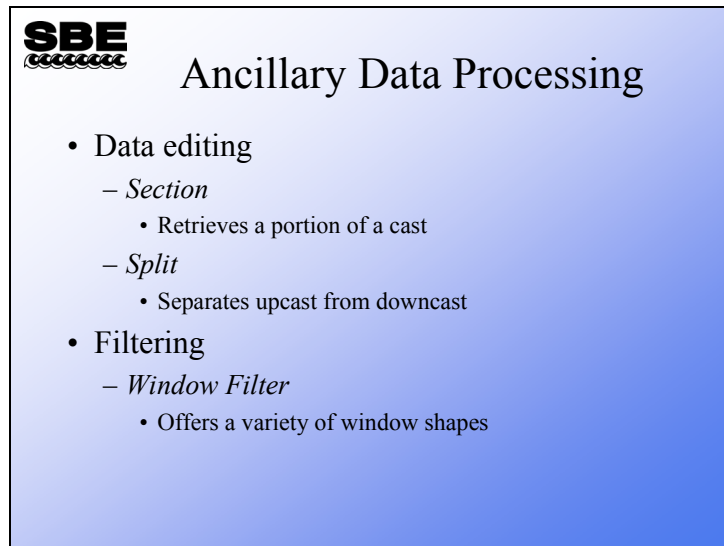
**SBE**  
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### Data Processing Notes

- Best data is collected at highest rate instrument is capable of
- Data should not be *reprocessed*
- Calculation of derived parameters and bin averaging should be done last

A final note. Collect your data at the highest speed you can. Do not reprocess data; if you advance data channels and bin average them or derive other parameters from them, do not advance them again. Derivation of salinity, density, etc. and bin averaging should be the last step after you process and edit your data. The decision to *Derive* and then *Bin Average* or to *Bin Average* and then *Derive* is yours. If you *Bin Average* first you will be *Deriving* from statistical estimates made from your data. If you *Derive* and then *Bin Average*, you will be creating statistical estimates of your derived quantities.

## Ancillary Data Processing

A blue gradient rectangular box containing the SBE logo (with a stylized 'cccccccc' below it) and the title 'Ancillary Data Processing'. Below the title is a bulleted list of data processing functions: 'Data editing' (with sub-items 'Section' and 'Split'), and 'Filtering' (with sub-item 'Window Filter').

**SBE**  
cccccccc

### Ancillary Data Processing

- Data editing
  - *Section*
    - Retrieves a portion of a cast
  - *Split*
    - Separates upcast from downcast
- Filtering
  - *Window Filter*
    - Offers a variety of window shapes

In addition to the data processing modules and procedures we have talked about, there are other modules available. You can clip out part of your data with *Section*, and separate your data into upcasts and downcasts with *Split*. And, there is a window filtering module with various shaped windows.

