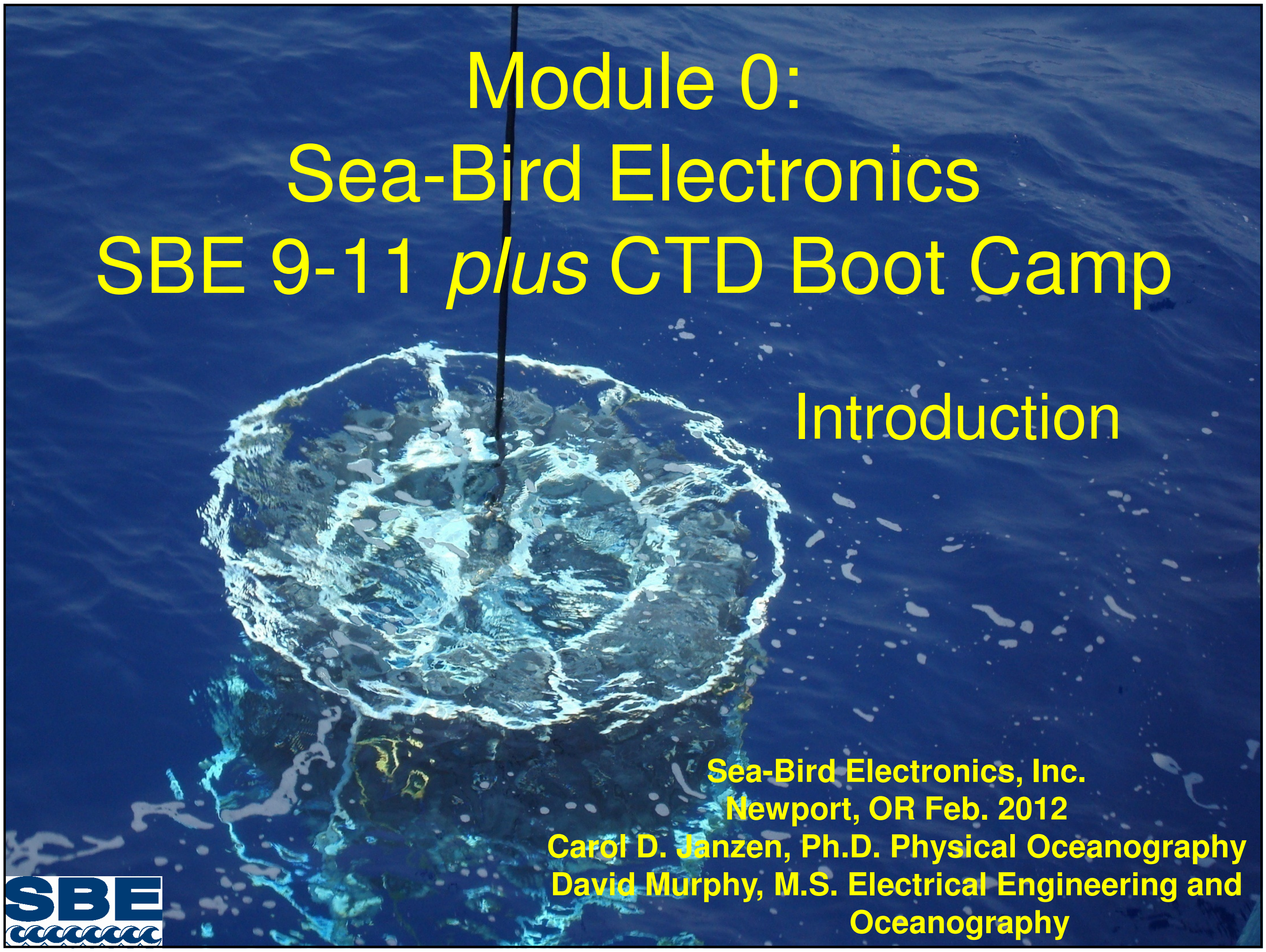
Module 0:
Sea-Bird Electronics
SBE 9-11 *plus* CTD Boot Camp
Introduction
Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and Oceanography
SBE

Introductions

At the end of this course, we will have covered

- **Setup, Configuration and Real Time Sampling with the SBE 9-11 *plus* CTD System**
  - Review of SEASAVE and Configuration Files

- **Sources of error in CTD data**
  - Static Error (Calibration – brief overview)
  - Dynamic Errors (More detailed discussion, symptoms and corrections)
  - Sampling Errors (not correctable, ways to minimize)

- **Understanding Data Characteristics and the Basic Data Processing Steps to Achieve Highest Accuracy Data**
  - Recognize a real problem versus a data processing issue
- **Troubleshooting**
  - Using Data to evaluate a problem
  - Using instrument diagnostics to evaluate problem
  - Field Repairs

- **Instructional examples and hands on demonstrations**

  Open to questions

Sea-Bird Resources

Brief Web Tour
Boot Camp PDF - Booklet
SBE Training PDF - Manual
Data Exercises
Software

Sea-Bird Website
www.seabird.com

- Manuals:
  - Instrument and Software manuals
  - upload free from online
- 98+ Application Notes, by topic, sensor type/number etc.
  - i.e. App-Note 64-3 Hysteresis Corrections for Dissolved Oxygen
- FAQs – commonly asked questions
- Software – upload from FTP site, Free!!!
  - Update to be sure you have latest version with most capability
- Customer Service
  - Service technicians can answer many questions regarding instrument problems and data processing
  - Oceanography staff assist with more difficult problems
  - RMA forms for service online, email contacts
- Technical Papers and Presentations
  - Sourced literature relevant to SBE products
  - SBE presentations, papers, and course materials

Application Notes

- Instrument Configuration
- Data Corrections
- Troubleshooting
- Other relevant topics

SBE
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APPLICATION NOTE NO. 15 September 2003

TC Duct Assembly and Plumbing Installation

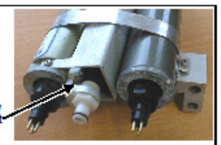
This Application Note describes use of the PN 90085 Customer-Installed TC Duct Kit, covering:

- Installation and removal of the TC (Temperature-Conductivity) Duct Assembly on the SBE 3 temperature sensor and SBE 4 conductivity sensor on an SBE 9 / 9*plus* or SBE 25 SEALOGGER CTD, when equipped with the standard sensor mounting bracket.
- Installation of system plumbing for the CTD with a pump and (optional) SBE 13 or SBE 23 Dissolved Oxygen (DO) Sensor. Sea-Bird stopped selling the SBE 13 and 23 in early 2001, and began selling the SBE 43 DO Sensor. The orientation / location of the SBE 43 differs from what is shown in this application note, although the same parts are used for the plumbing; **see Application Note 64-1 for plumbing installation for a system including the SBE 43.**

Both the installation and removal procedures require slow, deliberate movements to avoid breaking the temperature or conductivity sensor. Therefore, Sea-Bird recommends that you perform these procedures in a lab, not on deck.

Note:
If your conductivity sensor does not have a conductivity tube support, install the conductivity tube support kit (see Application Note 36) before installing the TC Duct and plumbing.

Conductivity tube support kit:
PN 50094 for aluminum sensors
PN 50108 for titanium sensors

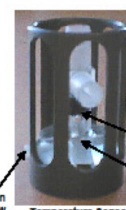


TC Duct Installation

Preparation

Parts Included in PN 90085 Kit that are Used for TC Duct Installation

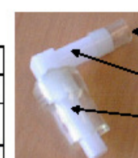
- Temperature sensor guard assembly (replaces existing temperature sensor guard), which consists of:
  - Temperature sensor guard
  - T Duct
  - Morrison seal 0.026 ID x 0.24 OD, installed in T Duct
  - (2) Phillips-head nylon machine screws, 2-56 x 1/4, attaching T Duct to temperature sensor guard



Temperature Sensor Guard Assembly

- C Duct assembly (fits into end of conductivity cell), which consists of:
  - C Duct
  - Flexible plastic (Tygon) tubing – 3 pieces:

	Inner Diameter (ID)	Wall Thickness	Approximate Length	Function
a	6.35 mm (0.25 in.)	0.76 mm (0.03 in.)	13 mm (0.5 in.)	Connect C Duct to T Duct
b	6.35 mm (0.25 in.)	3.18 mm (0.125 in.)	10 mm (0.375 in.)	Installed under tubing 'c' to provide seal at conductivity sensor
c	11.11 mm (0.4375 in.)	1.59 mm (0.0625 in.)	25 mm (1.0 in.)	Installed over tubing 'b' to provide seal at conductivity sensor



C Duct Assembly

1

FAQs
Frequently Asked Questions

EXAMPLES of General instrument questions

How do instruments that can be internally or externally powered handle external power if internal batteries are installed?

For an RS-232 Sea-Bird instrument, what is the maximum cable length for real-time data?

Why do some instruments have zinc anodes, while others do not?

What is Triton? Does it harm sensors? Do I need to purchase it from Sea-Bird?

My CTD has a Digiquartz pressure sensor. Can I use it above its rated pressure?

Why am I getting negative density values when testing the instrument?

Updating Software

- **Descriptions**
- Sea-Bird FTP file descriptions
- **Instructions**
- Downloading (using your browser) and installing:
  SEASOFT V2 (SBE Data Processing, Seasave V7, Seasave-Win32, SEATERMV2, SEATERM, SEATERMAF, Deployment Endurance Calculator, Plot39)
  SEASOFT for Waves - Win32
  SEASOFT-DOS
  SEASOFT for Waves - DOS
- Downloading via FTP utility
- Sending data to Sea-Bird

Subset of Published Technical Papers and Publications on SBE sensors:

Considerations for CTD Spatial and Temporal Resolution on Moving Platforms
Carol Janzen, Sea-Bird Electronics, Inc.
Ocean News & Technology, Volume 15, Issue 6, September 2009.

Assessing the Calibration Stability of Oxygen Sensor Data on Argo profiling floats using routine WOCE monitoring data from HOT
Carol Janzen and Nordeen Larson, Sea-Bird Electronics, Inc.
From Poster Presentation, 2008 Ocean Sciences Meeting, Orlando Florida,2 - 7 March 2008.

Temperature Measurements in Flowing Water: Viscous Heating of Sensor Tips Nordeen Larson and Arthur Pederson, Sea-Bird Electronics, Inc.
1st IGHEM Meeting, Montreal, Canada, June 1996

The Correction for Thermal-Lag Effects in Sea-Bird CTD Data
Morison, J., R. Andersen, Larson, N., D'Asaro, E., and Boyd, T.,
Journal of Atmospheric and Oceanic Technology (JAOT),
V11(4), August 1994, 1151-1164.

Dynamic Response of Sea-Bird CTD Pressure Sensors to Temperature
Chiswell, S.M.,
Journal of Atmospheric and Oceanic Technology (JAOT),
V8(5), October 1991, p 659-668.

Terms and Definitions Commonly Used

Training Materials
Spec Sheets
Calibration Records
Parameter Reporting Definitions

Terminology

- Time Constant (response time) – time to reach 63% of step input change
- Sampling frequency or Sample rate – number of measurements per second (reported in Hz)
- Accuracy (error) – reported value, true value
- Resolution – smallest measurable change
- Repeatability – difference in reading when input reapplied
- Precision – repeatability & resolution, independent of accuracy
- Stability – accuracy over time

Reporting Temperature
Application Note 42

- Output and Report Temperature in ITS-90
  - Calibration Reports show both sets of coeff.
- Use IPTS-68 to compute salinity
  - SBE software does this automatically for you
- What is difference?
  - IPTS-68 Versus ITS-90…1968 standards vs. 1990
  - ITS-90 (1990) standards include water triple-point and gallium melt cell, SPRT, and ASL F18 Temperature Bridge
  - Sea-Bird software and instrument converts between IPTS-68 and ITS-90 according to the linear relationship:

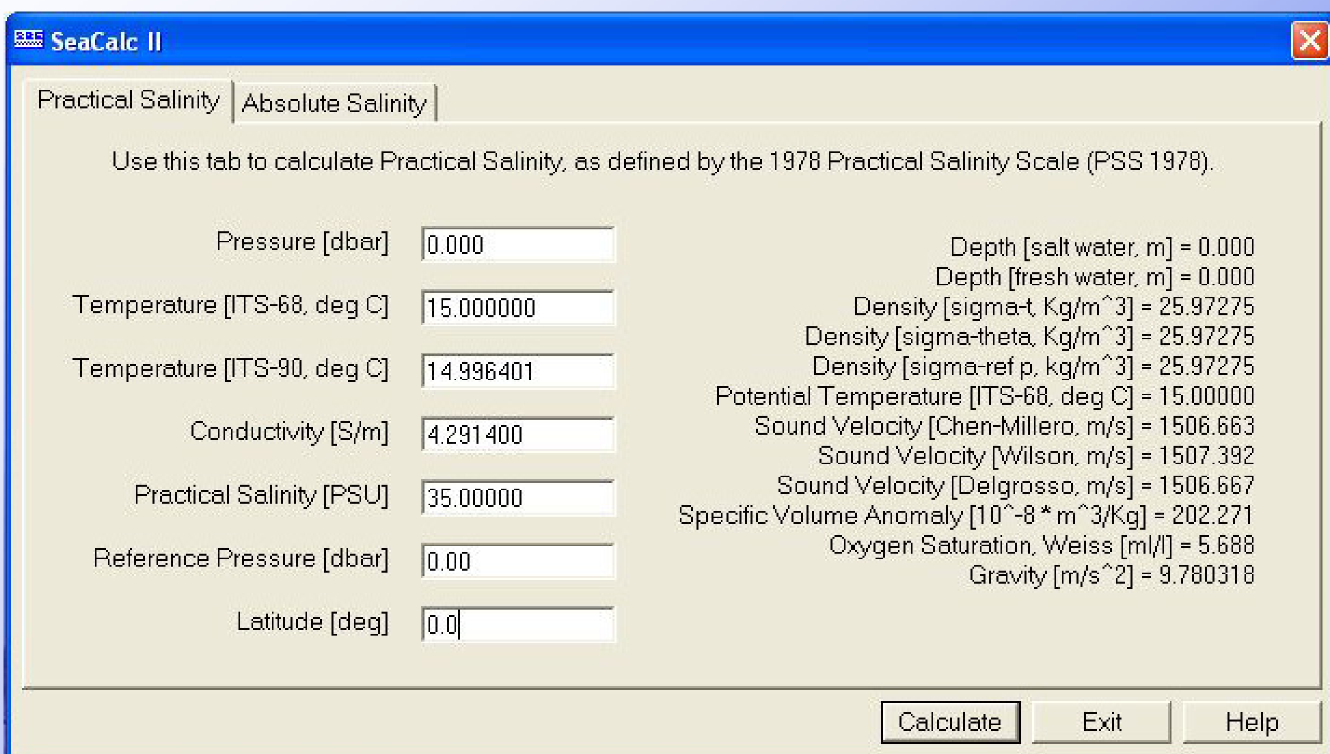
    $\mathbf{T_{68} = 1.00024 * T_{90}}$

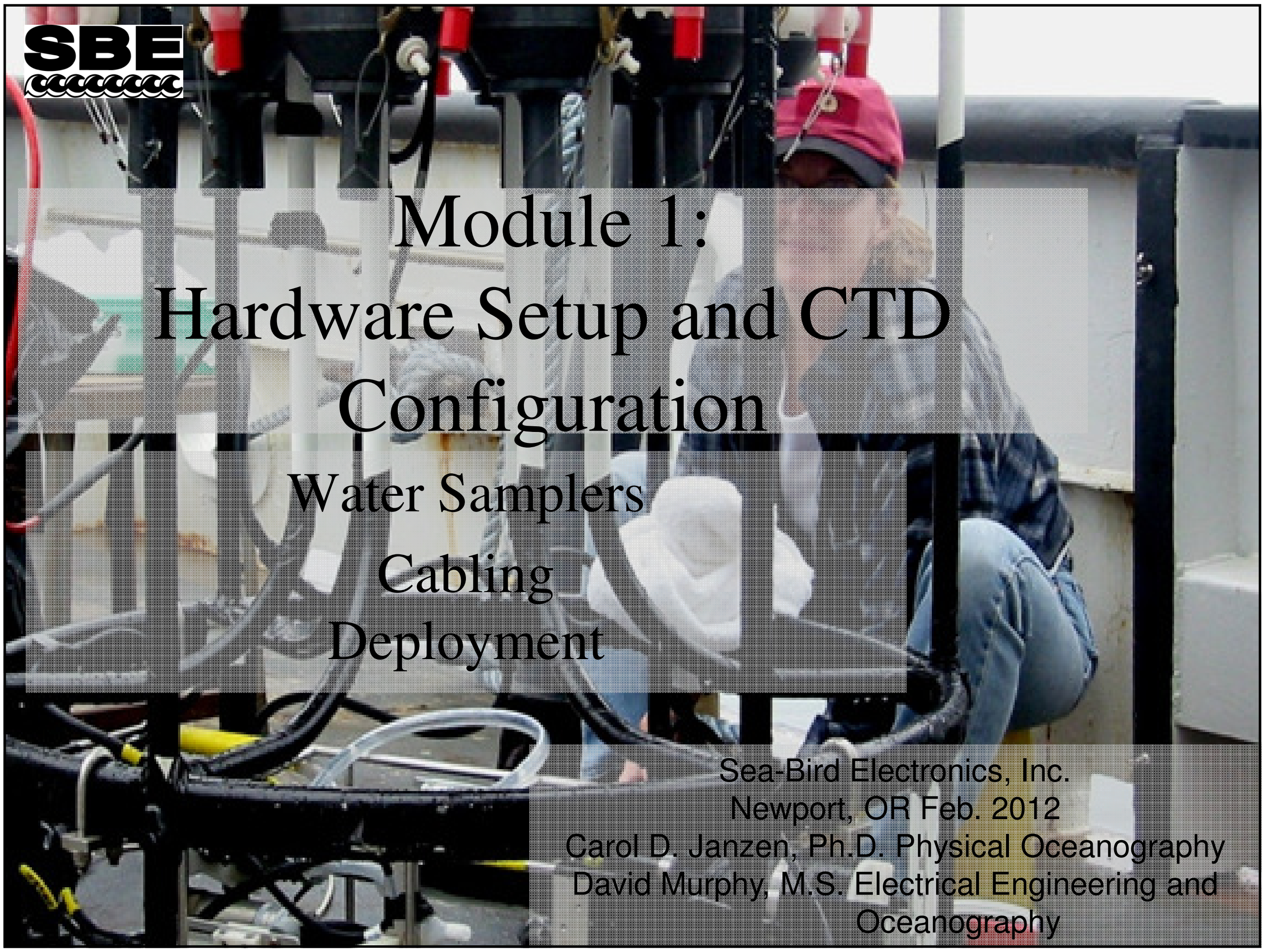
Reporting Salinity

- Output, report and archive Practical Salinity
- Practical Salinity Scale 1978 (App-Note 14)
  - Adopted by UNESCO in January 1980 in effort to obtain a uniform repeatable salinity based upon electrical conductivity, temperature (IPTS-68) and pressure measurements.
  - All instruments delivered by Sea-Bird since February 1982 have been supplied with calibration data based upon this standard
- Absolute Salinity 2010 (App-Note 90)

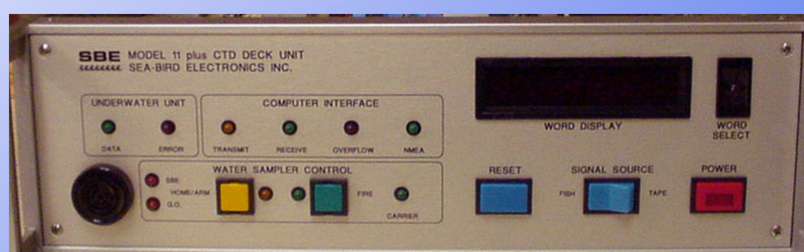
  http://www.marine.csiro.au/~jackett/TEOS-10/
  - Refers to the total mass of dissolved constituents
  - Algorithm used to estimate Absolute Salinity in terms of Practical Salinity, Latitude/Longitude and Pressure
  - SBE is developing this capability in software 2012

SBEDataProcessing Software
Seawater Calculator: SeaCalc II

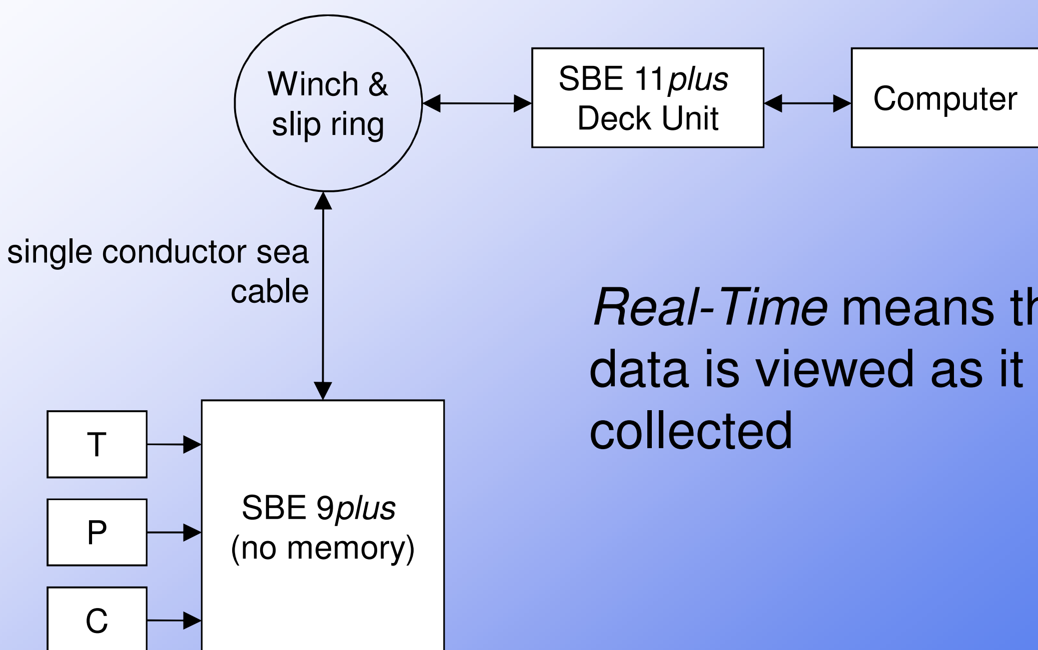



SBE
Module 1:
Hardware Setup and CTD Configuration
Water Samplers
Cabling
Deployment
Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and Oceanography

SBE 9 -11 *Plus*
Profiling CTD System



System Diagram for Real-Time Profiling



Real-Time means the data is viewed as it is collected

SBE 9*plus* / 11*plus* Data Channel

- Transmission rated for up to 10 km of sea cable
- Each data scan is 30 bytes, transmitted at 24 times per second
- Each scan contains status bits denoting: pump on, water sampler channel carrier detect, bottom contact, water sampler closure occurred

SBE 9*plus* / 11*plus* Water Sampler Channel

- Channel is 300 bps, 8 data bits, 1 stop; water sampler commands are transmitted with 8th bit set
- Other data is passed to connector JT7 on top end cap for use by instrument
- Successful bottle closure confirmation is sent back via SBE 11*plus* to computer

SBE 9*plus* Frequency Counters

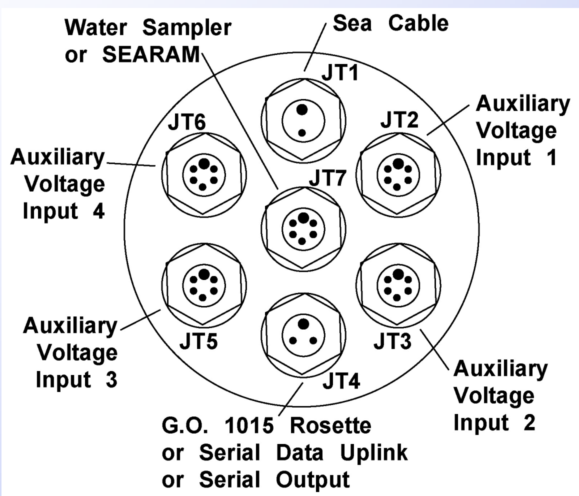
- 24-bit signal acquisition for T, C, and P
- Resolution in terms of degrees C / bit or Siemens/meter/bit depend on the magnitude of temperature or conductivity
- Equations for determining resolution and examples are included in the notes

SBE 9*plus* Voltage Channels

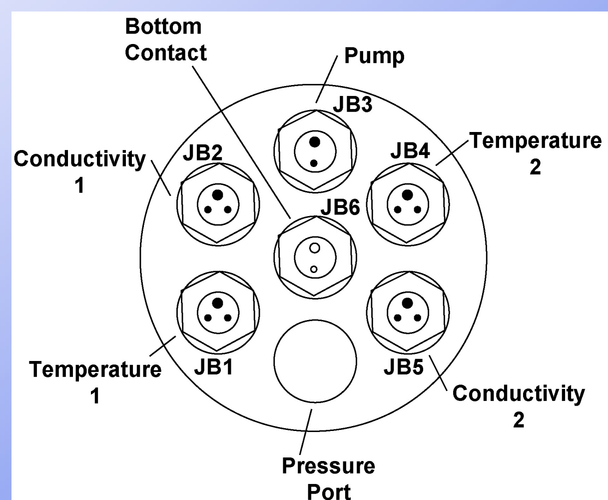
- 0 - 5V signal input, 12-bit A/D
- Each bit = 0.0012V
- Each of 8 channels has a 5.5 Hz low pass filter on input, allowing us to resolve features that change at a rate of 2.75 Hz

SBE

End Caps



Top End Cap



Bottom End Cap

Core Sensors
Conductivity, Temperature, Pressure

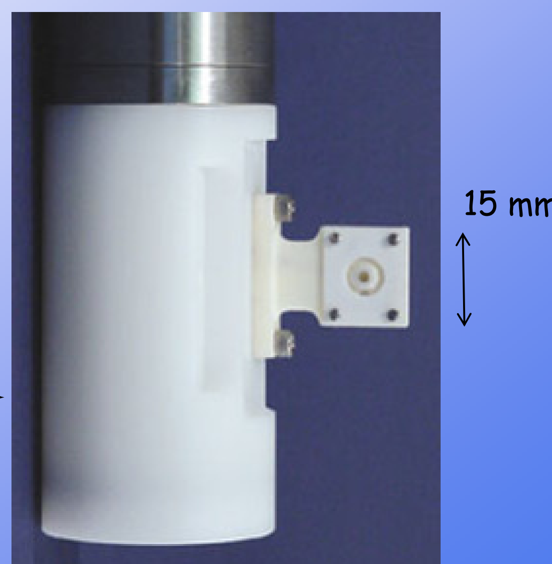
- Depth is derived from a pressure sensor
  - Pressure sensor is typically internal to the main pressure housing of the CTD
- Conductivity and temperature sensors may be mounted internally or externally

SBE 4 Conductivity Sensor

SBE 3
Temperature Sensor

SBE

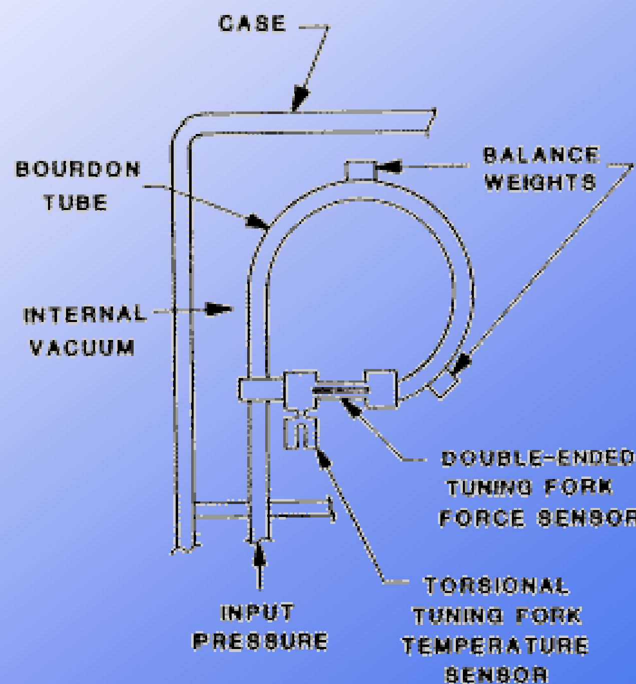
The SBE 43 is DO Clark Type Sensor



Sea-Bird Sensor
Without Plenum Housing

Digiquartz Pressure Sensors
SBE 9+ CTDs

- Digiquartz Bourdon tube transforms pressure to force
- Connected to environment through a capillary tube filled with mineral oil
- Pressure generates a force across a quartz resonator as the tube tries to unwind with applied pressure
- The measured change in the frequency of the quartz oscillator is a measure of applied pressure



Schematic of Digiquartz pressure sensor
Courtesy of Paroscientific, Inc.

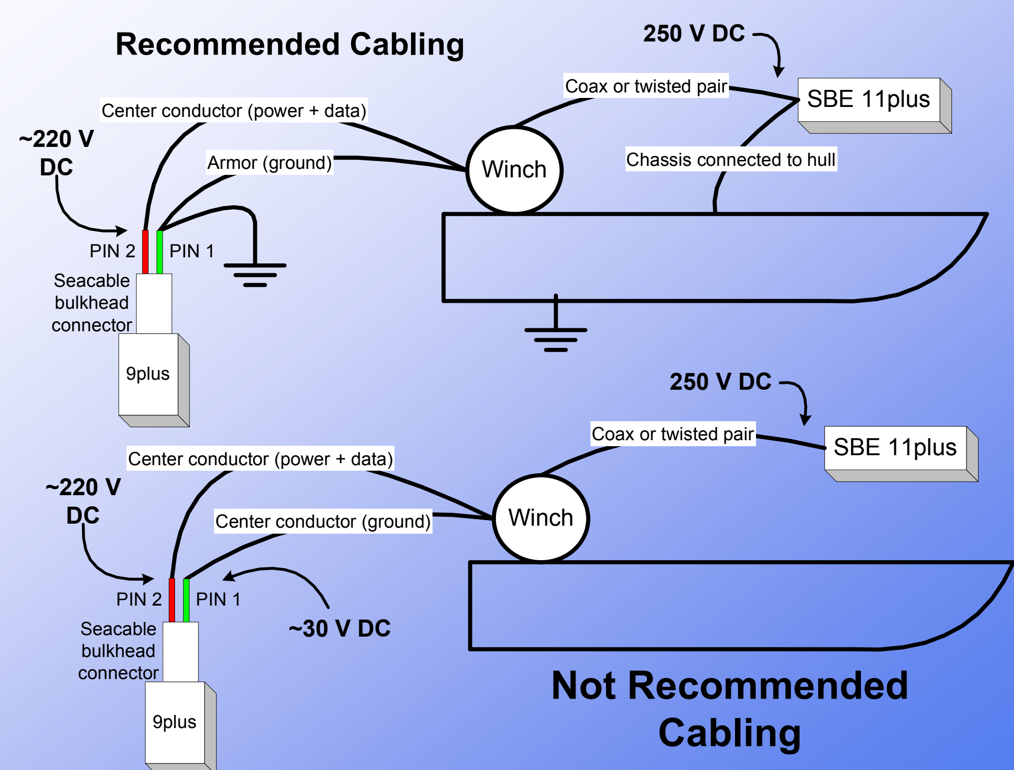
SBE 17*plus* V2: Autonomous Sampling Back Up

- SBE 17*plus* V2 provides memory and power for SBE 9*plus*, has
  - 16 Mb of nonvolatile memory, supports conductivity advance and suppression of channels
  - Also features Carousel auto fire capability
- Use SBE 17*plus* Version 2 SEARAM with SBE 32 Carousel
  - SBE 17*plus* V2 receives pressure information from SBE 9*plus*
- Receives closure protocol from user via SeatermAF
- Refer to Sea-Bird Training Manual for more details

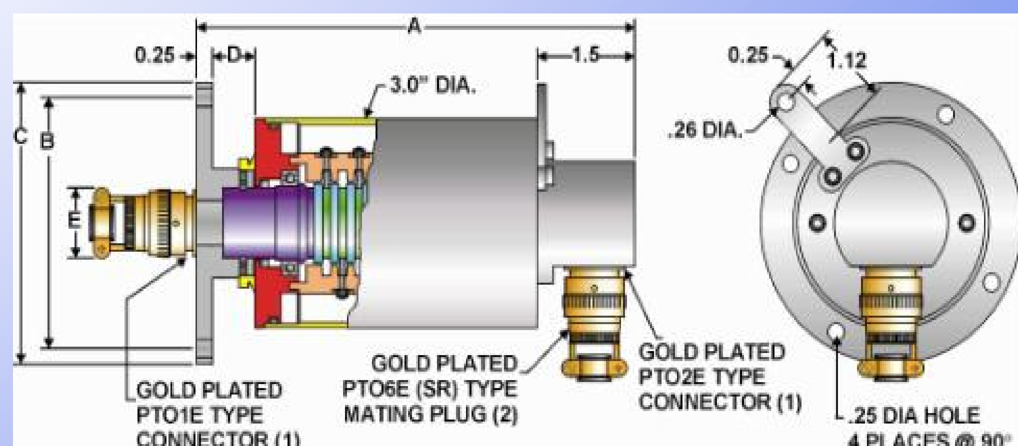
Cabling the 9*plus* to the 11*plus*

- Use #20 twisted pair or coax to cable between SBE 11*plus* and winch
- Seacable is typically single or multi-conductor armored cable up to 10,000 meters, with less than 350 ohms resistance
- Grounding considerations
  - Use armor of sea cable for ground
  - Remember, salt water conducts, ship is metal (usually)
  - Ground chassis of your deck unit to hull of ship

Cabling the 9*plus* to the 11*plus*



What is a Slip Ring?



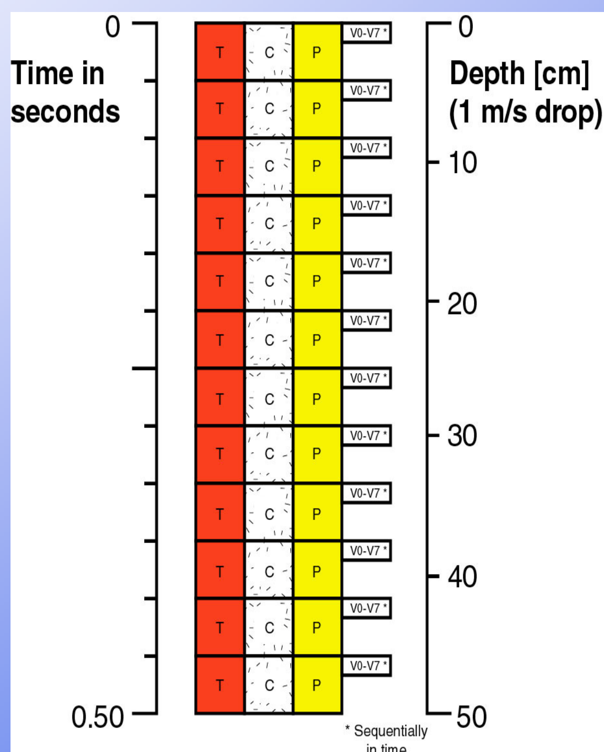
SBE

Configure Sensors and CTD Hardware for Clean Data Collection

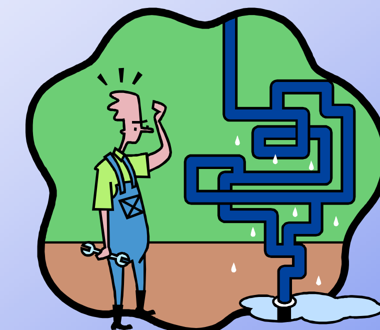
- Understanding how the CTD samples
- Insure that sensors sample the same water
  - Plumbing
  - Place T, C sensors together and duct
- CTD deployment orientations (vertical vs. horizontal)
- Insure that sensors sample undisturbed water
  - No flow blockage/distortion on frame
  - No foreign thermal mass or wakes
- Provide for independent data validation
  - Redundant T,C, and DO sensors
  - Rosette water bottle samples

SBE 9+ CTD Sample Scheme

- SBE 9*plus* measures C, T, and P simultaneously
- Can sample as fast as 24 Hz
  - Recommend to sample at maximum rate
  - Average later



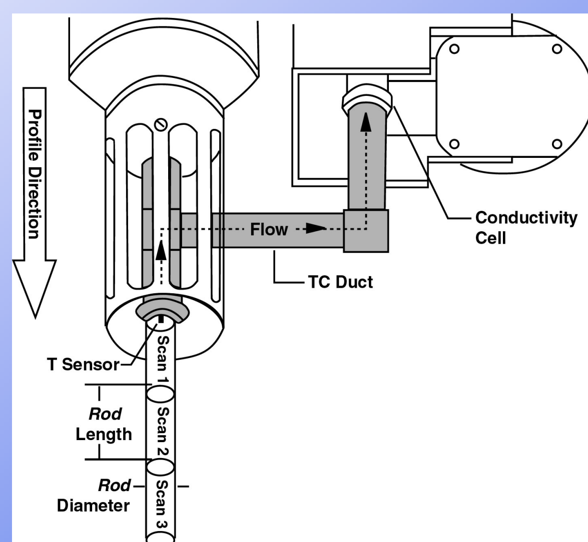
Plumbing for Success



- Sea-Bird conductivity cells and oxygen plenums rely on water passing through them, usually via a pump
- Pump is magnetically coupled impeller type, not self-priming
- Arrange tubing on instrument package to allow all air to escape from plumbing

Coupling T and C Measurements using the *TC Duct*

- Deliberate sampling of the water column at the location of the intake of the pipe
- Water is pumped past active element of temperature sensor and into conductivity cell at a fixed, constant rate (same for DO)
- Plumbing setup greatly lessens effects of ship heave (reduces *sloshing* through cell)
- Filtering and other data manipulation is much more successful because flow rate is constant (Constant response times regardless of lowering rate)
  - This helps match response times of T and C



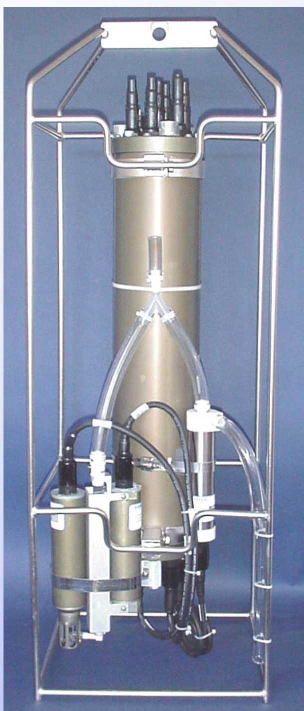
Connecting the TC Duct

How TC Duct should look When it is connected correctly

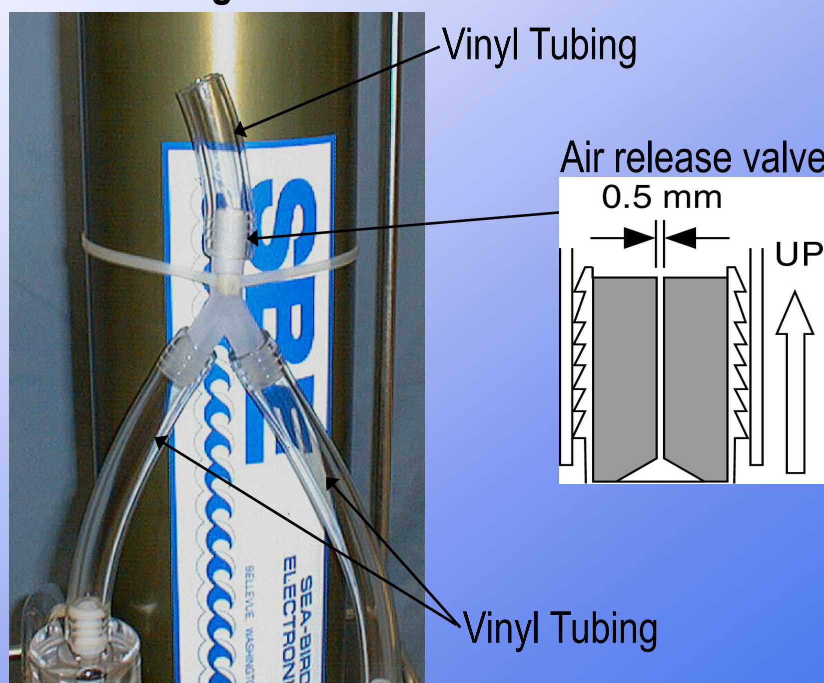
This TC Duct is disconnected Conductivity cell will not get flow

If flow problem appears in data, (you will see poorly aligned data when this happens), check the TC Duct apparatus

Plumbing for Success



Y Fitting Detail



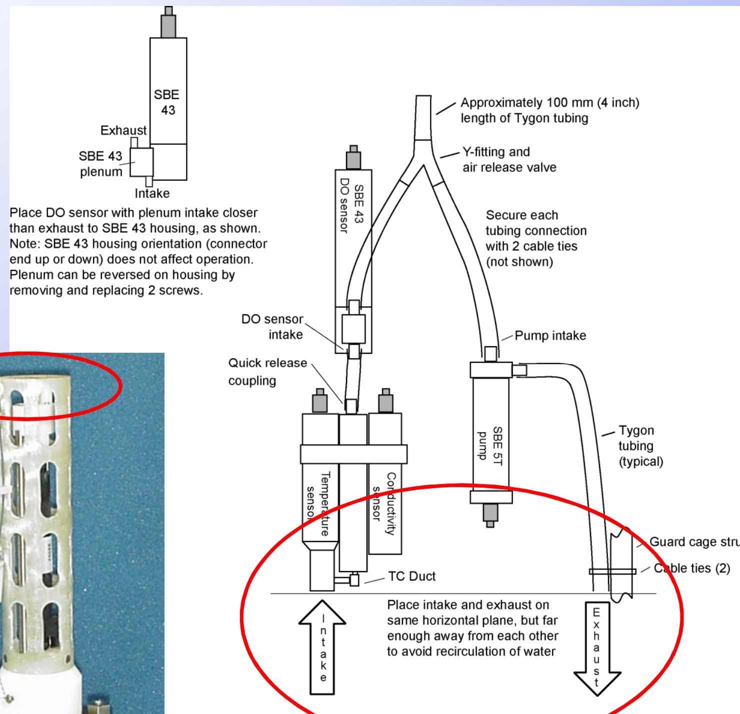
Bernoulli Balanced Plumbing

We plumb so that the intake and exhaust of the plumbed system are flush (balanced).

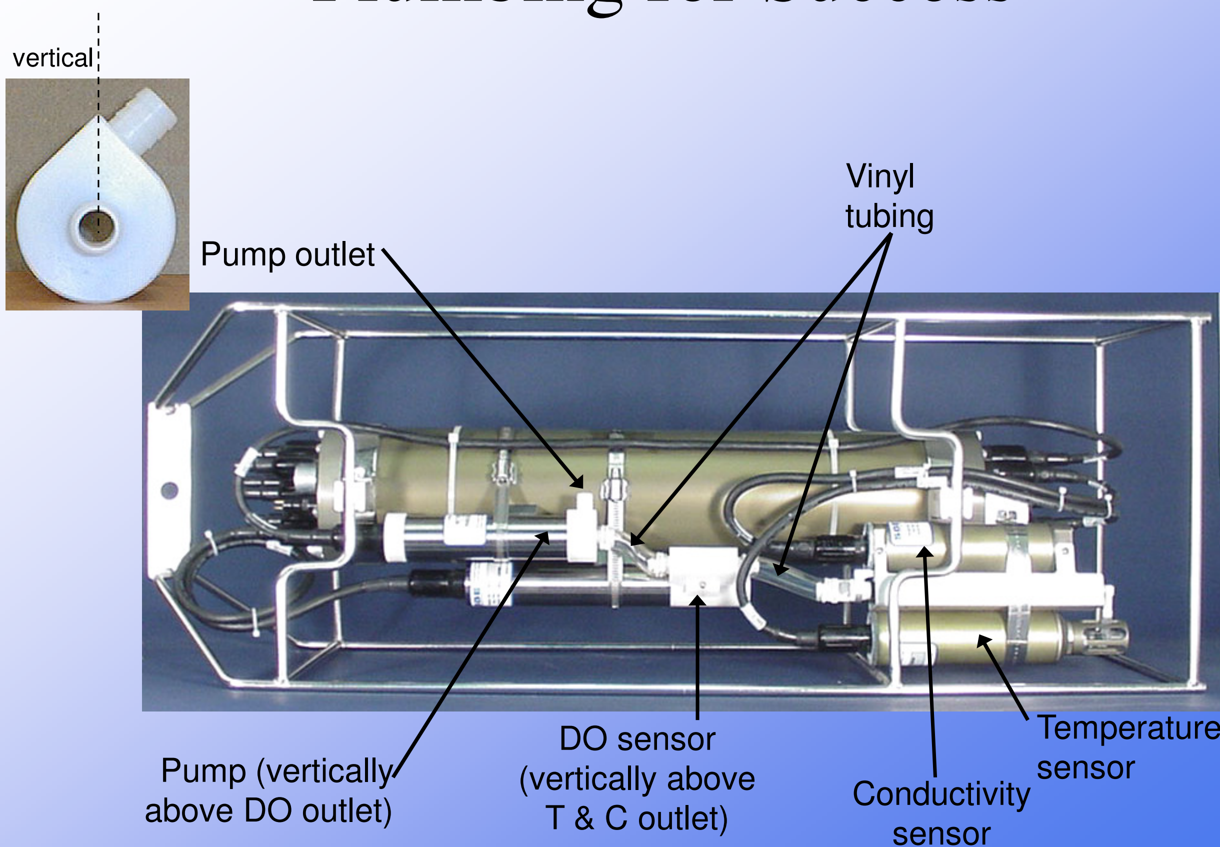
Controls flow on descent of CTD

Reduces Bernoulli Flushing (which would be additive to pump Flow)

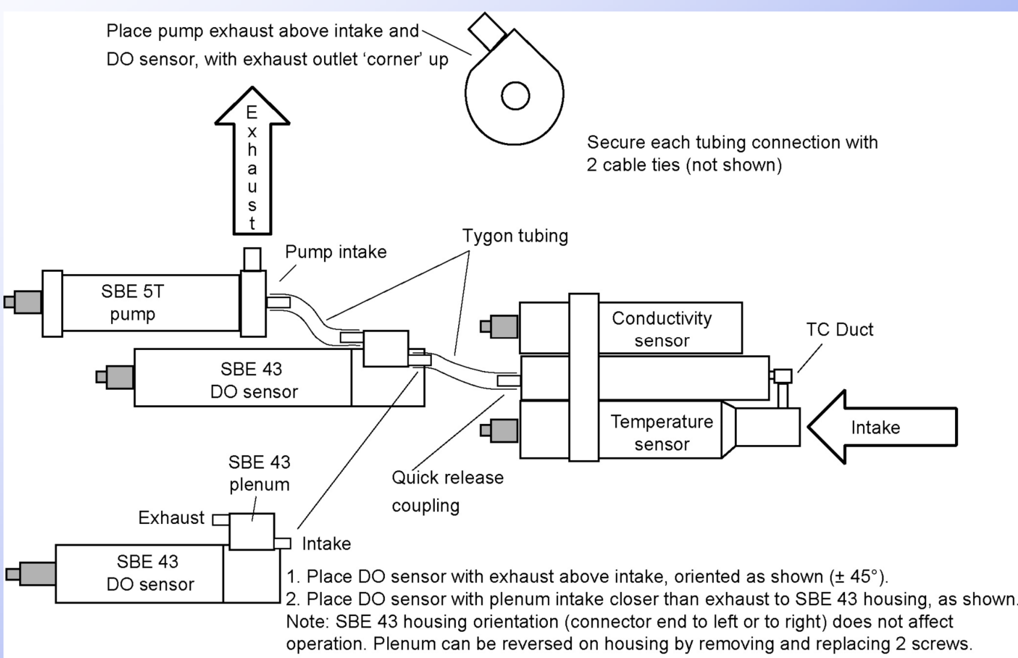
Alace float CTDs use same Principal to prevent flushing Of CTD during deep Lagrangian drifting phase. This Allows antifoulant to remain in the trapped water, making it it more effective. Also prevents fouled water from entering cell.



Plumbing for Success

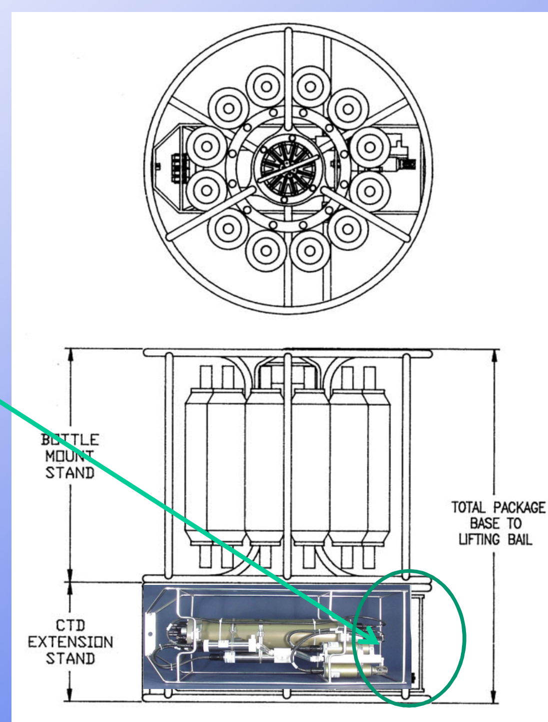


Horizontal Mount



SBE 9+ CTD Mounting on a Carousel

- An SBE 9*plus* CTD that is deployed with the Carousel shown mounted in a horizontal position
- This provide sensors a clear flow path of fresh sample water
- **Does not place sensors behind objects with thermal mass**
- Minimizes Bernoulli flow accelerations
- Helps avoid the urge to attach sensors past the pump exhaust!

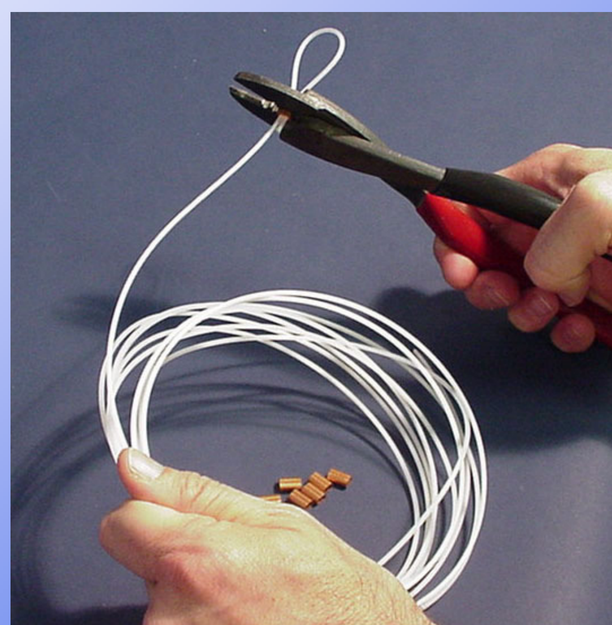


Make a Neat Underwater Package

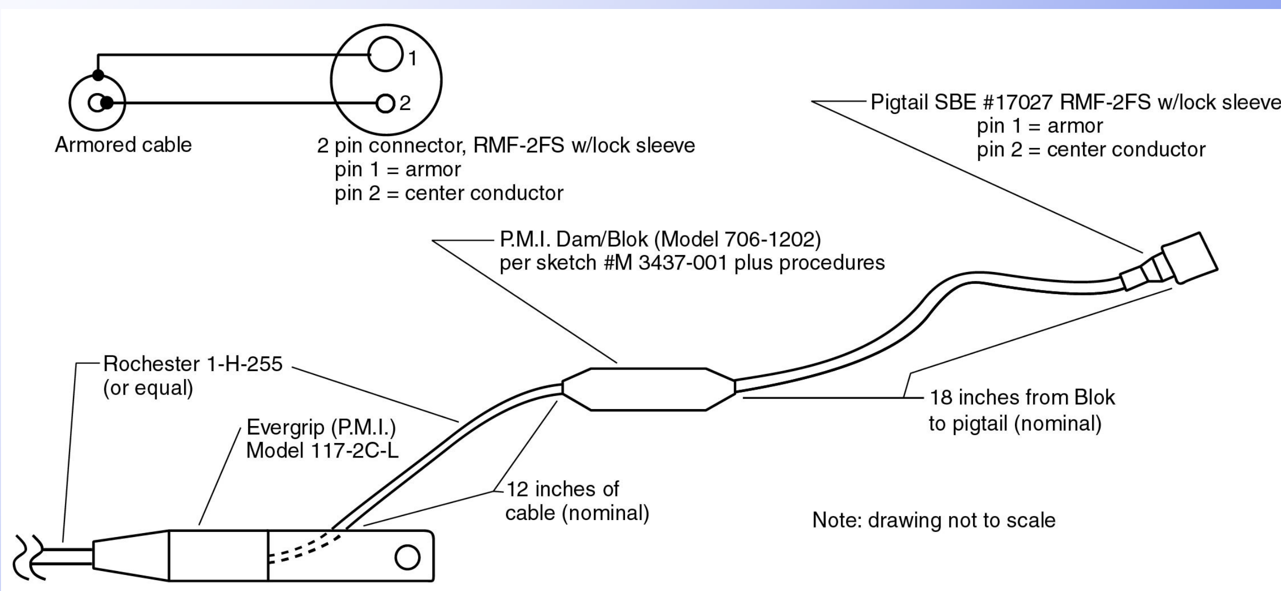
- Cable tie or tape all loose cabling to frame of package
  - Loose cables flap as package rises or drops, resulting in wire fatigue
- Make sure no cables are in path of inlet to temperature sensors
- Instrument with aluminum housing: check zinc anodes occasionally; grounding problems can cause them to disappear

Carousel and ECO Maintenance

- **Wash with fresh water** after each use
  - Tiodized trigger surface is water lubricated
- Oil will gum triggers
- Replace worn lanyards



How Do I Make the Wet End Connection?



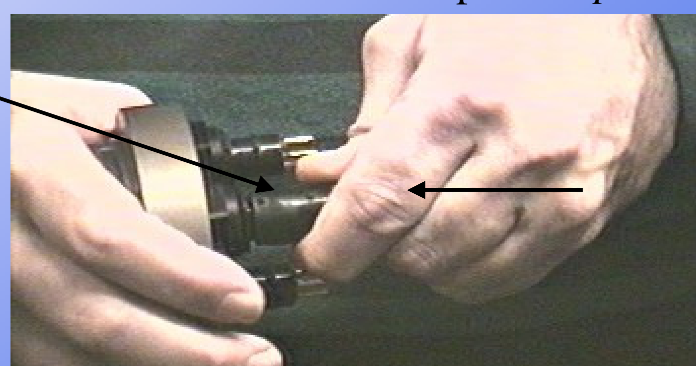
Mating Habits of Underwater Connectors

Lubricate molded ridge on bulkhead connectors with 100% silicone grease

Do not over do it!

Slide hand toward end cap to *burp* air

Note bulge due to entrapped air



Practice Table Exercise

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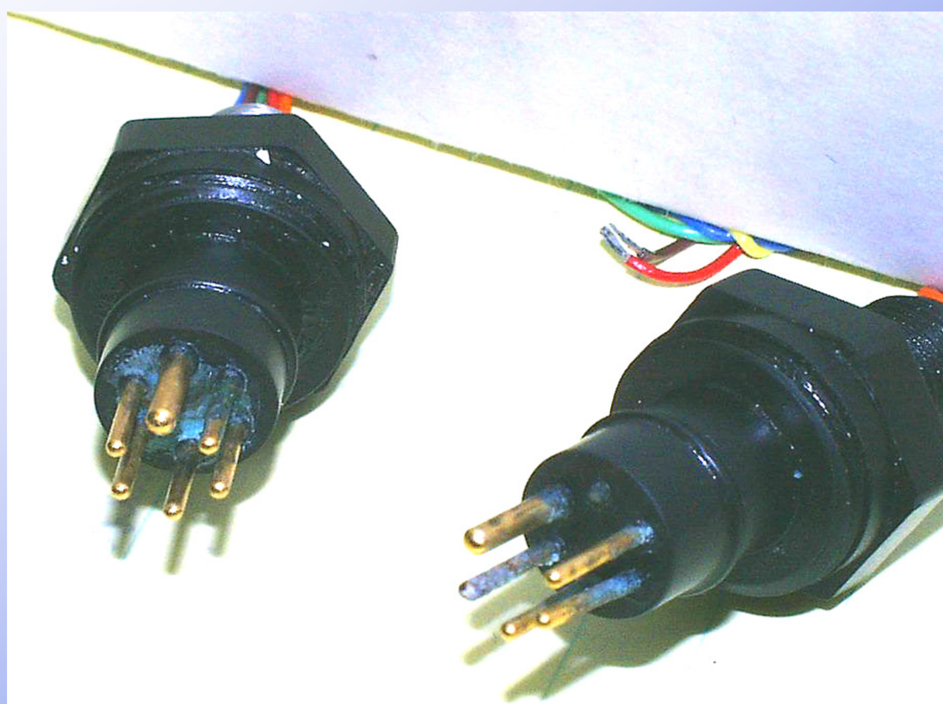
When Underwater Connectors Go Bad




SBE
Module 2
SEASAVE Data Acquisition Software
Setup and Configuration
Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and Oceanography

SBE

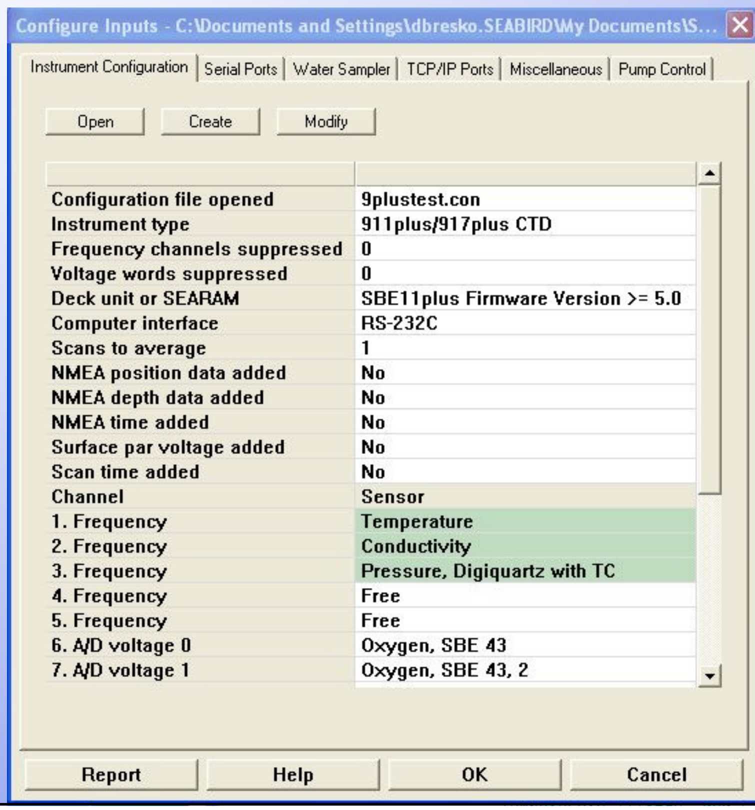
Real-Time Data — Seasave

- Instrument configuration
  - What kind of instrument
  - How many sensors
  - What type of sensors
  - Communication issues
    - Which computer interface
    - What data transmission protocol
- How does Seasave know all this stuff?

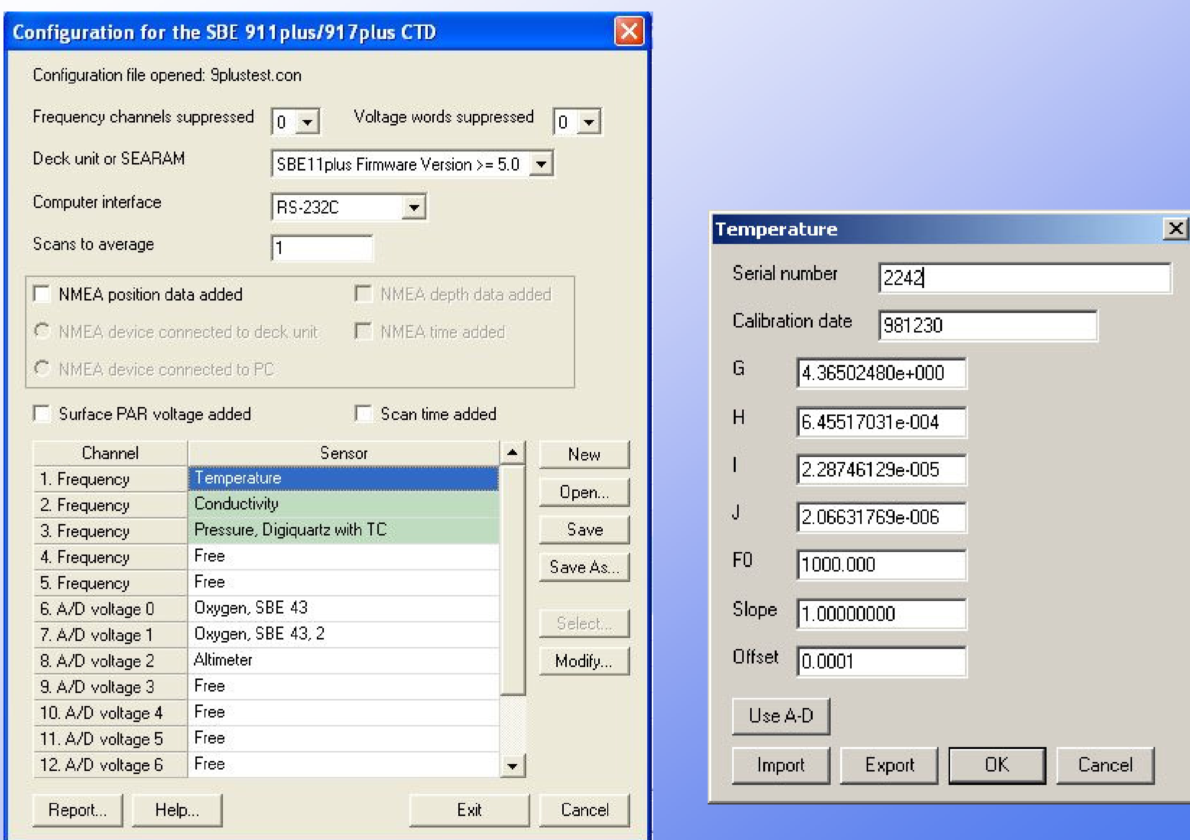
Setup Parameters Stored in Configuration (*.con* or *.xmlcon)* File

- Configuration data and calibration coefficients for sensors are stored in the *.con* or *xmlcon* file (i.e., *seasoft.con*)
- You may edit *.con* or *.xmlcon* files directly from Seasave or in SBE Data Processing
  – You can also double click on the *.xmlcon* file to edit

Seasave Instrument Configuration

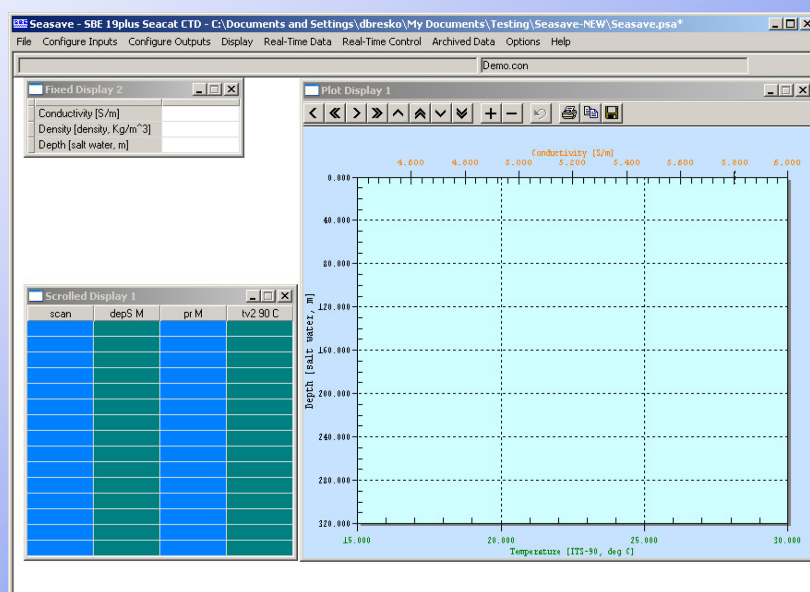


Examining the Configuration File



Default Display for Seasave

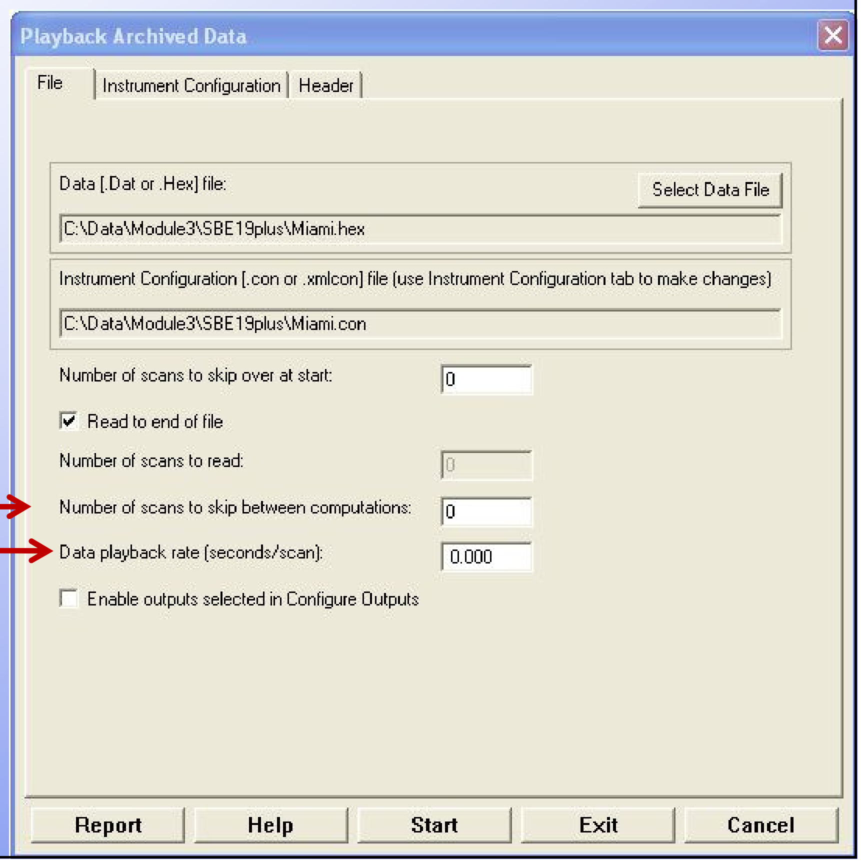
To modify, right click on the display you want to change.



Archived Data Dialog

Reduces data resolution of viewed profile only

Slows down the playback so you can watch for changes easier



SBE

Activity: Display an Archived Data File from an SBE *9-11*

- Use Seasave to display the some SBE 9-11 CTD data
  - GO to Data folder (i.e., F:/Data/Module4/)
  - Display Hawaii.dat in Seasave
  - Use the Hawaii.con file for configuration

  - Right Click on the plot to set plot types and depth ranges
  - Plot Type single Y multiple X, 4 axes
Y	Pressure	0-1200 dbar
X1	Temperature	0-30 deg C
X2	Conductivity	0-6 S/m
X3	Salinity	26-36 psu
  - Right click on scrolled display to do similar
  - Play around with displays to see what there is offered

Things to Configure for Real-Time Data Collection

Configure Inputs

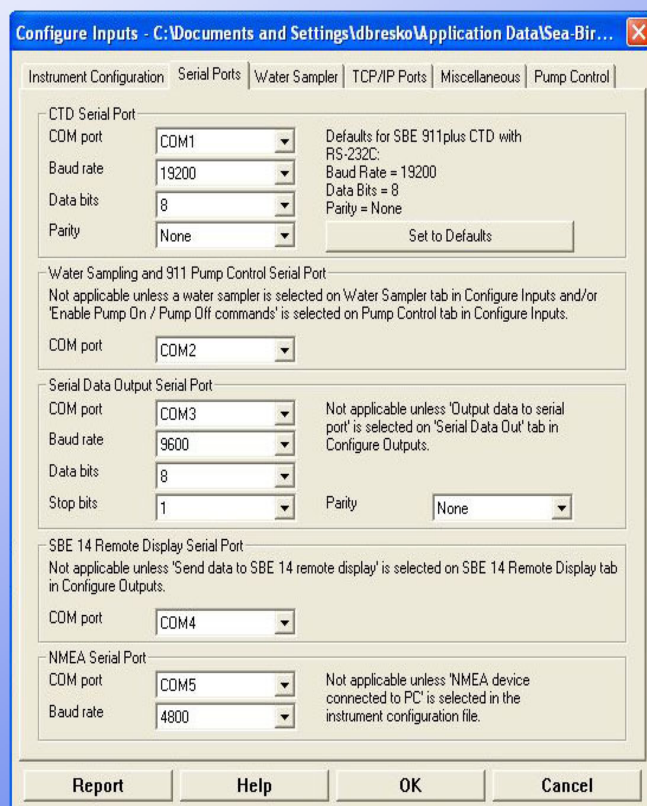
- Instrument configuration (.con file) – discussed already
- Serial ports – can set up in Configure Inputs or Configure Outputs
- Water sampler
- TCP/IP ports – can set up in Configure Inputs or Configure Outputs
- Miscellaneous
- Pump control (SBE 9*plus* with pump control option only)

Configure Outputs

- Serial data output
- Shared file output
- Mark variable selection
- TCP/IP output
- SBE 11*plus* alarms – pressure, altimeter, bottom contact switch
- SBE 14 Remote display / alarms – pressure, altimeter, bottom contact switch
- PC alarms – pressure, altimeter, bottom contact switch
- Header form / prompts
- Diagnostics

Serial Ports

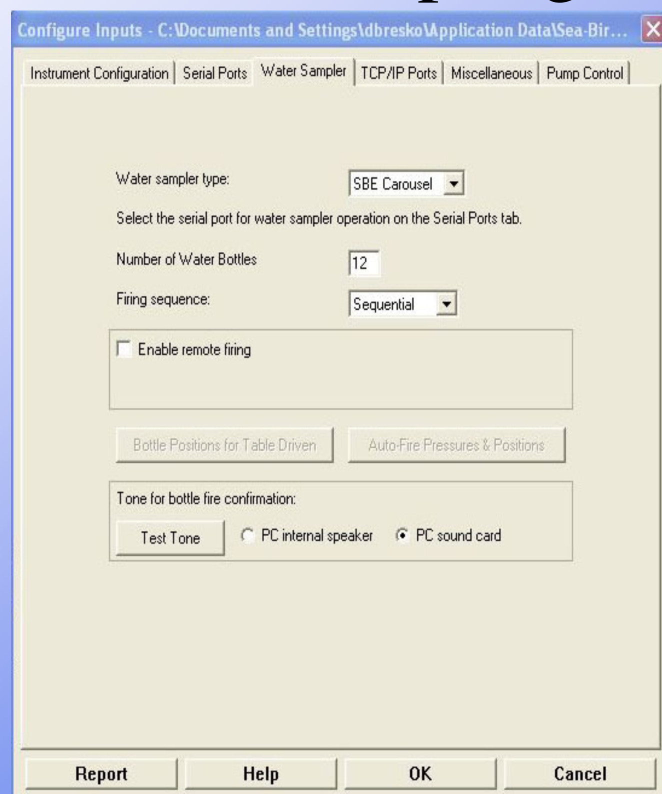
- Define up to 5 ports:
  - Communicate with CTD (required)
  - Communicate with water sampler and/or CTD for pump control (9*plus* must have pump control option)
  - Output data to serial port
  - Output data to SBE 14 Remote Display
  - Input data from NMEA device connected to PC
- Define in Configure Inputs or Configure Outputs



SBE

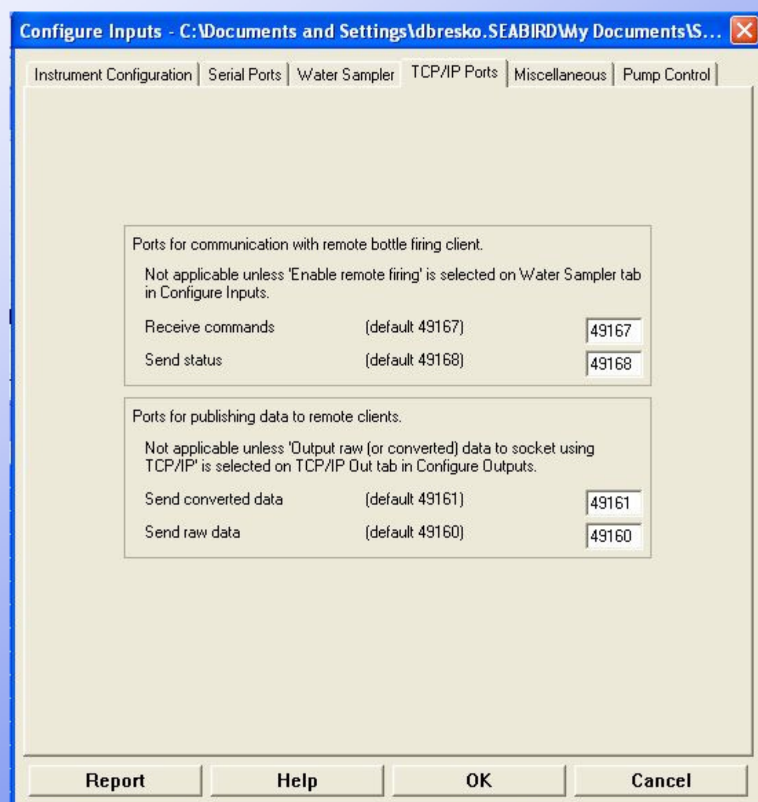
Real-Time Water Sampling

- Water sampler configuration
  - Type: SBE 32 Carousel, GO 1015, GO 1016
- Bottle closure protocol
  - Sequential
  - User Input
  - Table Driven
  - Auto Fire
  - Firing bottles from a remote computer



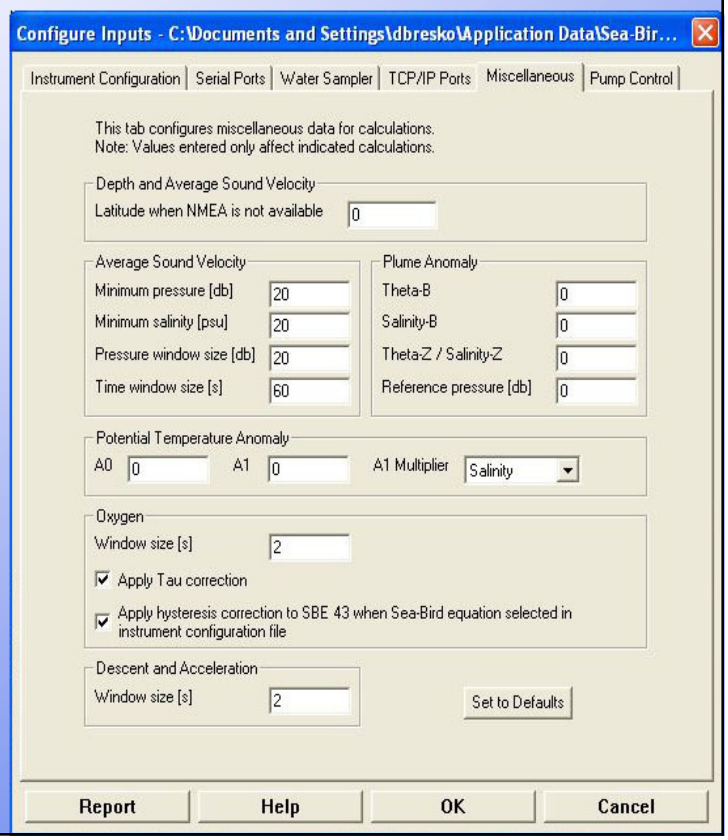
TCP/IP Ports

- Connect hosts over ship's networks
  - Communicate with water sampler
  - Output data to TCP/IP port
- Define in Configure Inputs or Configure Outputs



Miscellaneous

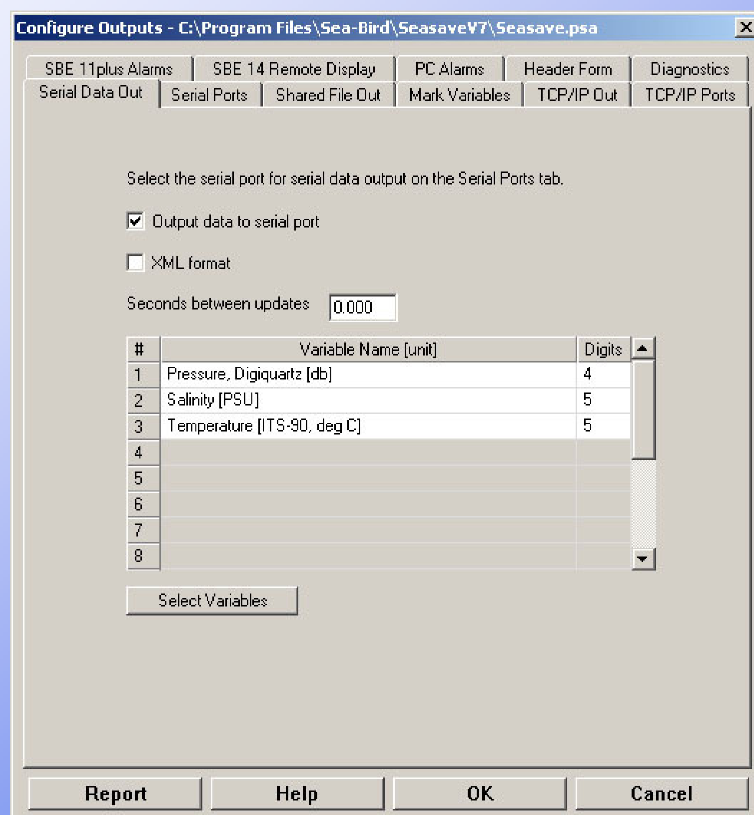
- These parameters are needed to calculate specific variables
- Entries are used only if outputting associated variable to display window, shared file, remote device, TCP/IP port, etc.



SBE

Serial Data Output

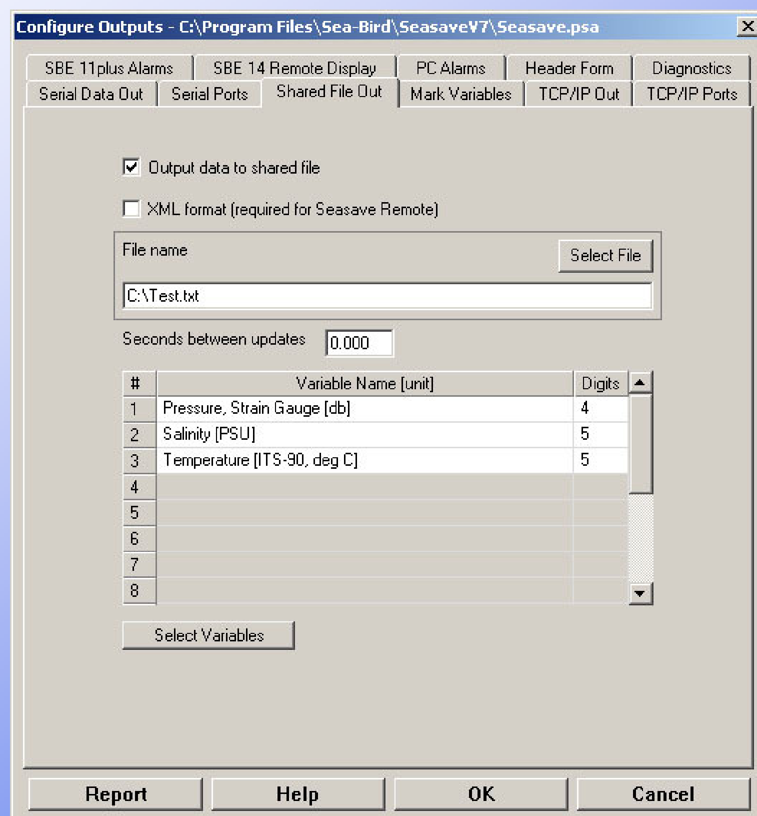
- Selected text data can be sent from computer running Seasave to another computer, in ASCII or in XML format



SBE

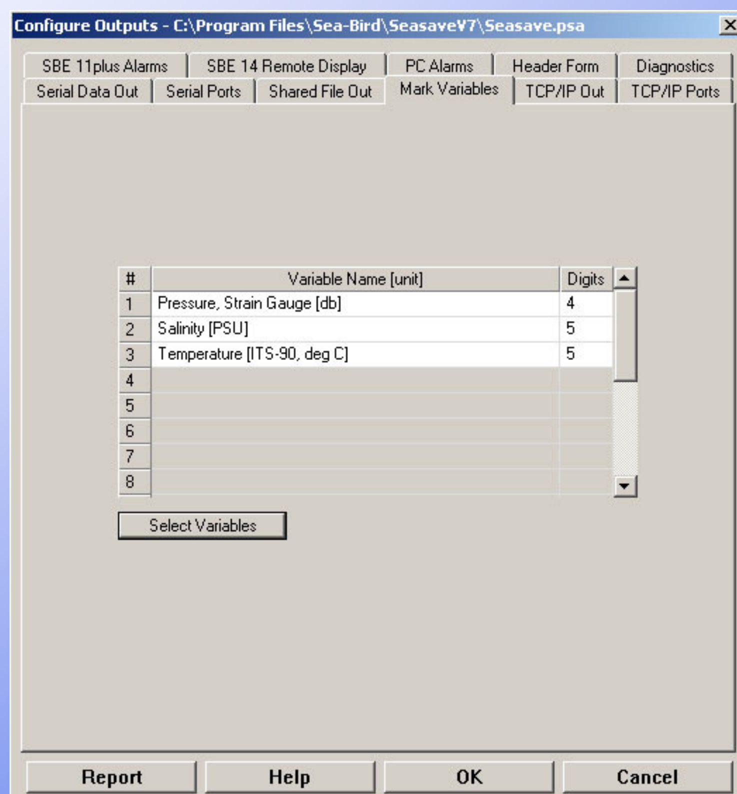
Shared File Output

- Selected text data can be sent to a file, in ASCII or in XML format
- Allows for output data into a shared file directory, so others can use it when completed



Mark Variable Selection

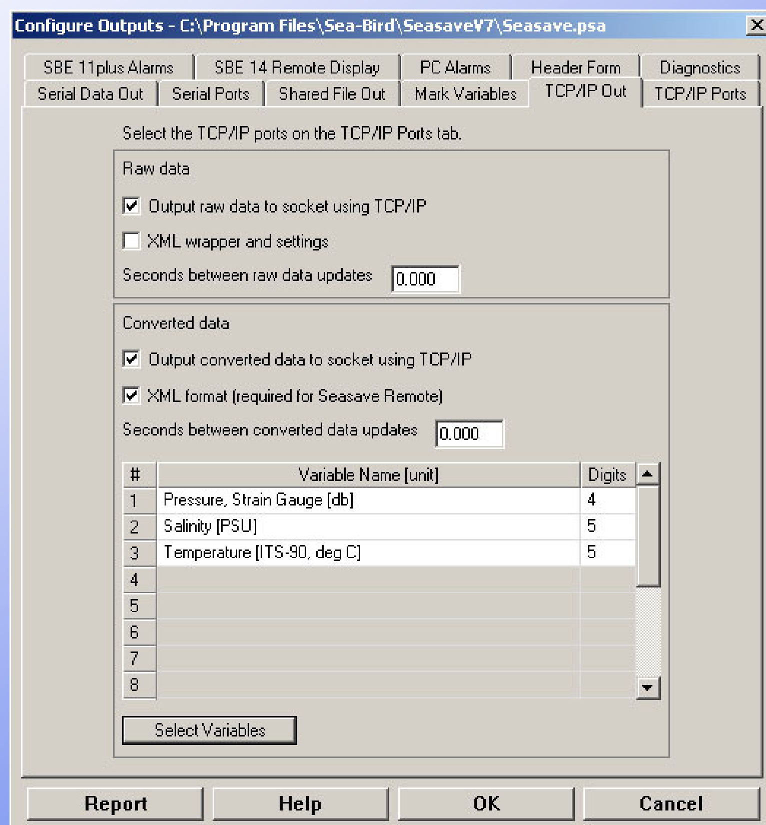
- Mark variables are placed onto real-time plot when *Mark Scan* is clicked
  – Used to annotate plot at points of interest



TCP/IP Output

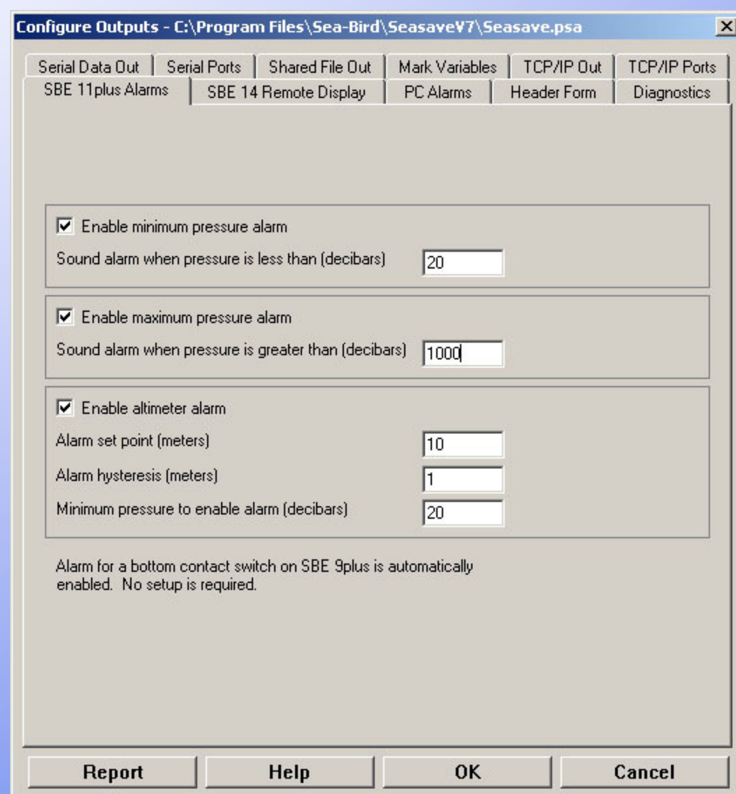
- Selected text data can be sent from computer running Seasave to another location on shipboard network in ASCII or in XML format
  - For example:

PI’s State Room



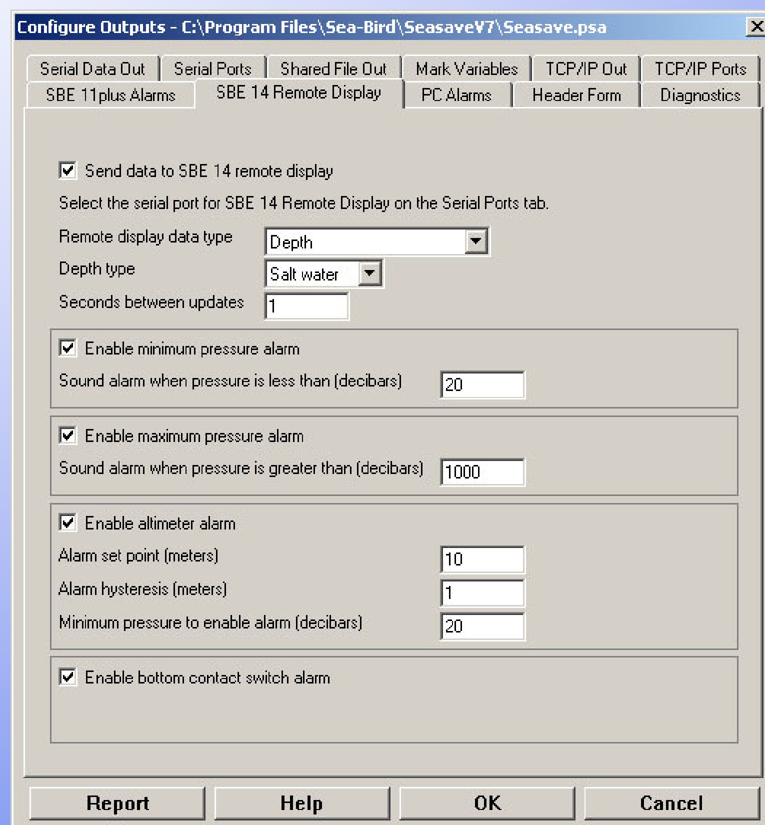
SBE 11*plus* Alarms

- Alarm (11*plus* makes an irritating noise to notify you)
  - Pressure -- minimum and/or maximum
  - Altimeter
  - Bottom contact switch (no setup required)

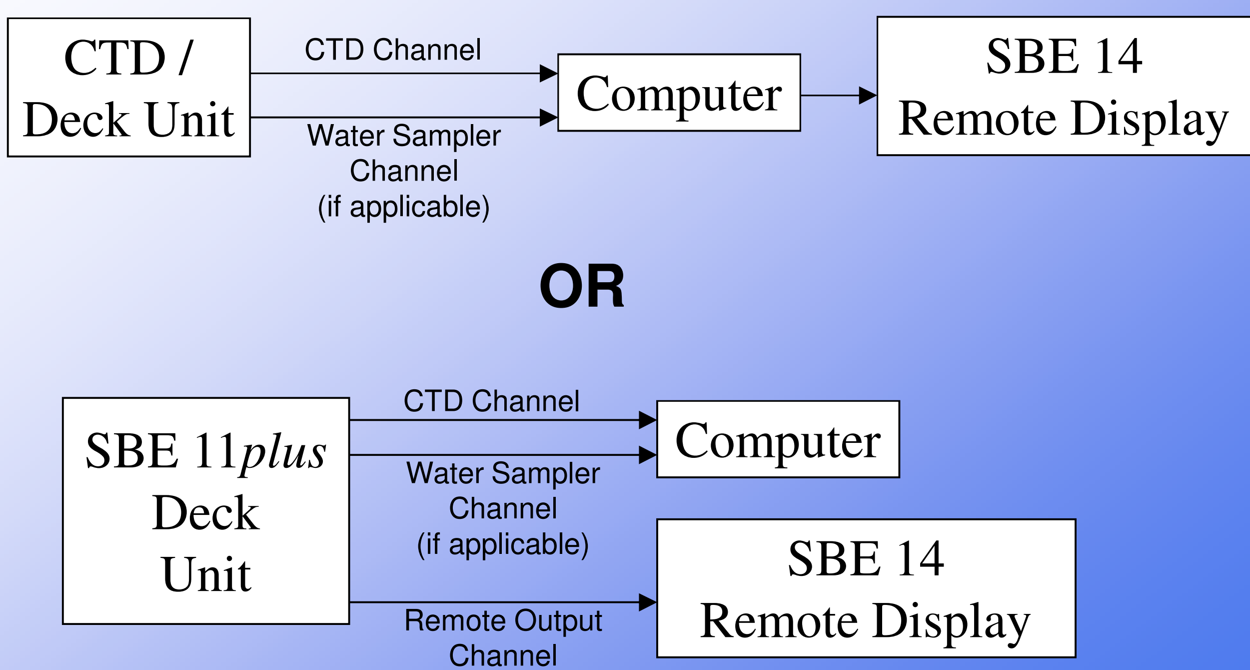


SBE 14 Remote Display

- Remote display variables are transmitted to an SBE 14 in a remote location (i.e., bridge)
- Also has alarm based on pressure, altimeter, and/or bottom contact switch data

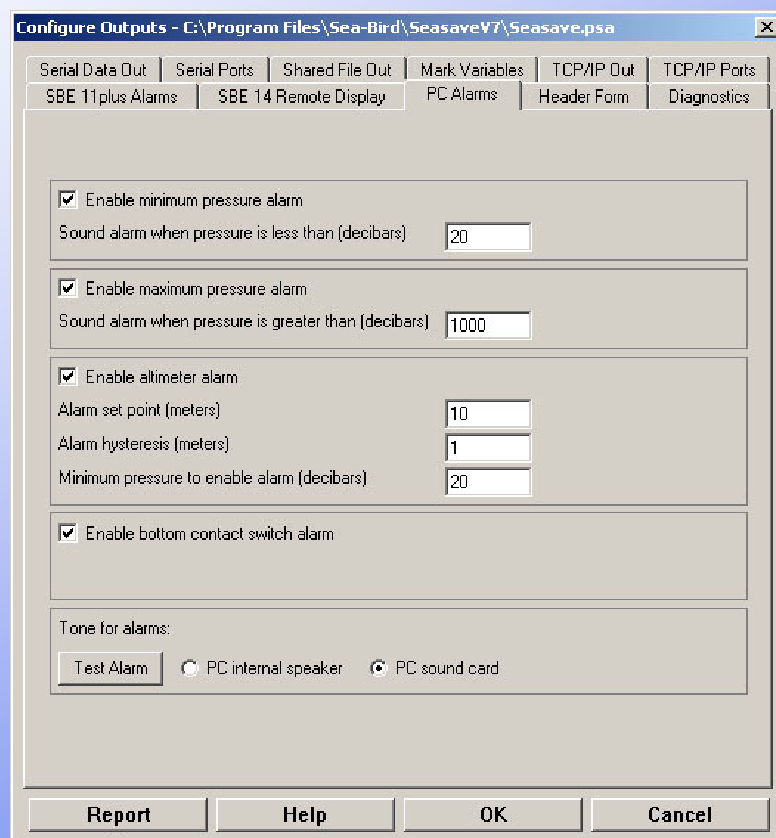


Remote Display Cabling and Communication



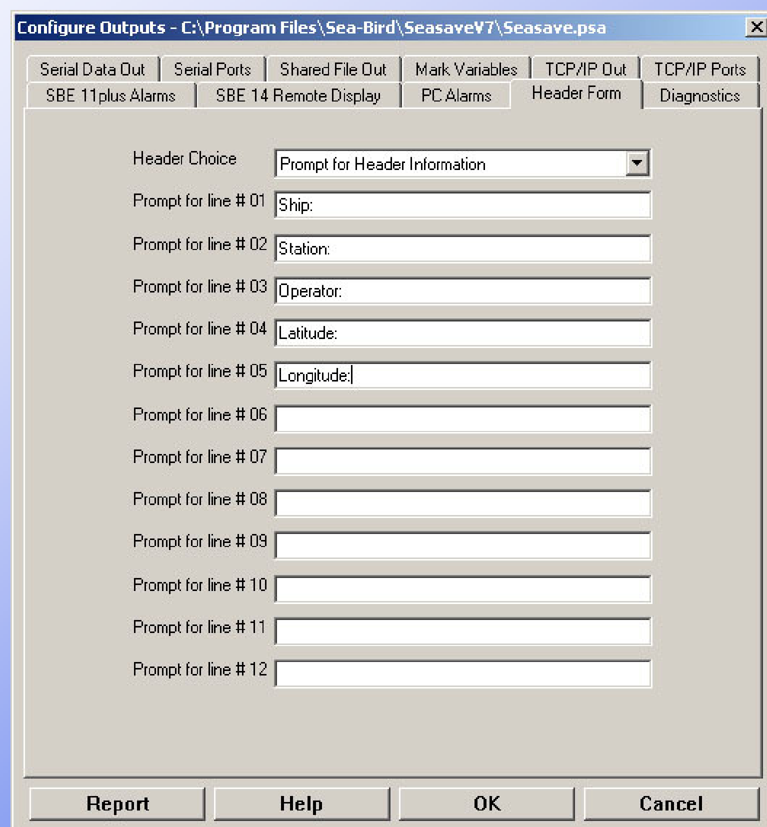
PC Alarms

- Set up alarms in your computer
  - alarm based on pressure, altimeter, and/or bottom contact switch data



Cast Headers

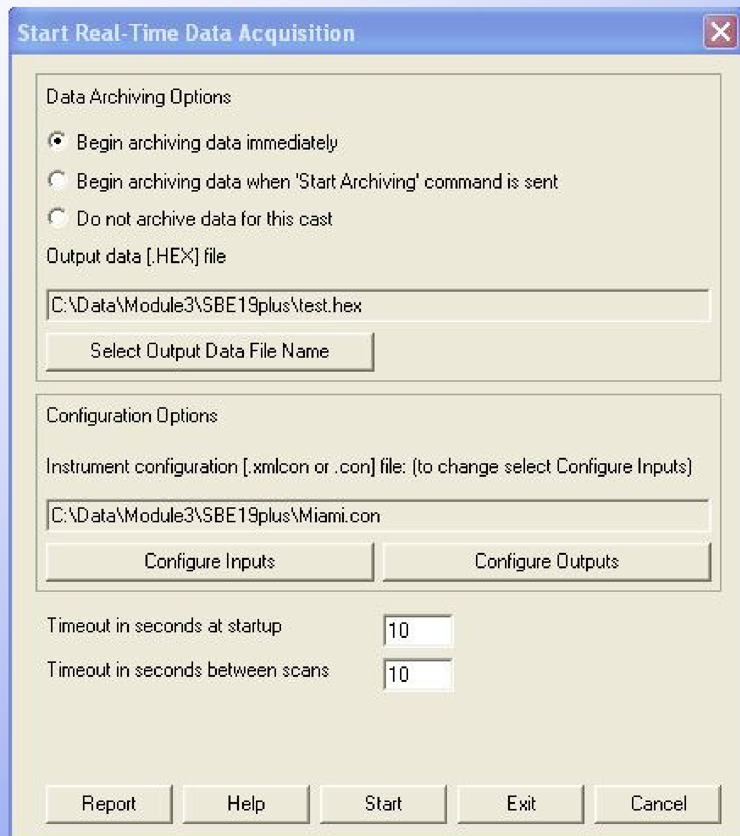
- Header form and prompts
  - Information that is appended to beginning of data saved to file
  - Operator may select prompts appropriate to his or her work



Saving Your Setup

- Data collection parameters and display setup parameters may be saved in a file with a name of your choosing, with a *.psa* extension
- Each display setup may be saved separately in a file with a name of your choosing, with a *.dsa* extension

Acquiring Real-Time Data



What Files Does Seasave Create?

Always

- Data file, *.hex* (ASCII representation of binary)
- Header file, *.hdr*
- Configuration file, *.con* or *.xmlcon*
  - instrument configuration for cast of matching file name

Depends on Setup

- Mark file, *.mrk*
- Bottle file, *.bl*
- Navigation file, *.nav*

All these files have the same name as the .hex data file, but different extensions

Header Files: *.hdr*

- Lines beginning with:
  - * have information from raw data file
  - ** have user-input header information
  - ***END*** flags end of header
- Same file name as data (*.hex*) file

Mark Files: *.mrk*

- Contains 1 data scan for each time *Mark Scan* button is clicked (variables set up on Mark Variables tab of Configure Outputs)
- Same file name as data (*.hex*) file

```
e:\hot-101\0008A001.MRK:
       Scan   Pressure    TempP90   CondPS/m    SalnP,P
mark number 1, system time is Jan 15 1999 02:41:57
      44617   1021.872     4.1177   3.268962    34.4987
mark number 2, system time is Jan 15 1999 02:47:06
      52033    770.993     4.7046   3.294753    34.3185
```

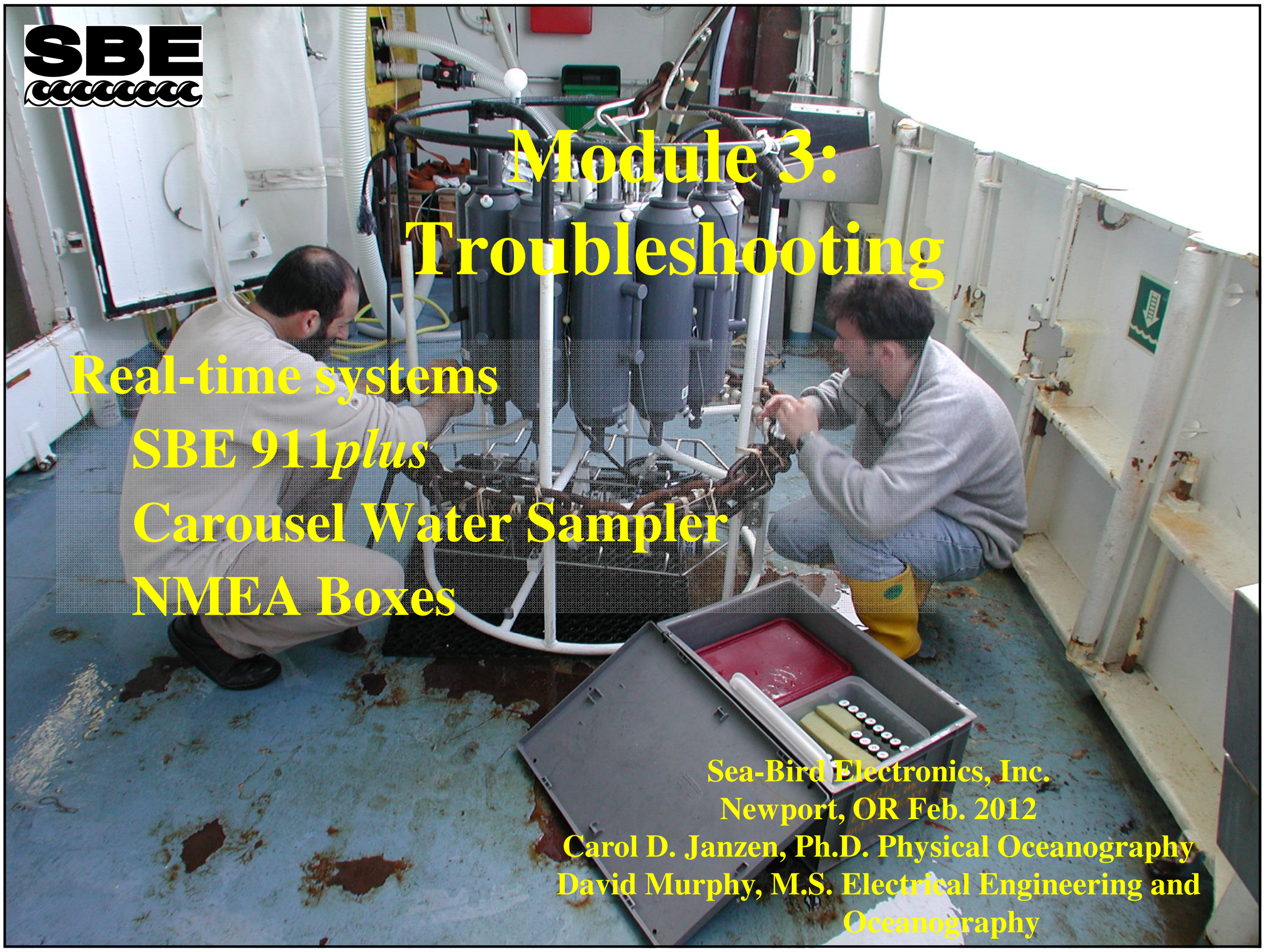
SBE

Bottle Data File: *.bl*

- Created when water sampling is enabled
- Contains bottle fire sequence number and position, date and time, and beginning and ending scan number corresponding to 1.5-second duration for each bottle
- Data written to .bl file each time confirm bit in data stream is set or when a confirmation is received from water sampler
  - Same file name as data (*.hex*) file

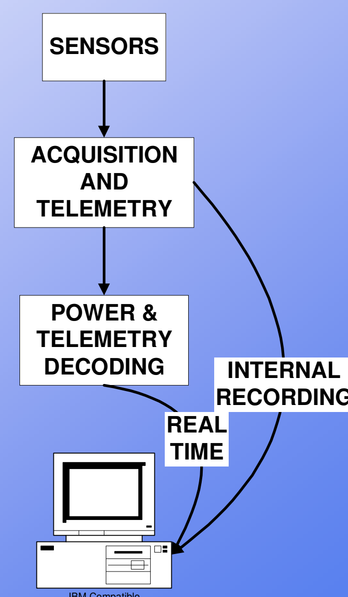
Cross-Check
Correct Configuration Files and Inspect Data Regularly

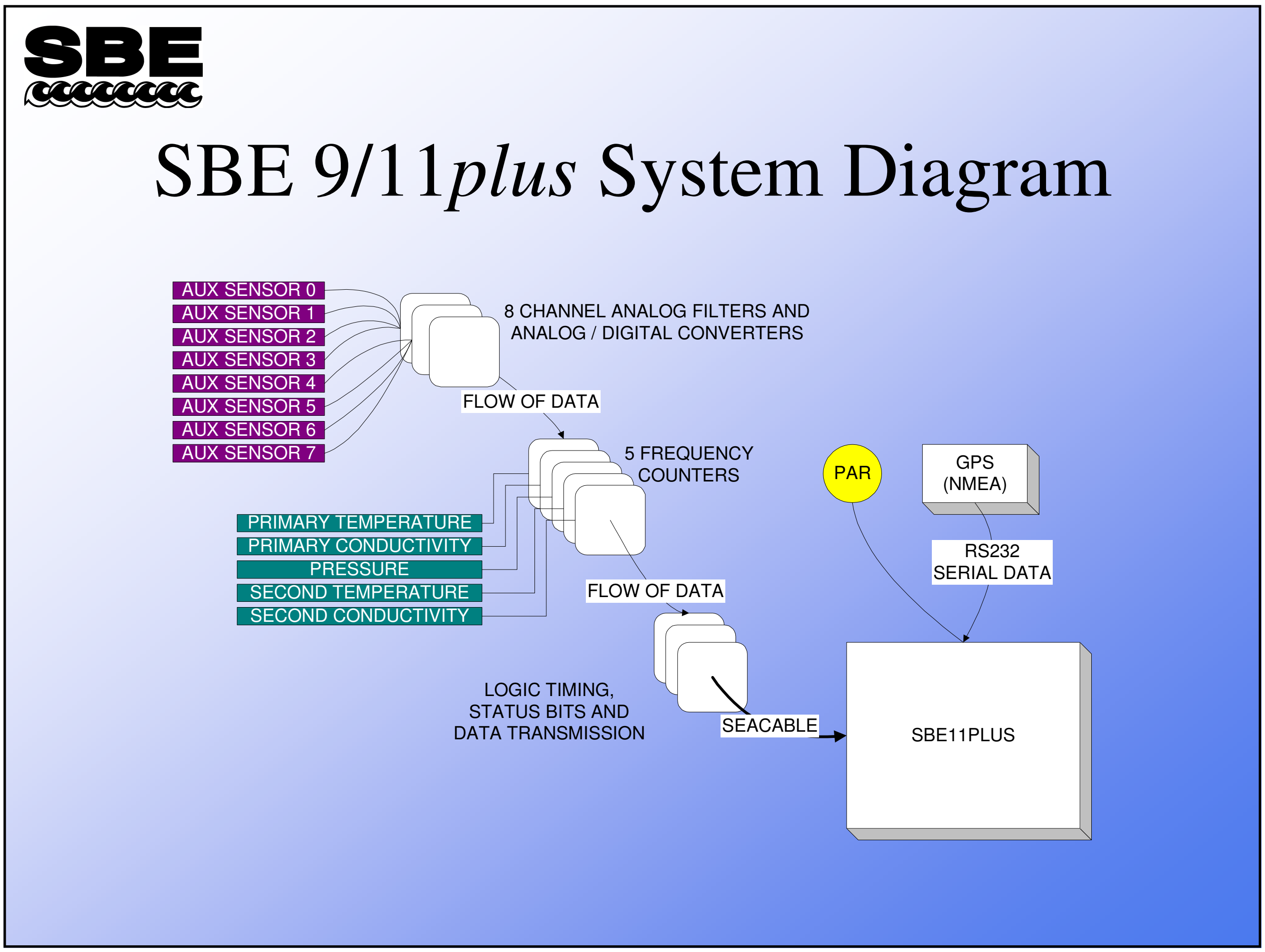
- Inspect data routinely by converting to scientific units (or output as such in SEASAVE)
  - Be sure correct CON file with the correct sensor calibration coefficients is being used by software
  - If sensors are changed mid-cruise, be sure to change the CON file to reflect these changes
  - Examine data on each cast to evaluate performance and to notice if any problems (like MODULO ERRORS) occur.
- ALWAYS keep an archive copy of RAW, non-corrected data
  - This allows a return to the original data for correction or reprocessing


SBE
Module 3:
Troubleshooting
Real-time systems
SBE 911plus
Carousel Water Sampler
NMEA Boxes
Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and Oceanography

Troubleshooting: The Basics

- The first step is determining which part of the system has the problem:
  - Do the sensors have valid output?
  - Is the data properly acquired, formatted, and telemetered or stored?
  - Is the data properly received and converted to scientific units?




SBE
SBE 9/11plus System Diagram
AUX SENSOR 0
AUX SENSOR 1
AUX SENSOR 2
AUX SENSOR 3
AUX SENSOR 4
AUX SENSOR 5
AUX SENSOR 6
AUX SENSOR 7
8 CHANNEL ANALOG FILTERS AND
ANALOG / DIGITAL CONVERTERS
FLOW OF DATA
5 FREQUENCY
COUNTERS
PRIMARY TEMPERATURE
PRIMARY CONDUCTIVITY
PRESSURE
SECOND TEMPERATURE
SECOND CONDUCTIVITY
FLOW OF DATA
PAR
GPS
(NMEA)
RS232
SERIAL DATA
LOGIC TIMING,
STATUS BITS AND
DATA TRANSMISSION
SEACABLE
SBE11PLUS

Note about 9/11*plus* Data Flow

- 9*plus* data is transmitted serially
  - First are the status bits
  - Second are the frequency channels
  - Last are the A/D channels
- A bad printed circuit card will shorten the length of each data scan
  - A bad A/D board will result in no A/D data
  - If the first frequency counter is bad, there will be no A/D data and the first frequency will be missing
  - If the third frequency counter is bad, there will be no A/D data and the first and second frequency will be missing
  - And so on….

SBE 11*plus* Deck Unit

- No lights on the deck unit front panel
  - Check the main power fuse (2 A slow blow for 120 V and 1A slow blow for 240 V supply).
  - Check that power is being supplied to the deck unit (120 or 240 VAC)!
- Most lights on, but green data light not lit
  - Check the sea cable fuse (1/2 A fast blow).
  - Check that the underwater unit is receiving power – ***be careful*** (250 VDC)!

Auxiliary Sensor (0 – 5V analog) Not Working (no signal)

- Could be the sensor
  - Swap sensor for another on a working channel, check deck unit. Note: 4095 A/D counts = 0 V, 0 A/D counts = 5 V
- Could be the cable
  - Check bulkhead connectors for signs of corrosion
  - If possible, swap in a spare cable
- Could be the low pass filter card or the A/D card
  - Channels 0 – 3 are on one low pass filter card, 4 – 7 on other; try both cards
  - If no channels are working, it is probably A/D card or first frequency counter card is not passing A/D data to next counter card

Auxiliary Sensor (0 – 5V analog) Not Working (no signal) (continued)

- Test the voltage channel with a ‘D’ Cell battery
  - Referencing the end cap drawing for the SBE 9*plus*, connect the positive terminal to signal and the negative terminal to signal ground
  - A new ‘D’ cell should read approximately 2800 on the deck unit display or 1.5VDC for the voltage channel in Seasave
- Check that power is being supplied to the sensor
  - Referencing the end cap drawing for the SBE 9*plus*, connect a voltmeter between pins 1 and 6 of the 6-pin connector
  - There should be approximately 14VDC between pins 1 and 6 with the deck unit powered on

Temperature, Conductivity, or Pressure Not Working (no signal)

- Check the sensor
  - Swap the sensor for another on a working channel, check the deck unit
- Check the cable
  - If the sensor works on another channel, swap cables
- Check the counter card
  - If the primary T or C is affected, switch to the secondary T or C
  - If pressure is affected, open the SBE 9*plus*, swap counter cards, and check the deck unit display
- Check that power is being supplied to the sensor
  - Referencing the end cap drawing for the SBE 9*plus*, connect a voltmeter between pins 1 and 3 (for temperature or conductivity channel) of the 3-pin connector
  - There should be approximately 14VDC between pins 1 and 3 with the deck unit powered on

Pump Not Working

- Could be the pump
  - Hook the pump up directly to a 12 VDC power supply, and verify the pump impeller is spinning
  - Swap the pump out if a spare is available
- Could be the cable
  - Install a spare cable if possible

Pump Not Working (continued)

- Test the pump on deck (standard pump circuitry)
  - Temporarily connect the primary temperature sensor to the primary conductivity channel (JB2)
  - The primary conductivity frequency must be greater than 3500 Hz for 60 seconds to turn the pump on (monitor the frequency on the deck unit display)
  - Turn the deck unit on
  - The pump should be powered after 60 seconds
  - Verify the pump impeller is spinning

Pump Not Working (continued)

- Test the pump on deck (water contact pin)
  - Connect a jumper from the contact pin to one of the end cap screws
  - Turn the deck unit on
  - After 60 seconds the pump should be powered
  - Verify the pump impeller is spinning
- Test the pump on deck (modem controlled turn-on)
  - Start real-time acquisition in Seasave (second communication port must be connected to the modem channel)
  - Select *Pump On* in the Real-Time Control menu
  - Verify the pump impeller is spinning

Modulo Errors

- Modulo errors are normally a symptom of sea cable issues
  - A modulo error will normally cause a spike in **ALL** of the sensors installed on the SBE 9*plus*
  - If the number of modulo errors increases over time, it may be necessary to re-terminate the sea cable connection
  - All cables and connectors on the SBE 9*plus* and sensors should be inspected for any signs of corrosion or excessive wear

How Can I Tell if My Wet End Termination Needs to be Replaced?

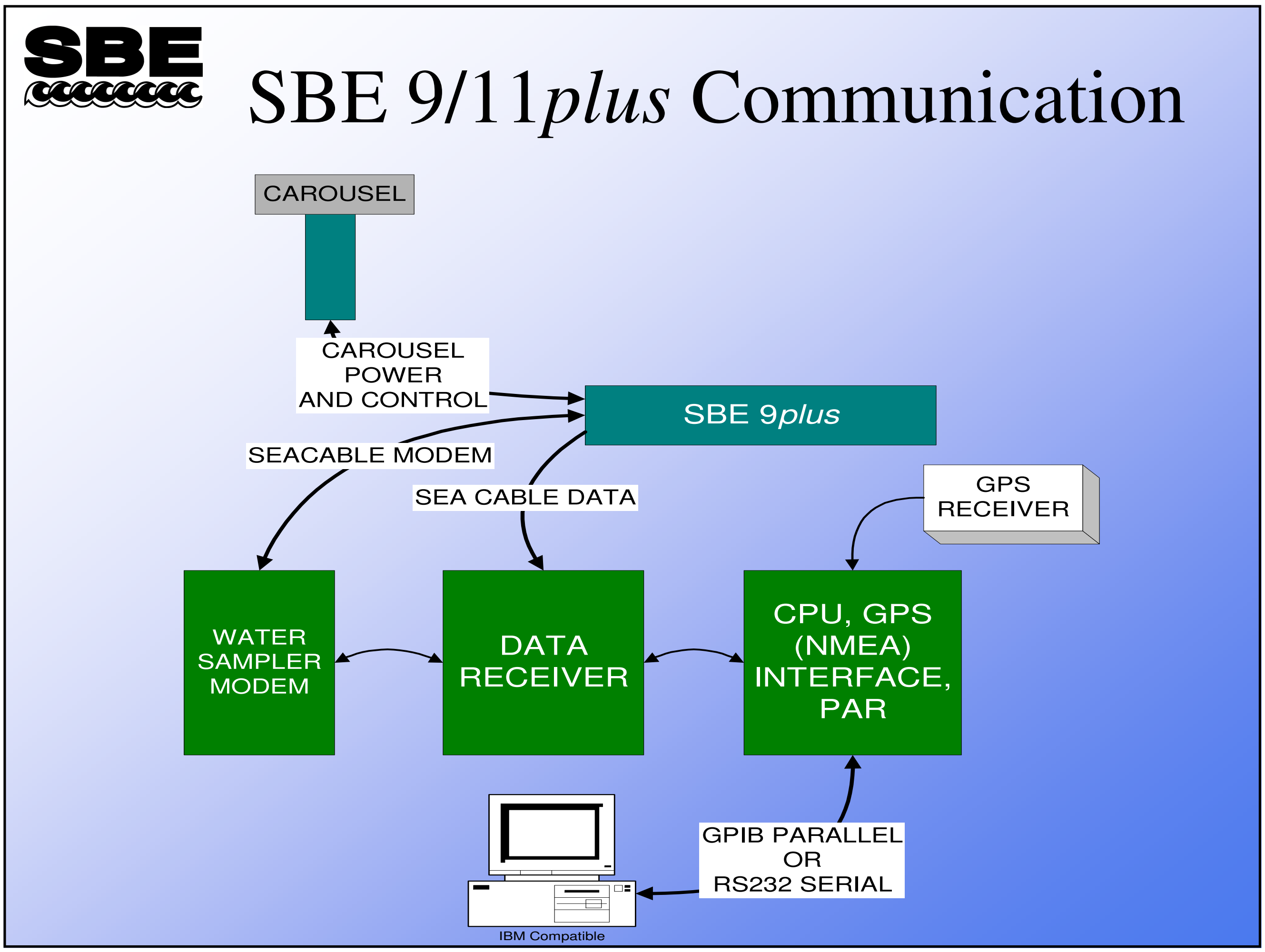
- Intermittent data dropouts, error light blinks on deck unit, check modulo errors
- Sea cable fuse blows in deck unit
- 9+ works fine on test cable
- 9+ works on deck, but not underwater

How Do I Know It Isn't the Slip Ring?

- Disconnect 9+ and 11+ deck unit
- Connect volt meter to signal wire and sea cable armor; check for small DC voltage
  - Wet end terminations usually fail when seawater intrudes into splice between underwater connector and cable. Dissimilar metals and seawater will cause a battery to be formed. This manifests itself as a small DC voltage between signal wire and armor.

Why Can't I Use the Ohm Setting on My Multimeter?

- You can BUT:
  - 10 kilometers of cable has capacitance, and when wound on winch spool may have some inductance
  - These properties can give confusing readings on your multimeter in Ohm setting


SBE
SBE 9/11*plus* Communication
CAROUSEL
CAROUSEL POWER AND CONTROL
SBE 9*plus*
SEACABLE MODEM
SEA CABLE DATA
GPS RECEIVER
WATER SAMPLER MODEM
DATA RECEIVER
CPU, GPS (NMEA) INTERFACE, PAR
GPIB PARALLEL OR RS232 SERIAL
IBM Compatible

SBE 11*plus* Fish/Tape Switch

- Fish/tape switch
  - If the fish/tape switch is accidentally moved to the tape position, the display will show all 0's

SBE 11*plus* Deck Unit Communications

- Baud Rates
  - Normally 19200 baud from the computer to the deck unit
  - Modem channel is 300 baud from the computer to the deck unit
- Two communication ports must be available to acquire real-time data and fire bottles from the computer

SBE 11*plus* Deck Unit, No Communication with Computer

- Green *Computer Interface Receive* LED does not flash
  - Check cable
  - Check serial port
  - Wrong interface selected
- Red *Underwater Unit Error* LED does not flash during initialization
  - Wrong baud rate

SBE 11*plus* Keeps Blowing Fuses

- Main power fuse
  - If the main power fuse continues to blow when the deck unit is powered on and the sea cable is not connected, the main supply transformer could be bad
- Sea cable fuse
  - Disconnect equipment until fuse does not blow
    - Disconnect the SBE 9*plus*
    - Disconnect the sea cable
    - Connect the SBE 9*plus* to the deck unit using a test sea cable

Troubleshooting NMEA Interface

- Navigational data must be in the proper format, NMEA 0183
- It must transmit at the proper speed, 4800 baud (9600 also available for SBE 11*plus*), with 8 data bits and 1 stop bit, no parity
- Use the NMEA simulator program NMEATest (supplied with the software CD and installed in the SBE Data Processing folder on your computer)
- Capture some data from your GPS for comparison

Connecting the GPS into the SBE 11*plus* Box

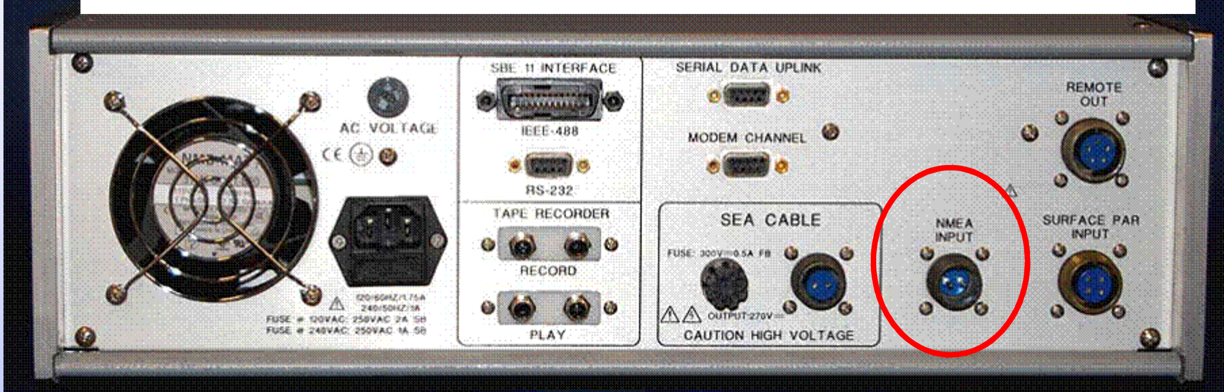
Note:
A NMEA navigation device can be connected directly to the computer instead of to the Deck Unit. This feature is supported by Seasave V7 version 7.17 and later; see *Setting Up CTD Configuration (.xmlcon or .con) File in Seasave* in *Section 5: Setting Up System*. The output from Seasave is the same, regardless of whether the NMEA data was appended in the Deck Unit or in the computer.

NMEA Navigation Device to Deck Unit

Connect the NMEA navigation device to the *NMEA Input* connector on the Deck Unit back panel with the supplied 2-pin MS connector (MS3106A12S-3S). The connector pin designations are:

Deck Unit	Function
Pin A	NMEA *A* (signal)
Pin B	NMEA *B* (signal return)

14



NMEA Simulation

- Sea-Bird provides a simulation program that you can run on a second computer or on the same computer if the computer has a spare COM port
  - Cable your computer to the NMEA port on the deck unit
  - Run the simulator program; if it works, the problem is with your cabling or your GPS

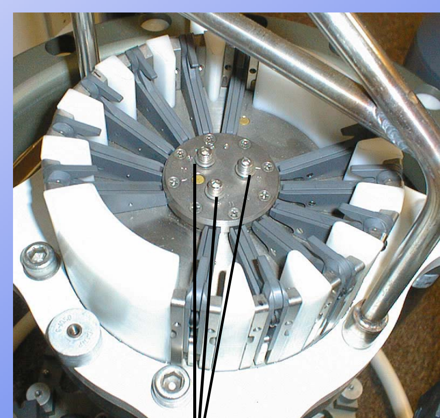
Capture Some Data for Comparison

- Cable your computer to your GPS
- Use Seaterm to check the transmit speed, data bits, etc.
- Use Seaterm to capture some data to compare with the standard NMEA formats shown in the deck unit manual

SBE

Water Sampler Physical Problems

- Soak triggers in soap and water
- Never lubricate triggers
- Check 3 screws holding trigger assembly to pylon for over-tightening, which causes distortion of trigger assembly
- Lanyards must run straight from trigger to water sampler



Check screws for over-tightening

Water Sampler Electrical Problems

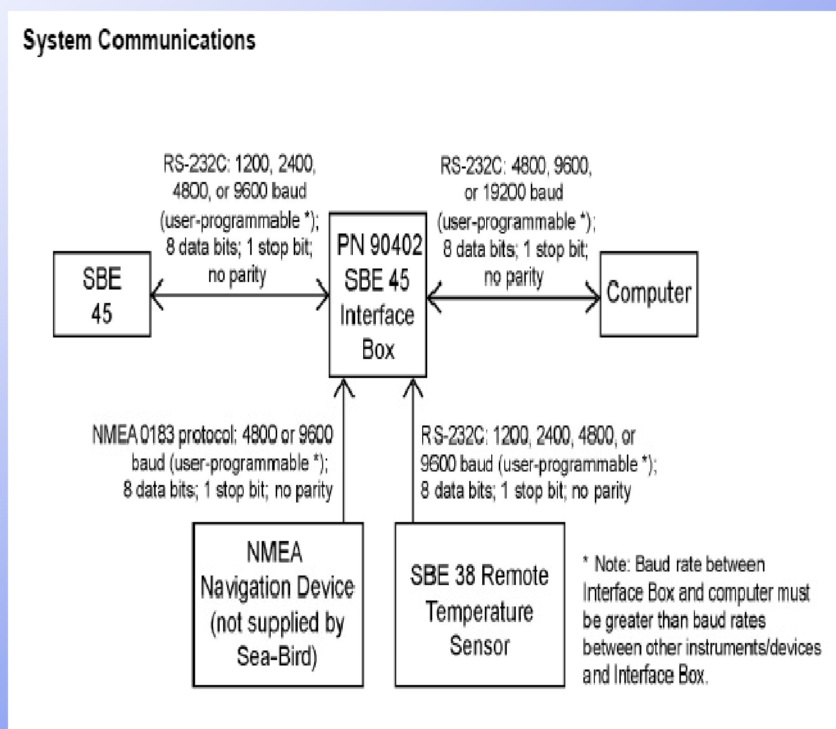
- SBE 11*plus* carrier detect LED must be lit and 9*plus* carrier detect bit must be set
- Computer must have a functioning second communication port for sampler control
- SBE 11*plus* modem board switch settings must match sampler type (G.O. 1016, SBE 32, etc.)
- Check cables
  - If the cable is suspected, install a spare cable if possible

NMEA Box Troubleshooting

- Most problems are setup or cable related
- Configuring baud rates
  - Box with firmware version < 3.0
    - Configure baud rates using dip switches
  - Box with firmware version $\geq$ 3.0
    - Configure baud rates in Seaterm; in the Configure menu, select the instrument being used with the Box

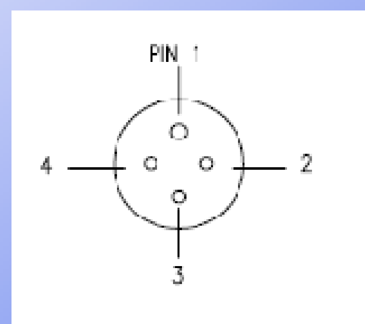
ASIDE: Troubleshooting TSG SBE 45 / 38 / NMEA Box

- Most issues are setup related
  - Baud rates must be configured properly
  - Box must be in the proper format
  - See manual for setup and troubleshooting information



Troubleshooting I/O Cable

- Perform a loop-back test to test the computer, comm port, and cable
- With the I/O cable connected to the computer:
  - Disconnect the I/O cable from the CTD
  - Use a bent paper clip to insert into pins 2 and 3 at the CTD end of the cable
  - Any characters typed in terminal program should echo on the screen (the paper clip creates a loop back to the computer)



Troubleshooting Data Problems

- There are only two ways you can ruin your data:
  - Deleting your *.dat* or *.hex* file
  - Opening and then saving your *.dat* file with a word processor
- There are many ways you can produce useless data by making errors in processing
  - Mismatching instrument setup and configuration (*.con* or *.xmlcon)* file
  - Having errors in calibration coefficients in *.con* or *.xmlcon* file

Data Scan Mismatch

- The SBE 9*plus* has varying scan length, because unused voltage or frequency channels can be suppressed
- However, *Seasave* and *Data Conversion* both check the scan length of the configuration (*.con* or *.xmlcon*) file against the *.dat* or *.hex* file.

Troubleshooting Activity

- What is wrong with this instrument?

Troubleshooting Activity

- Use *Seasave* to examine data in C:\Data\Module15\Cast1\BadCast1.dat
  - Use BadCast1.con
  - Plot display: P 0..6000, T 0..10, S 30..36
  - Fixed display: add Modulo Error
- Use Seasave to examine data in C:\Data\Module15\Cast2\BadCast2.hex
  - Use BadCast2.con
  - Options: Select *Check Scan Length*
  - Plot display: P 0..100, T 0..30, S 24..34


SBE
Module 4:
Best Practices
Collecting Quality CTD Profiles
and
Water Samples
Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and Oceanography

Best Practices:
Collecting good CTD Profiles and Water Samples

- Understanding how your sensors work
  - Response times and drift characteristics
    - What you need to know about these things
- Calibration
  - Factory and In-Field w/ Water Samples
- Minimizing Potential Sampling Errors
  - Best Practices

Sensor Components

- Device that allows a physical characteristic of environment to be converted into an electrical signal
- Composed of:
  - Active element having a property that changes in response to physical characteristic, and
  - Circuit that converts this change into a signal that may be measured by normal methods
- Normal methods mean frequency measurement or analog-to-digital conversion

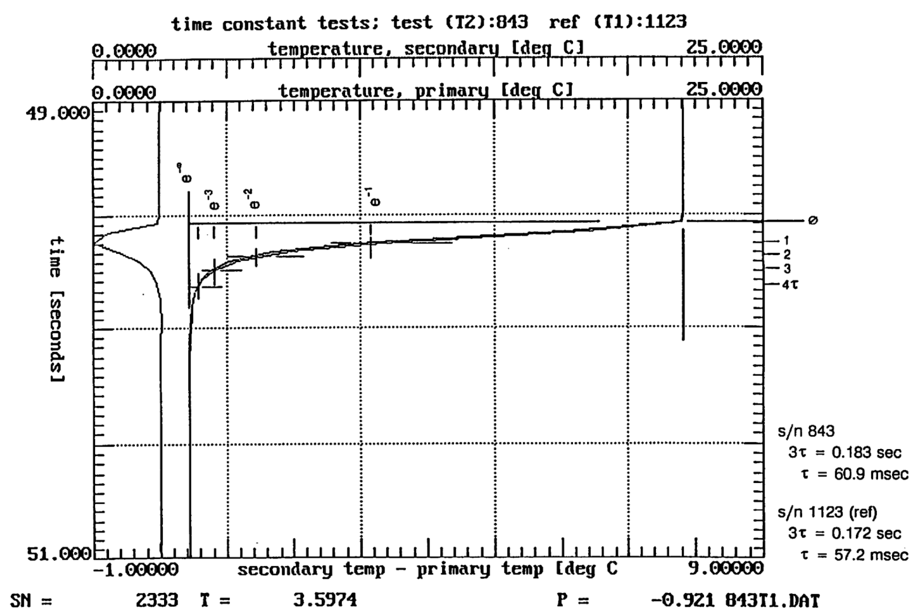
Ideal Sensor vs. What you get

- Perfection:
  - Reacts to only one physical characteristic of environment
  - Has a response to physical characteristic that is easily modeled mathematically
- Reality:
  - May react to more than one physical characteristic of environment
  - Response of sensor may be non-linear or may be parametric, with terms that reflect its reaction to physical characteristics other than one of interest

Characteristic of all sensors is their response time

- Sensor response to a step change in their environment is termed their *time constant*
  - Sensors do not respond instantaneously to changes in their environment
- Time constant is typically stated as time to come to 63% of final value, given a *step* change in environment
  - Takes 5 tau to reach +99% of final value

Typical Response Time Curve for a Sensor In this case, and SBE 3 (Temperature)



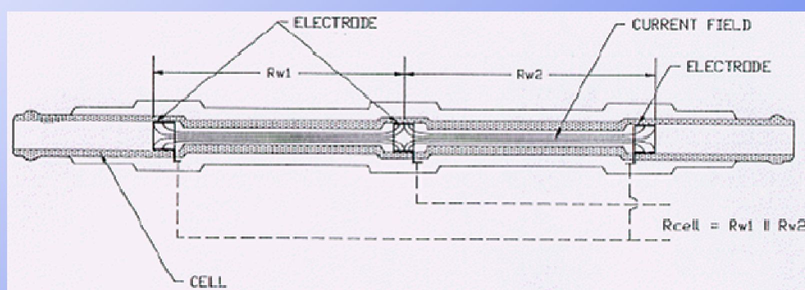
SBE dynamic response tests of SBE 3/F sensors yield a time constant of 60 milliseconds when used with a TC duct. A very sharp temperature step (~ 0.010 sec) is presented through a TC duct. The reference sensor (s/n 1123) provides a reference measure of the step sharpness.

Conductivity Sensors Measure Resistance of Water

- Volume in the cell acts as the resistor
  - Length/Area = constant
  - Measure conductivity directly between wet electrodes
  - Need to keep volume of cell constant
- All conductivity sensors responses are influenced by
  - Flow of sample through the cell
  - Temperature (90% of the C signal T dependent!)
  - Heat capacity of the cell (cell thermal mass)
  - Electrode condition (platinization, position)
  - Cell geometry (keep clean from fouling)

SBE Conductivity Cells Easier to Control Because of Zero External Field

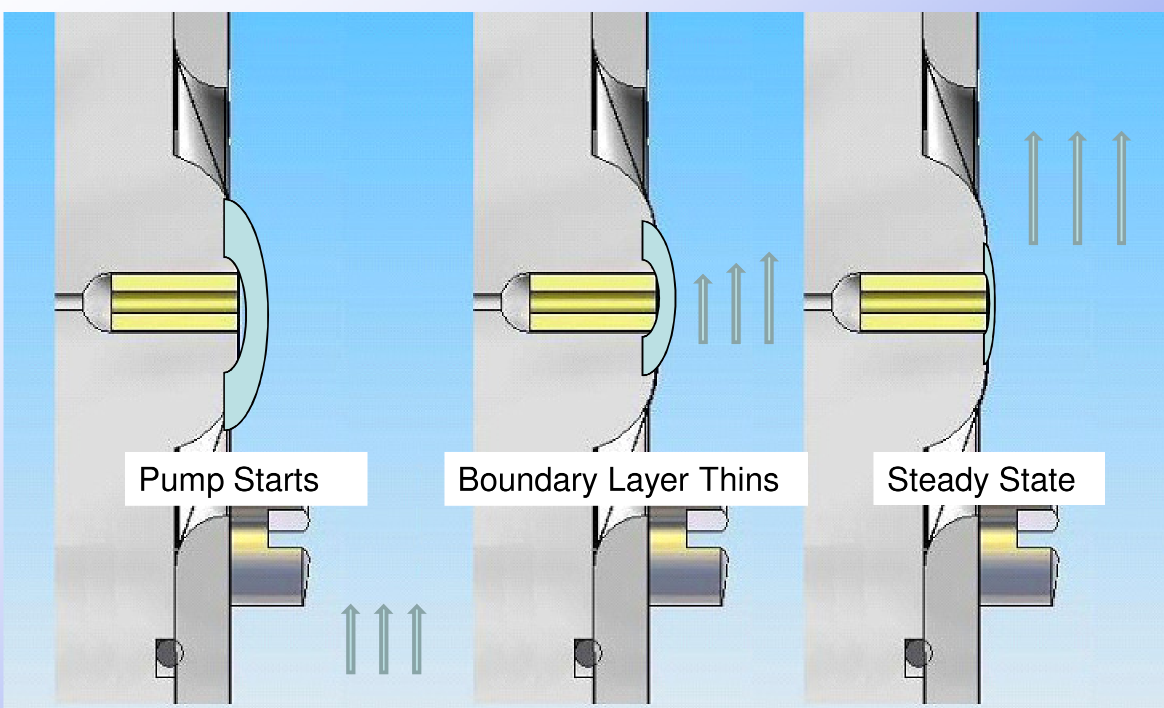
- Outer electrodes are connected together so no voltage difference exists to create an external electrical current
  - Immune to proximity errors
  - This allows for attaching a pump for flow control
- DO NOT STICK ANYTHING INSIDE THE CELL



A good estimate of SBE 4 time constant is 30 milliseconds
- Typical for all Sea-Bird conductivity cells
- Sea-Bird modifies flow configurations to match thermistor response times

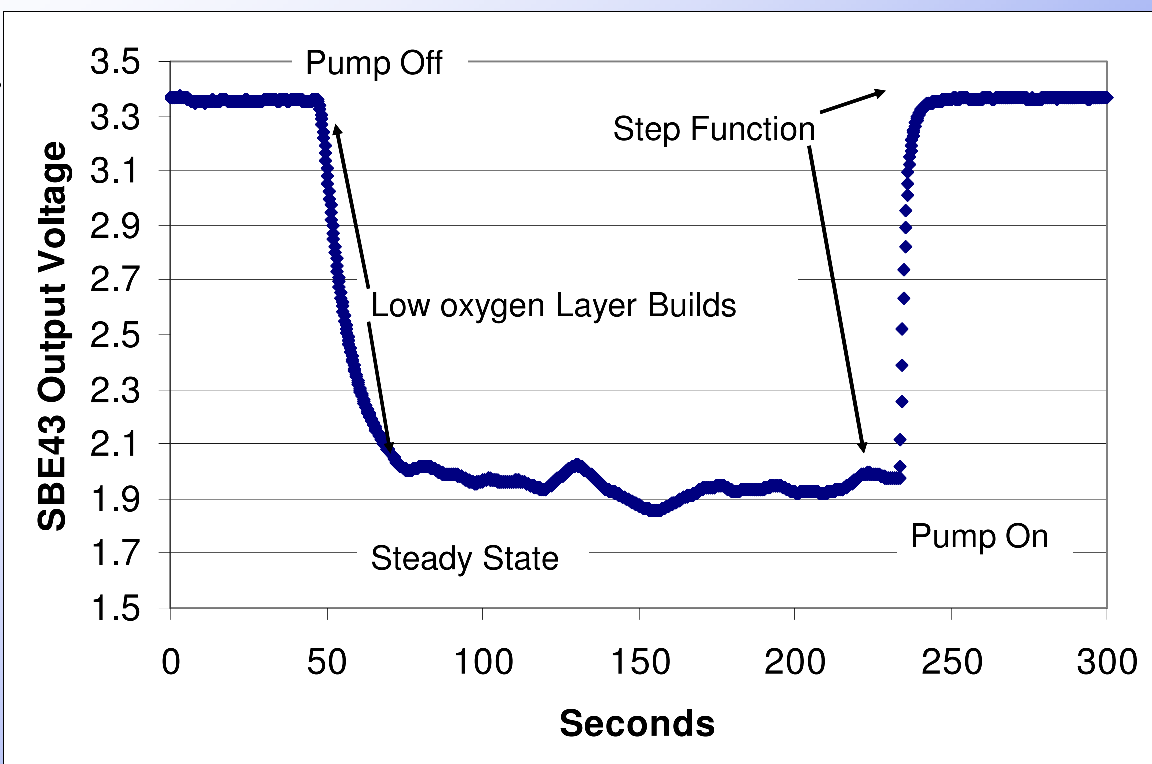
Response of SBE 43 DO Flow Dependent

Boundary layer near sensor when pump turns on



SBE 43 Sensor Response

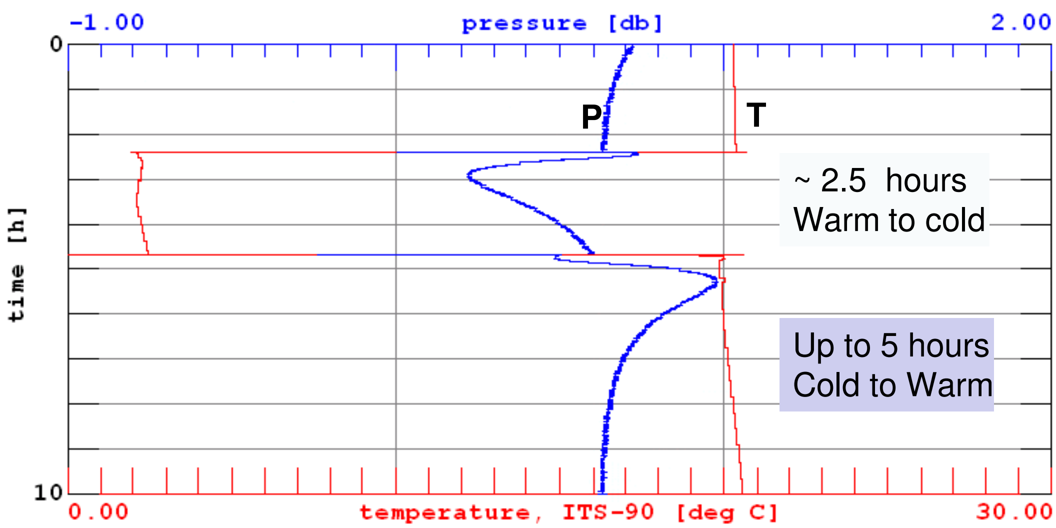
•



Pressure

- Step changes in pressure not typically seen in the ocean environment
- Pressure sensor time constant is not an issue
- Sensors are temperature sensitive, so SBE mitigates this by insulating the pressure sensor inside the CTD main electronic housing

Temperature Effect on Pressure

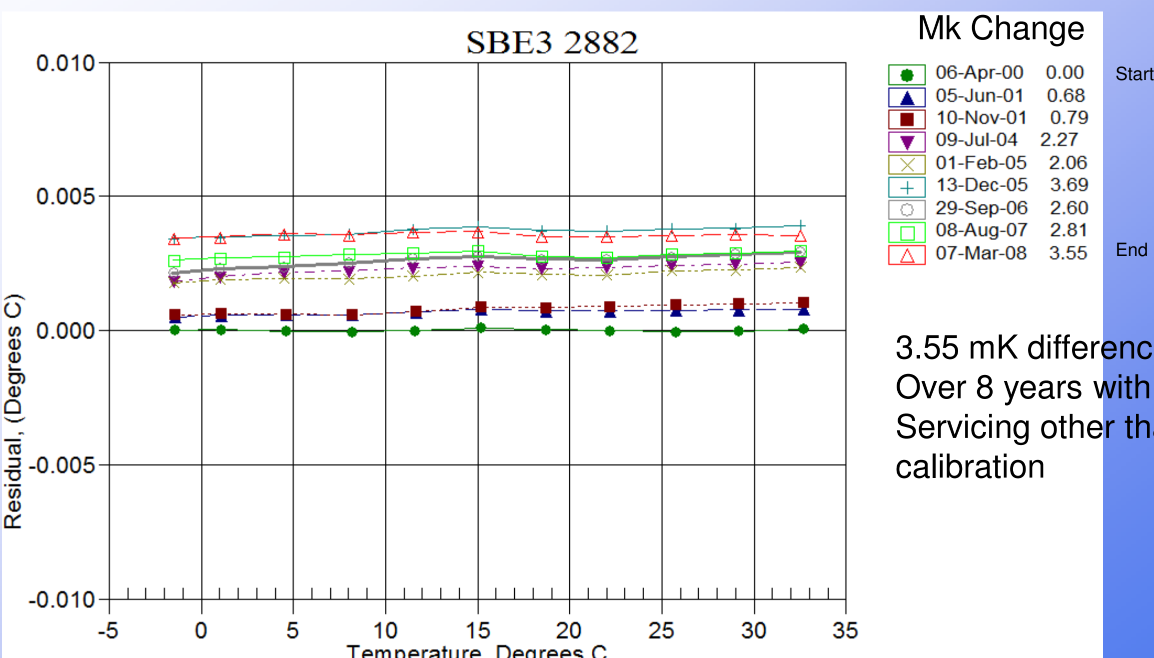


If the CTD is brought up from very cold depth, it can take 4-5 hours for pressure sensor to be completely at equilibrium. If making a pressure check on the ship deck, do so before making a CTD profile and after the CTD has been at a stable temperature.

Drift In SBE Sensors

- Temperature and Pressure sensors tend to drift in offset
  - Due mostly to aging ~0.001°C per year for SBE 3 temperature sensors
  - Fatigue on mechanical components in pressure sensors
- Conductivity and Oxygen sensors tend to drift in slope
  - Due mostly to fouling inside cell and on sensor face (i.e., membrane)

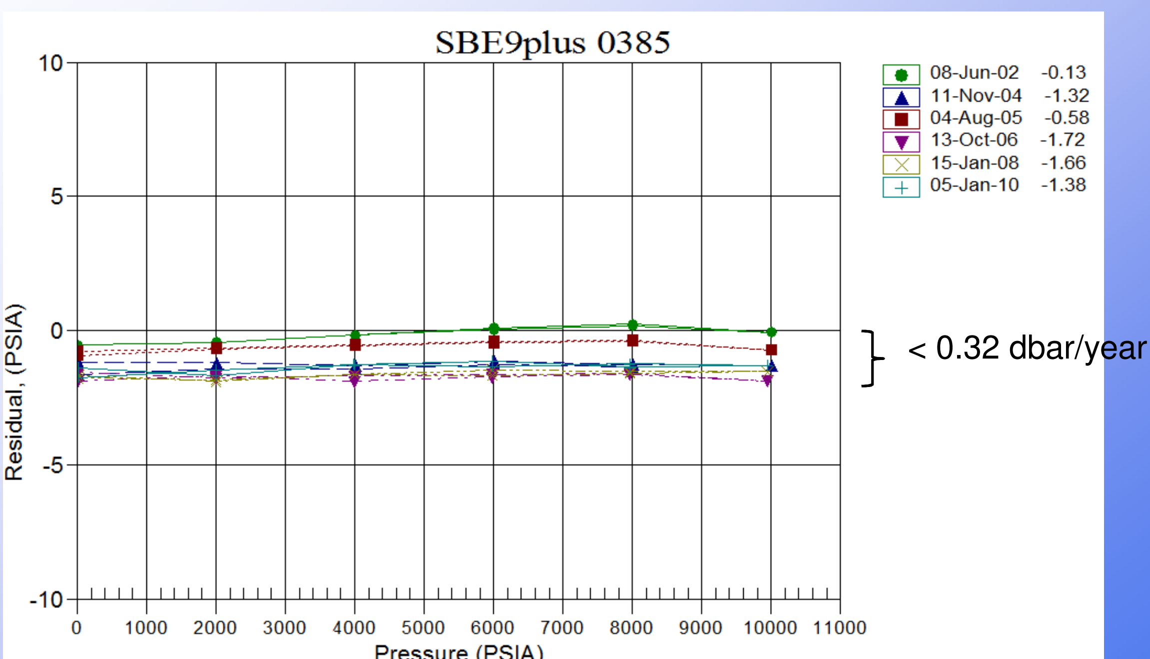
Example of Offset Drift
SBE 3 Temperature Calibration History
<0.000625 deg C / Year



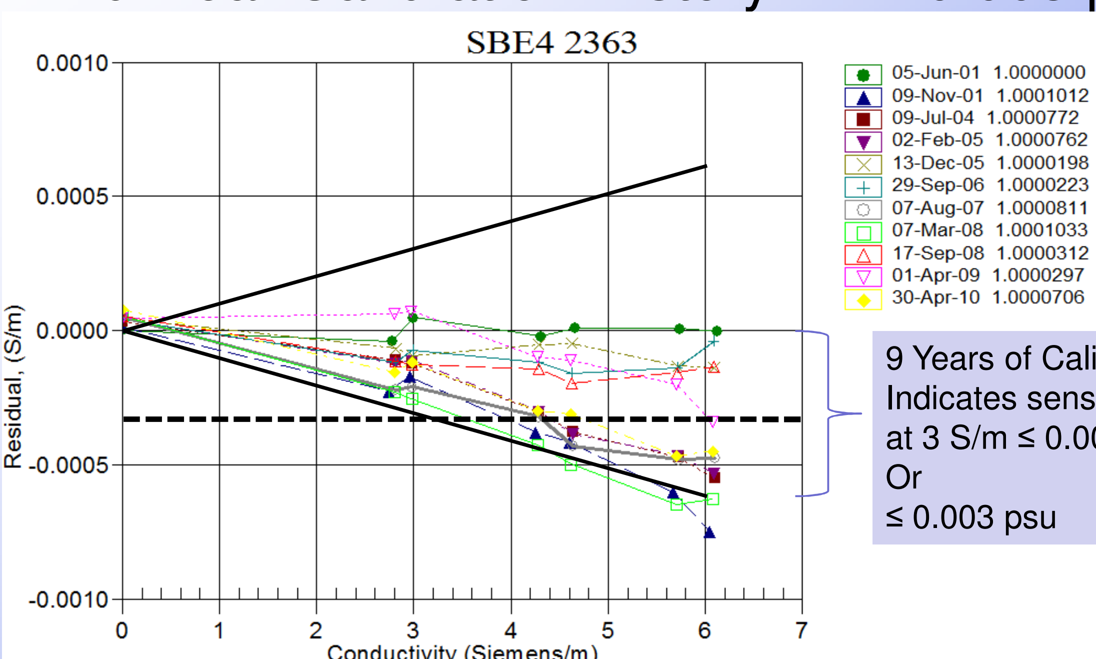
3.55 mK difference
Over 8 years with no
Servicing other than
calibration

SBE 3 Factory Specification < 0.001 deg C/yr

Example of Offset Drift
SBE 9+ Digiquartz Pressure Sensor
8 Year Calibration History

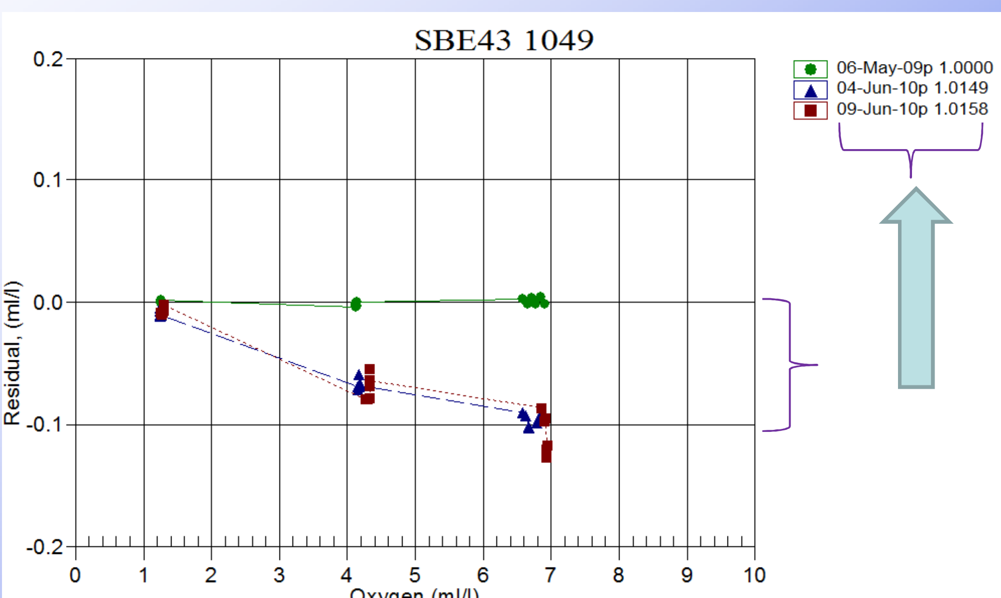


Example of Slope Drift
SBE 4
9-Year Calibration History < -0.003 psu



9 Years of Calibration Indicates sensor drift at 3 S/m ≤ 0.0003 S/m
Or
≤ 0.003 psu

Example of Slope Drift
SBE 43 Dissolved O_2 Sensor

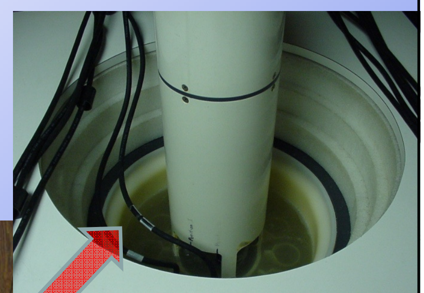


Drift
< 1.5% per year
normal for
healthy sensor

Factory Calibration Baths

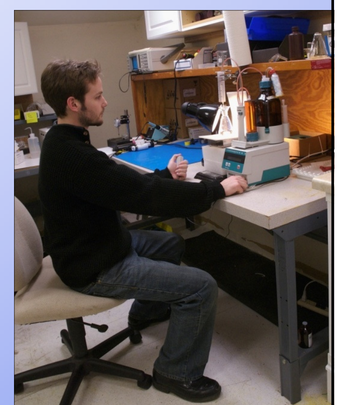
SBE 4 Calibration Bath

Water sampler on right takes a water sample at every calibration point



SBE 3 Calibration Bath

Sea-Bird Calibration Bath Operations



- Place sensors in a precisely controlled temperature environment
  - T, C, and DO baths
  - Temperature measured at 11 points
  - Salinity samples taken at each of 6 temperature steps
- Provides means of changing O_2 concentration for dissolved oxygen calibration using gases
  - DO calibrated at 18 points (6 temperature steps for 3 oxygen steps)
  - Response time tests are conducted on each sensor using gas
- Compare to either a physical standard (i.e. IAPSO SSW, triple point of water, Winkler) or a reference sensor (also called a secondary standard)

Reading SBE Calibration Sheets

Example SBE 3

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2700
CALIBRATION DATE: 28-Dec-99

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

IT90 coefficients

ITS-90 COEFFICIENTS
g = 4.36260004e-003
= 6.49083037e-004
= 2.42497805e-005
= 2.36365545e-006
= 1000.0

IPTS 68 coefficients

IPTS-68 COEFFICIENTS
a = 3.67991178e-003
b = 6.04738390e-004
c = 1.65374250e-005
d = 2.36525963e-006
f0 = 2978.914

ATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4039	2978.914	-1.4040	-0.00008
1.1062	3149.847	1.1063	0.00009
4.5979	3399.248	4.5980	0.00007
8.1955	3670.718	8.1954	-0.00004
11.6295	3943.970	11.6295	-0.00007
15.1862	4241.874	15.1861	-0.00009
18.6903	4550.560	18.6904	0.00008
22.1892	4874.139	22.1893	0.00007
25.7491	5219.423	25.7491	-0.00000
29.1638	5566.173	29.1637	-0.00005
32.6970	5941.274	32.6970	0.00001

Residuals = instrument T - bath T

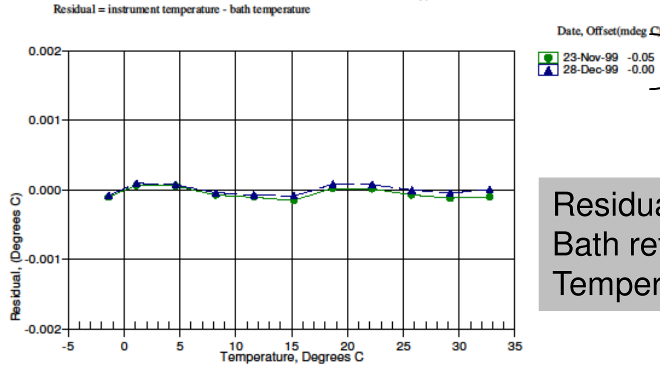
Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature

Calibration Equations



Pre and Post Calibrations Denoting drift in millidegrees

Residuals shown above plotted against Bath reference temperatures or Known Temperature

Pressure Sensor Calibrations

- Digiquartz sensors are supplied by Paroscientific with coefficients derived from a calibration performed over temperatures between
  0 - 125 ℃.

- When we calibrate pressure at Sea-Bird, a dead-weight pressure generator is used to subject the sensor to increments of known pressures.

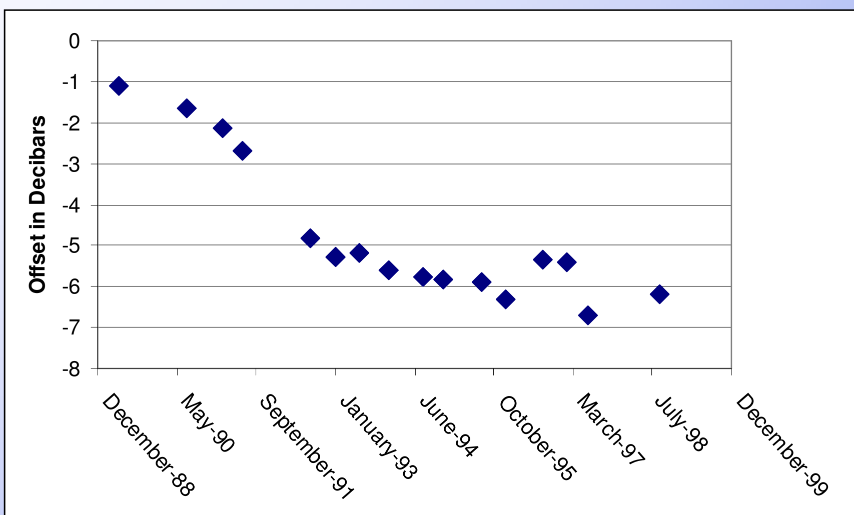
A maintained and calibrated Digiquartz pressure sensor serves as secondary standard for all instruments

For You to Do

Keeping Track of Pressure Offsets in the Lab or Field

- Physically locate the instrument in the orientation that it will have when deployed
  - All pressure sensors are sensitive to their orientation due to gravity on the fluids that fill their capillaries
- Make offset measurement in a constant temperature environment, with the instrument temperature the same as the environment
  - temperature transient residual effects
- Measure the offset
  - **Best practice**, measure pressure sensor offset against a barometer
  - In a pinch, measure offset against sea level
  - Measure offset needed to zero the sensor
- Maintain a log to observe pressure sensor drift

Track the Drift of SBE 9*plus* Pressure Offset with Time



Drift appears normal through October of 1995. It begins to change more randomly after that, indicating it is soon in need of calibration test at factory.

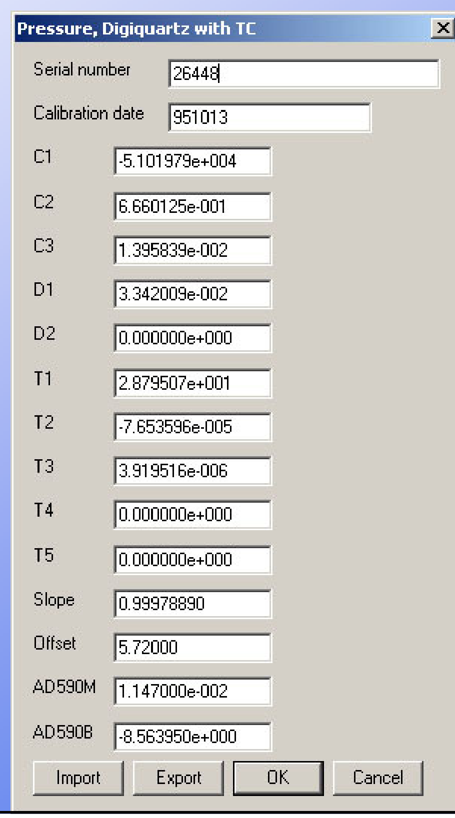
How to Measure Pressure Offset in the Lab Using a Barometer

- With offset in *.con* or *.xmlcon* file set to 0.0, pressure measured by CTD should equal barometric pressure
- Calculate offset (db) =
  barometer reading – CTD reading
  - Conversion of psia to decibars:
    decibars = (psia - 14.7) * 0.6894759
- Enter calculated offset in *.con* or *.xmlcon* file
- Example:
  - CTD reads -2.5 dbars
  - Barometer reads 14.65 psia.
    Converting to decibars, barometer reads
    (14.65 - 14.7) * 0.6894759 = -0.034 dbars
  - offset (db) = barometer reading – CTD reading
    = -0.034 - (-2.5) = 2.466

  - Application Note 73

Entering Pressure Offset in the CON or XMLCON File

- Pressure offset is entered with the calibration coefficients
- Adjust your CON (XMLCON) files prior to collecting or processing data



Profiling and Water Sampling Best Practices

- How long to soak before profiling
- How long to soak before firing water bottles closed
- Precautions in cold places
- Reducing sampling errors due to ship heave
- How to recognize a pump is not working
- Where to collect water samples for sensor comparisons

Soaking Before Profiling

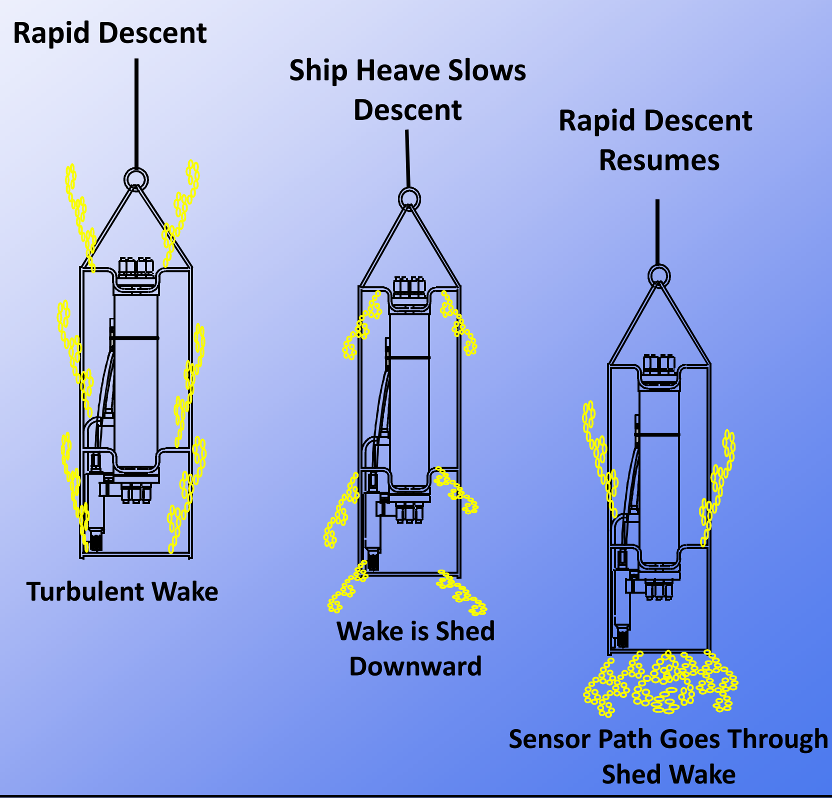
- Always allow CTD to soak at the surface before a profile
  - Purge air from plumbing before pumps turn on
    - SBE 9+ allows you to turn on CTD after it has soaked in water
    - At 10 m, trapped air bubbles are squeezed and are easily expelled from pump
  - This also allows equilibration of entire carousel to ambient temperature, so you have less risk of shed wakes
  - Allows power-on transients in sensors to decay
    - 2 secs in SBE T,C sensors for 100 ppm stability
  - Oxygen Sensor stabilization for 1% stability
    - 30 secs (SBE43) to set up boundary layer flow
- Soaking tip: use 2 display types
  - Fixed or scrolled text display
    to check all sensors and other parameters on deck and during soak
  - Multi-line plot for the cast

Deploying in Very Cold Places

- Glass conductivity cell is subject to breakage due to water freezing in cell
- Remove all water from conductivity cell
  - Repeated ice formation (film or droplets) on electrodes will degrade calibration at 0.001 - 0.020 PSU level
- Make a solution of 1% triton in sterile seawater
  - Use 0.5 micron filtered seawater or boiled seawater
- Never use anti-freezes like glycol or alcohol
- SBE 43 Oxygen Sensor – prevent freezing

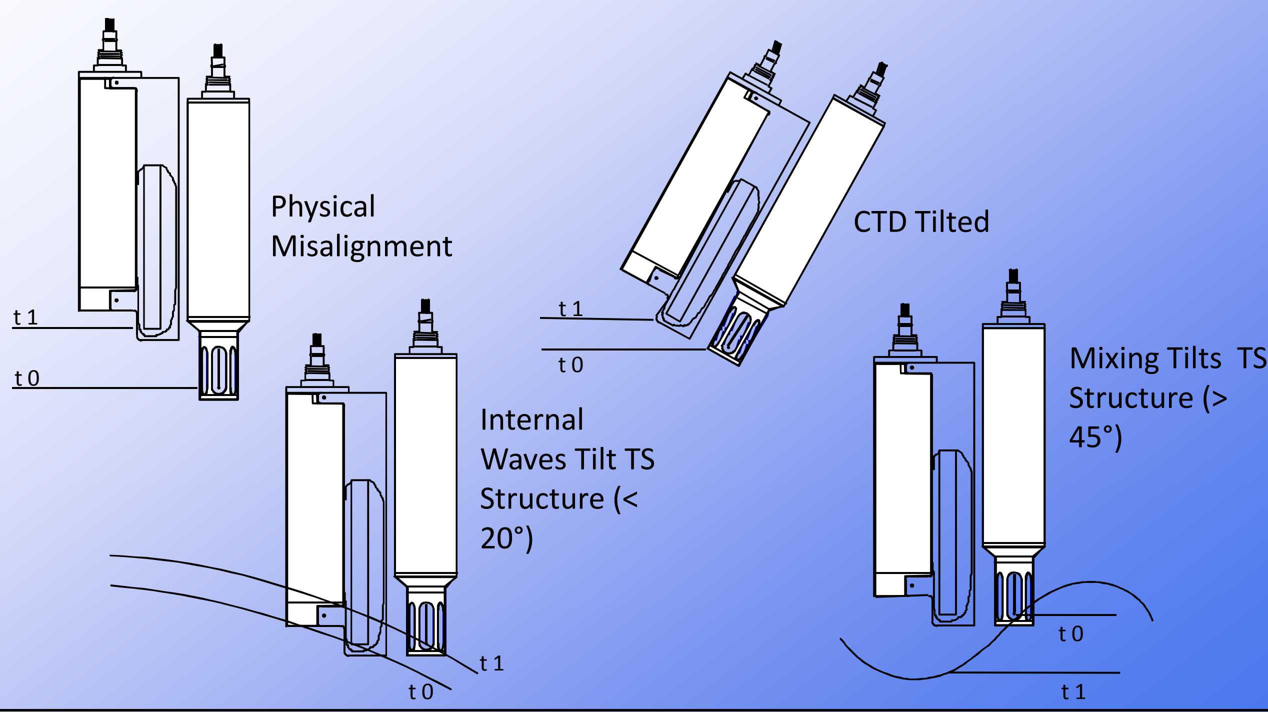
Data Artifacts Caused by the Underwater Package

- Ship heave causes underwater package to *loop* through water
- Accelerations and decelerations caused by ship heave cause water entrained within package to *blow by* sensors
- Use a higher drop speed (1.0-1.5 m/s) to minimize pressure reversals
  - Note: slower sampling CTDS have a reduction in resolution at faster drop speeds!



Other Sources of Measurement Misalignment

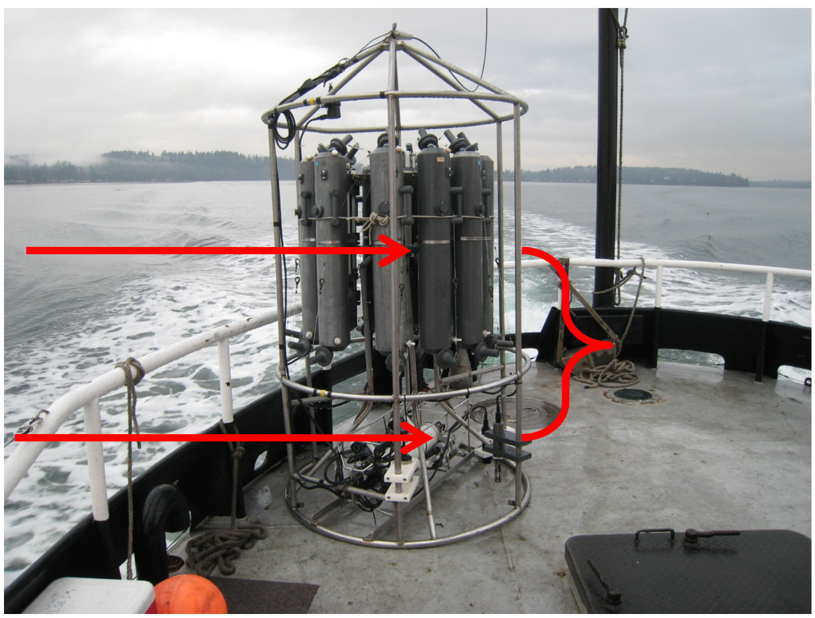
The CTD samples sensors uniformly in time, but unducted sensors arrive at corresponding structure at different times. Ducted TC sensors will always see the same water sample, reducing this effect. DO and Fluorometers will see them at different times



Optimize Sample Rate and Descent Speed

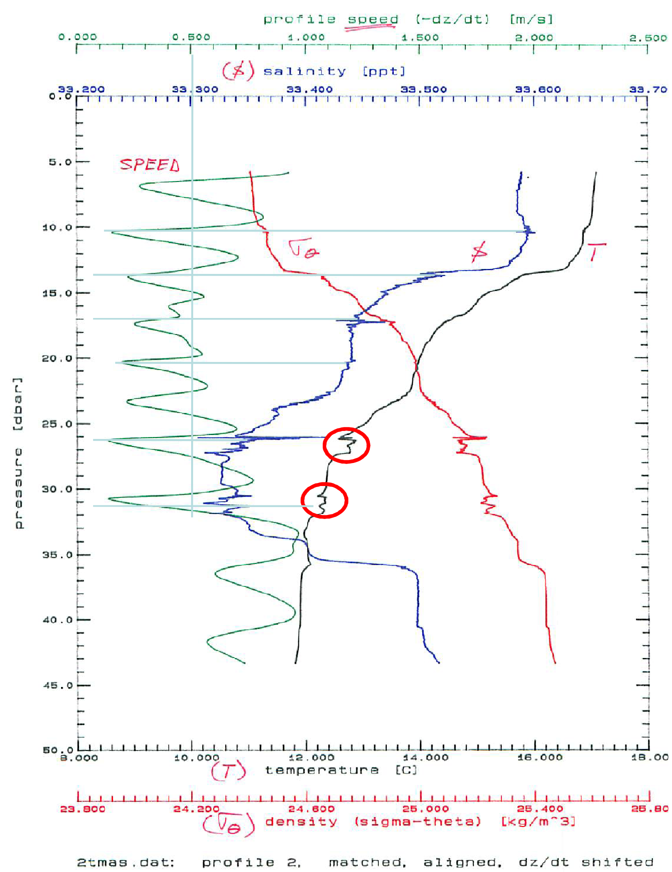
- Capture data at 24 Hz for best correction of salinity spiking error
- Use a higher drop speed (1.0-1.5 m/s) to minimize pressure reversals is experiencing a lot of ship heave
  - View descent rate output dz/dt realtime to see how well you are doing
- Know where your sensors are on your carousel frame
  - Measure from the pressure port or TC duct intake

Note position of Bottles with respect to the CTD sensors



Profile showing spiking of data due to drop speed variation

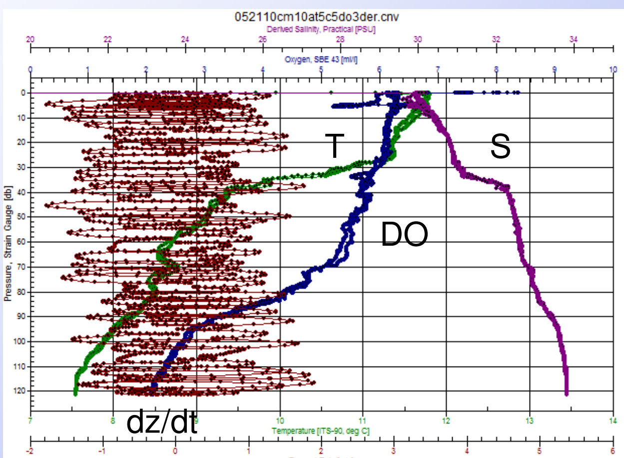
Example here had a drop speed average of 0.5 m/s
-Wire Lowered
-Calm Conditions



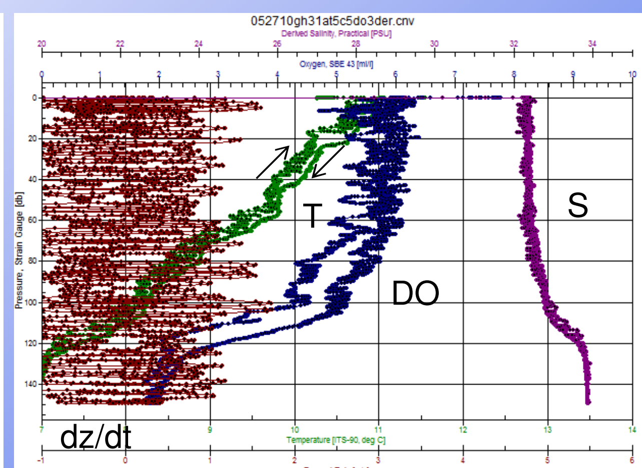
R/V New Horizon, SCRIPPS

Example of Ship Heave Effects With and Without the pump on

Pump On, reducing effect of ship heave



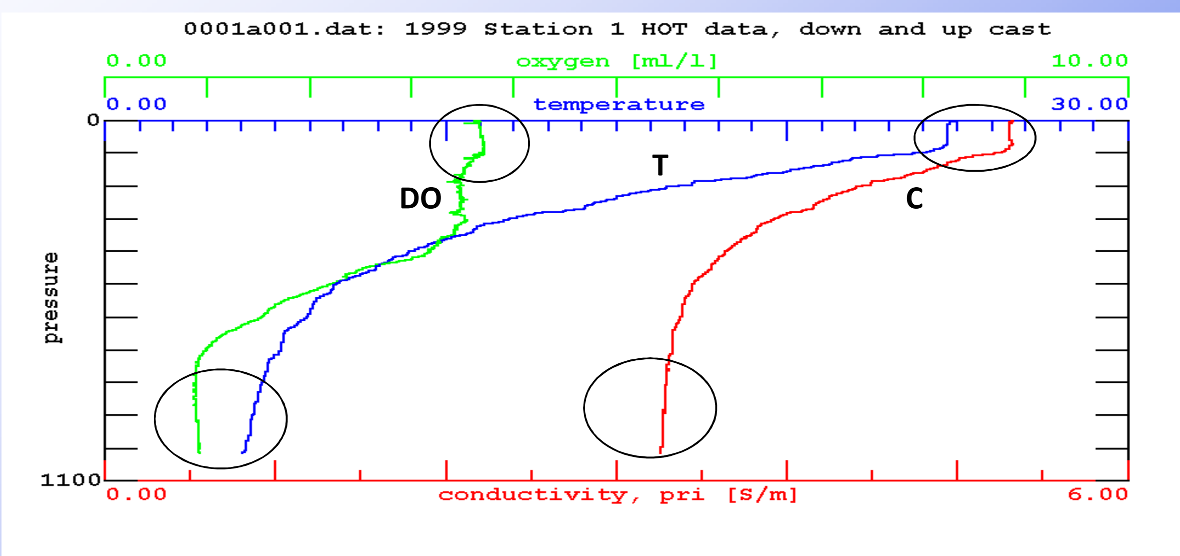
Pump Off, heave apparent in all data, and DO mismatch between up and down casts shows loss of flow from pump



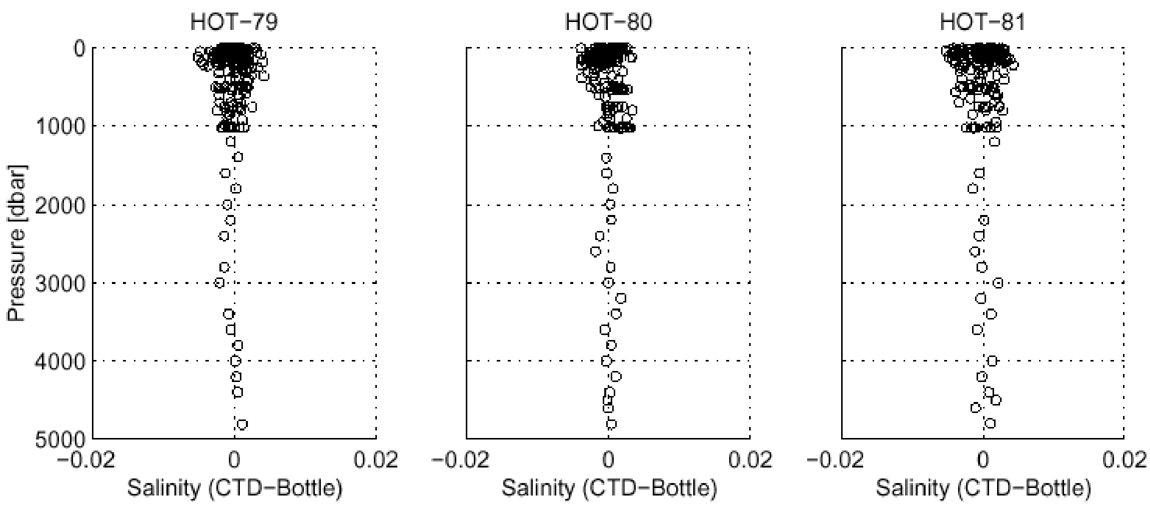
Making Independent Comparisons with Discrete Water Samples

- Take water samples in parts of water column where change in parameter of interest is small compared to size of underwater package
- Be sure to allow the carousel to stabilize in the water column prior to firing bottles
  - *How long should you hold the carousel before firing bottles closed?*
- Important point: sometimes water sample bottles leak

Collect water in regions where conditions are not changing



Variability in the surface layer can cause poor agreement with surface CTD measurements



L. Tupas, et al., Hawaii Ocean Time Series Data Report 9, 1997. University of Hawaii, School Of Ocean and Earth Science and Technology, page 21.

Why bottle samples do not always match CTD data

- Tracking sensor accuracy is goal
- Problems can arise
  - Position of Niskin bottle on frame with respect to sensors or intake of plumbing
  - Rinsing of Niskin bottles and thermal mass
  - Hold time at depth of bottle firing
  - Leaky Niskin bottles
  - Time of water sample draw and order of draw on deck
    - Always take DO first!
  - Analysis errors (replicates, blanks, standards tracking, dirty bottles, etc.)

How to Check Niskin Bottles for Leaks

- Bottle/CTD comparisons bad at one or few depths
- Run underwater package down deep to nice, uniform water
- Close all water bottles
- Run salinities on each water bottle
- Compare salinities, fix leakers, and repeat


SBE
Module 5:
Basic Maintenance of
Sea-Bird Equipment
Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and
Oceanography

SBE

Annual Preventive Maintenance

- Inspect all cables and connectors.
  - Replace as required (usually good for up to 5 years).
- Inspect all anodes.
  - Replace as required.
- Inspect the housing for corrosion.
  - Remove all installed sensors and clamps for cleaning and inspection.
    - Replace Teflon Tape as required
  - Remove, re-lubricate, and re-install the hardware (use DC4 and Blue Moly).
    - Ideally done after each cruise.
  - Replace jack-screw plugs as required.

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Re-Lubricating Hardware

- Place DC4 in the screw hole to fill the *blind* end of the hole.
  - This prevents sea water from filling the space and causing hardware and housing corrosion.
  - It also prevents the growth of salt crystals, which can cause stuck hardware.
- Coat the screw with Blue Moly to prevent corrosion and prevent binding of the hardware.
- Wipe up any excess from the instrument.
- These coatings dissipate with use, and require periodic replacement.

SBE

Hardware Lubrication

- When installing hardware in titanium housings:
  - DC4 -- No Blue Moly -- Yes
- When installing hardware in plastic housings:
  - DC4 -- Yes Blue Moly -- No
- When attaching the ground strap screw and anodes:
  - DC4 -- No Blue Moly -- Yes

SBE

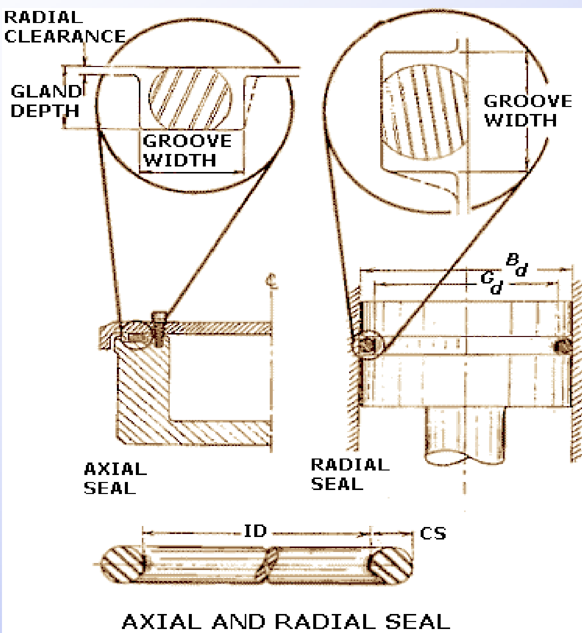
Handling *Opened* Instruments

- All electronics have varying levels of ESD susceptibility.
- When handling any electronics, observe ESD precautions.

O-Rings

- Inspect and replace O-rings that are accessed frequently with regularity.
  - For example, battery end cap O-rings.
- Replace O-rings that are not often disturbed at least every 3 to 5 years.
  - SBE 9+ pressure housing

Types of O-Ring Seals used by SBE



- Axial or face seal
- Radial or piston seal
- We use both seals in most of our instruments
- We also use L-seals

Seals

- Axial and piston seals are usually installed in conjunction with one another.
- Other instruments use dual piston seals.
- Some instruments use an L-seal.
  - L-seals work well for uni-directional pressure, and are well suited to high pressure.
  - L-seals also use a hard Teflon backup ring.
- The rules for handling and installing the seals are the same.

Open the Instrument

- Disassemble the instrument in accordance with the manual instructions.
- Remove the O-rings that are being replaced.
  - Do not use metal tools; use wood or plastic.
  - Clean the old Super O Lube residue from the instrument's sealing surfaces, and inspect for corrosion.

Cleaning O-Ring Surfaces

- Use Kimwipes or the equivalent when cleaning O-ring sealing surfaces and O-rings.
  - Kimwipes are a low-lint wipe.
- Avoid using paper-towels and Q-Tips, because they may leave fibers behind that could bridge an O-ring.

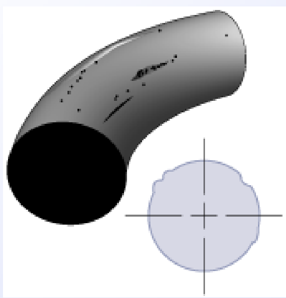
SBE

Inspect the New Seal

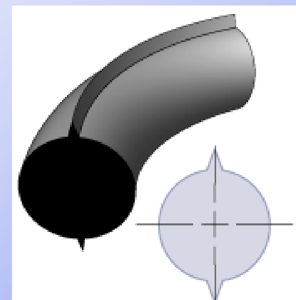
- Visually inspect the seal in *good light* for any flaws or imperfections.
- Also inspect by *feel*.
  - Perform the *feel* inspection when lubricating the seal, just prior to installation.

SBE

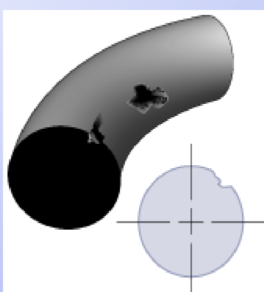
Flaws to Look and Feel For



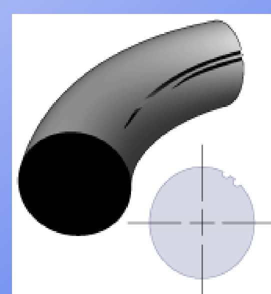
Foreign Matter



Parting Line Flash



Voids and Indentations



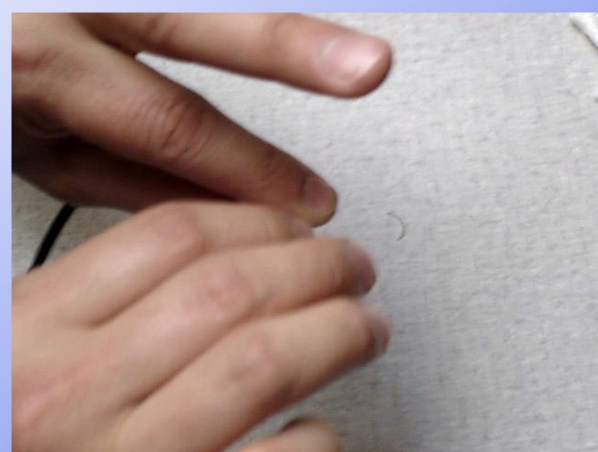
Flow Marks

Proper O-Ring Lubrication

- SBE uses **<u>ONLY</u> Parker** Super O-Lube for lubrication of O-rings that we install.
- The **<u>KEY</u>** to proper application is to use a small amount and provide a light film where it is applied.

Applying the Lubricant

- Apply a **thin** continuous film of lubricant over the entire O-ring surface by *running* it through your fingers, checking one last time for flaws.
- Install the O-ring in the O-ring groove.



Excessive lubricant is worse than too little!

Lubricate the Housing

- Inspect the housing O-ring surface.
- Apply a **light** coating of Parker O-ring lube.
- This prevents the O-ring from binding during installation.

Again, excessive lubricant is worse than too little!

Closing the Instrument

- Replace or re-condition the desiccant bag.
- Back-fill the instrument with a dry gas if possible (for example, dry Nitrogen or Argon).
- Properly lubricate and re-install the hardware.
- Verify operation of the instrument before reassembling into cage, etc.

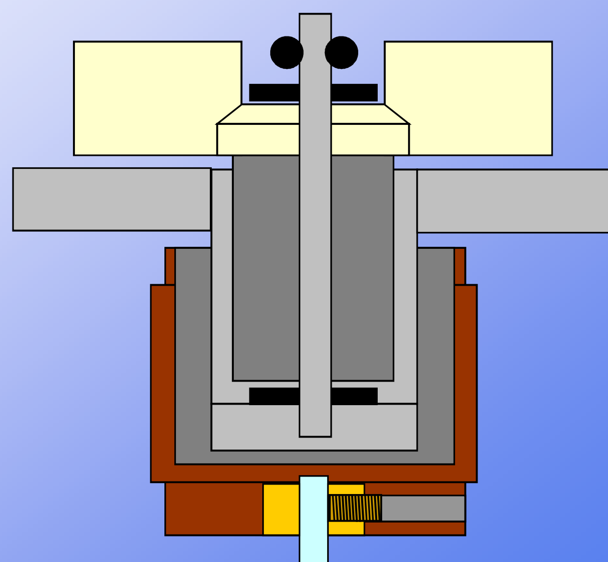
SBE

Pump Maintenance

- The pump drive motor is magnetically coupled to the impeller.
- The shaft has an upper and lower thrust washer, with the impeller mounted in-between. The thrust washers and impellers are retained by a single O-ring installed on the shaft.
- Avoid running the pump when *dry*.

Pump Impeller

- Periodically inspect the impeller thrust washers and the pump impeller housing.
- Replace the thrust washers and impeller retaining O-ring annually or as required.



SBE

What if the Pump isn't Running?

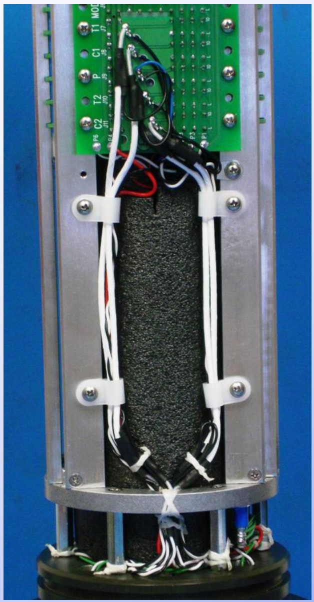
- The pump impeller can become bound by sand, sediment, and salt crystals.
- If the pump is not running, remove the pump head and inspect the impeller and thrust washers to determine if a clogged impeller is the problem.

Emergency Maintenance

- Replacing a damaged bulkhead connector is the most common emergency.
- Re-wiring of CTD connectors is difficult. We recommend that maintenance on the instrument's electronics be left to SBE.
- Connector replacements on modular sensors are easier to perform.

SBE

What to Expect Inside -- SBE 9*plus*



Bottom End Cap Wiring

Top End Cap Wiring

If you Decide to Replace a Connector

- Remember to observe ESD precautions.
- After removing the damaged connector, remove all LocTite® residue.
  - Use wooden or plastic tools if a tap isn't available.
- Prepare the new connector for installation.
  - Trim and terminate ends before installing.

SBE

Connector Installation

- Connectors installed at SBE are installed using LocTite® 242 (Blue).
- This LocTite® is *service removable*, but when set, will keep the connector firmly in place.
- Use LocTite® or a substitute thread-locker when replacing connectors.

SBE

Install Connector O-Ring

- Lightly lubricate the connector O-ring groove.
- Inspect and lubricate the connector O-ring.
- Install the connector O-ring.

Connector with O-Ring

Install Connector

- Apply LocTite® 242 (Blue) to ONLY the bottom two threads of the connector.

SBE

Install Connector

- Check ***<u>one last time</u>*** for any foreign matter that may get caught under the O-ring.
- Feed the wires through and install the connector vertically; this will allow the LocTite® to *wick up* the length of the threads as it is screwed in.
- *Finger* tighten the connector.

SBE

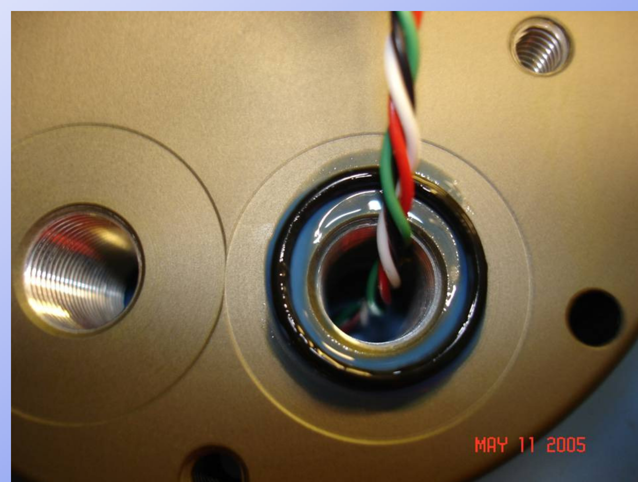
Incorrect use of LocTite®

- Excess LocTite® on the connector shank will cause the LocTite® to overflow the threaded hole of the end cap, allowing it to contact the O-ring.
  - Contact with the O-ring may cause damage to or *bridge* the O-ring and allow the instrument to flood.

WRONG !

Excessive Use of LocTite®

- **No** LocTite® should overflow the threaded hole. If this occurs:
  - Remove the connector,
  - Clean the connector and spot-face,
  - Replace the O-ring and re-install.
- LocTite® that reaches the *spot-face* may bridge the O-ring, causing the instrument to flood.



Example of EXCESS LocTite®

Final Connector Tightening

- Use a socket installed on a Torque Wrench (if available) for final tightening of the connector.

SBE

Torque Specifications

Connector	Torque
2-pin Impulse	18 in-lbs
3-pin Impulse	18 in-lbs
4-pin Impulse	18 in-lbs
6-pin Impulse	15 in-lbs
MCBH (all)	100 in-lbs or 8 ft-lbs

SBE

Module 6: Data Post Processing

Outputting Bottle Data with CTD Data
Recommended Processing Steps
Data Processing for Troubleshooting Data Questions

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Newport, OR Feb. 2012
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David Murphy, M.S. Electrical Engineering and Oceanography

After Data Collection
Converting Data to Engineering Units

Data Conversion

Convert raw data, creating *.cnv* file that can be used by
Sea-Bird's other data processing modules.
Converted data includes:

– Pressure, temperature, and conductivity data

– Auxiliary sensor data (light transmission, pH, etc.)

Check for Modulo Errors (Time series Gaps)

Advanced Data Processing

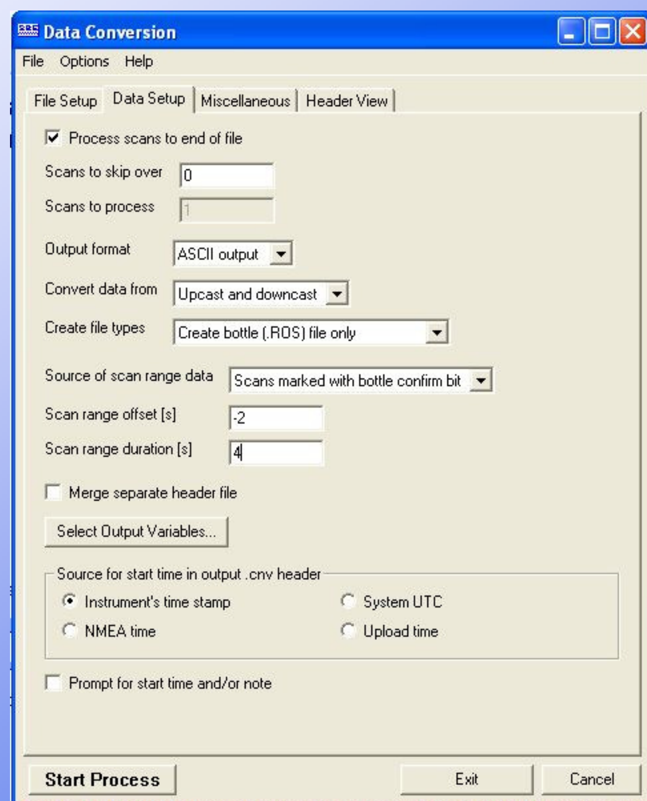
Align, filter, average, etc.

Sea Plot

Plot data using linear or log (for fluorescence and PAR) scales, in black-and-white or multi-color overlaid plots.

Extracting CTD Data with Data Conversion

- You may create a *.cnv* and/or a *.ros* file
- The source of the data is your *.hex* or *.dat* file
- The indicator of what data to extract is a status bit in the data or a file of type *.bl*, *.afm*, or *.bsr*
- Data written to the *.ros* file is specified in the output variable selection dialog



Specifying How Much Data Per Bottle Closure

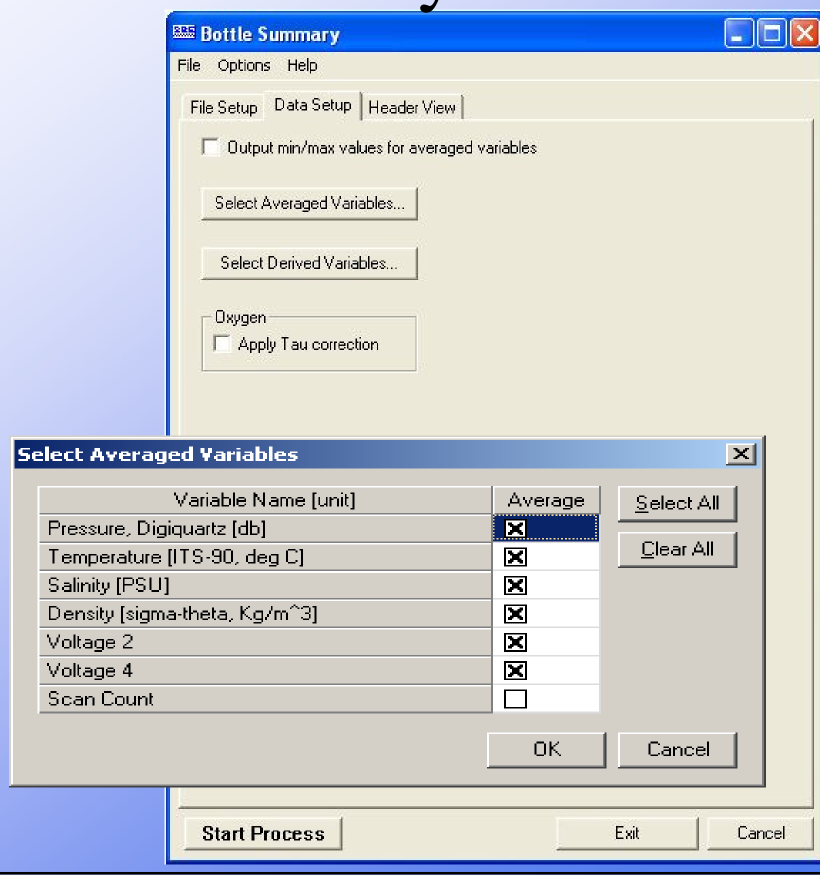
- Data extraction is referenced to the time of closure
- Scan range offset is how many seconds before the bottle closure to begin extracting data
- Scan range duration is how many seconds total to extract data

Summarizing and Tabulating Data

- *Bottle Summary* module creates a table of averages and standard deviations from data in *.ros* file
  - *.ros* file must contain pressure, temperature, and conductivity or salinity
  - Additional parameters may be derived from averaged variables
  - Data is output to a *.btl* file
  - If a *.bl* file is present, bottle numbers are inserted in *.btl* file

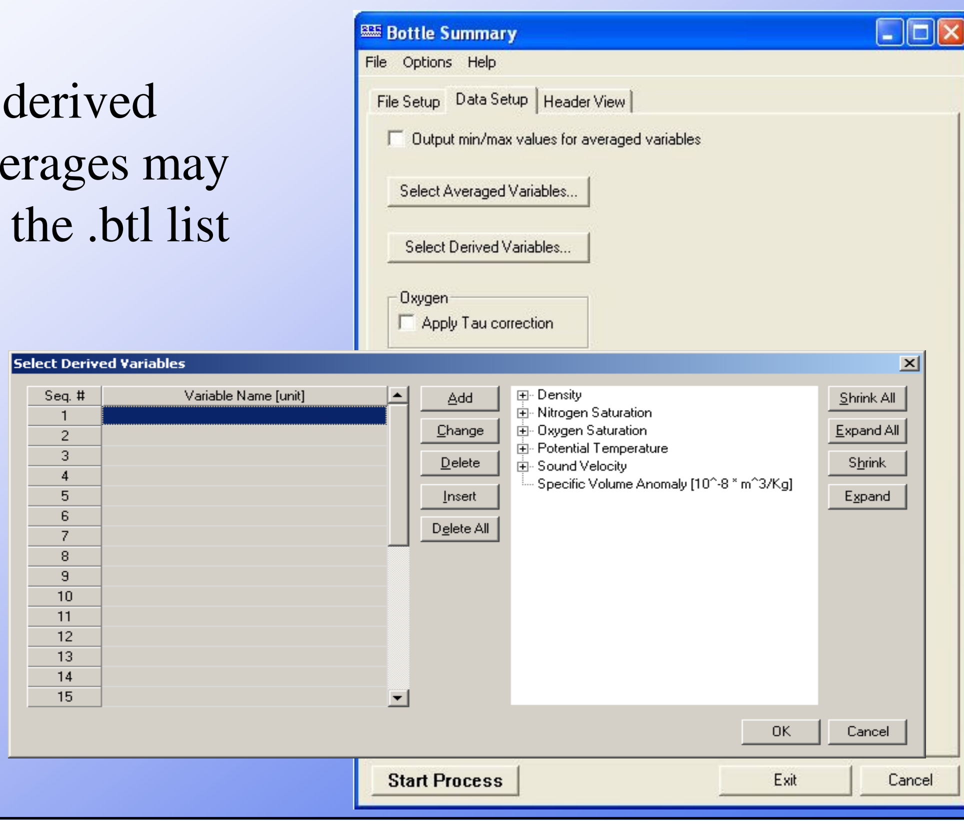
Bottle Summary

- Variables created by *Data Conversion* may be selected for inclusion in the *.btl* file



Bottle Summary, Deriving Parameters

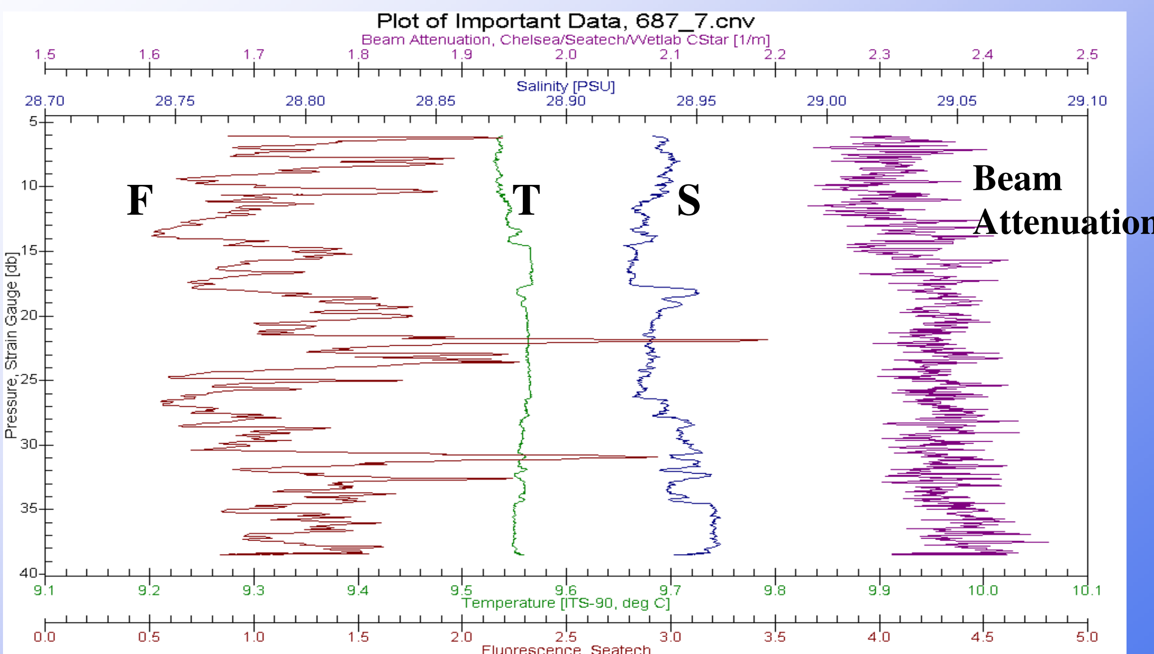
- Parameters derived from the averages may be added to the .btl list



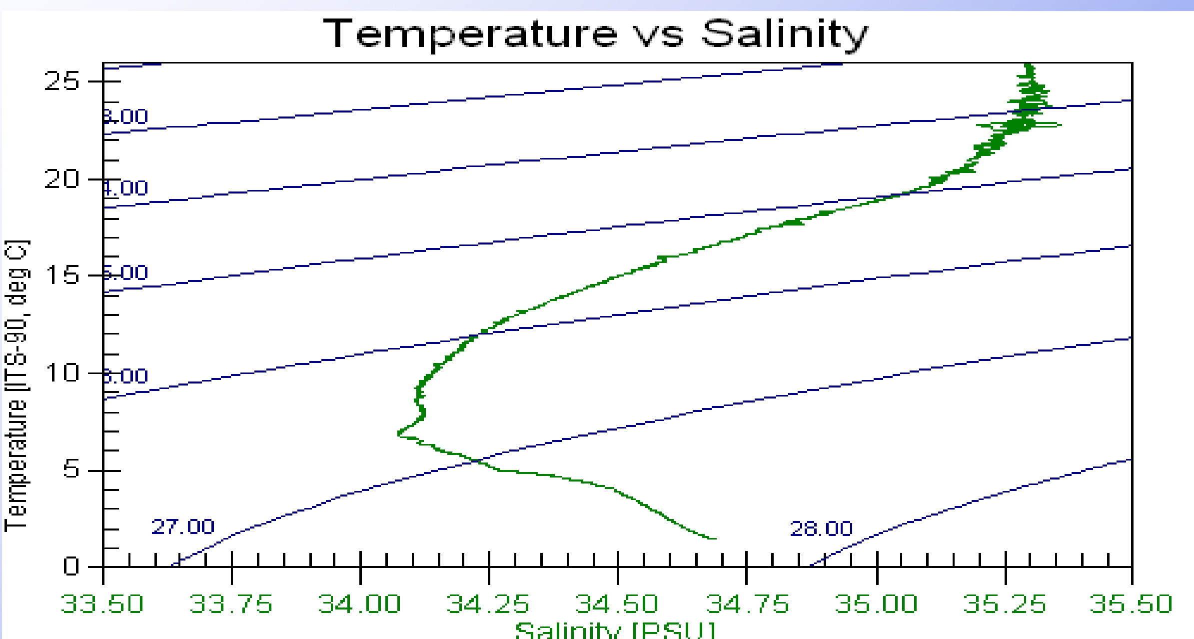
Activity: Create *.ros* and *.btl* Files

- Use SBE Data Processing to convert data from an SBE 9*plus* and create bottle files; see notes for instructions

Example of Converted Data Using Sea Plot



Example of Converted data in a TS Plot



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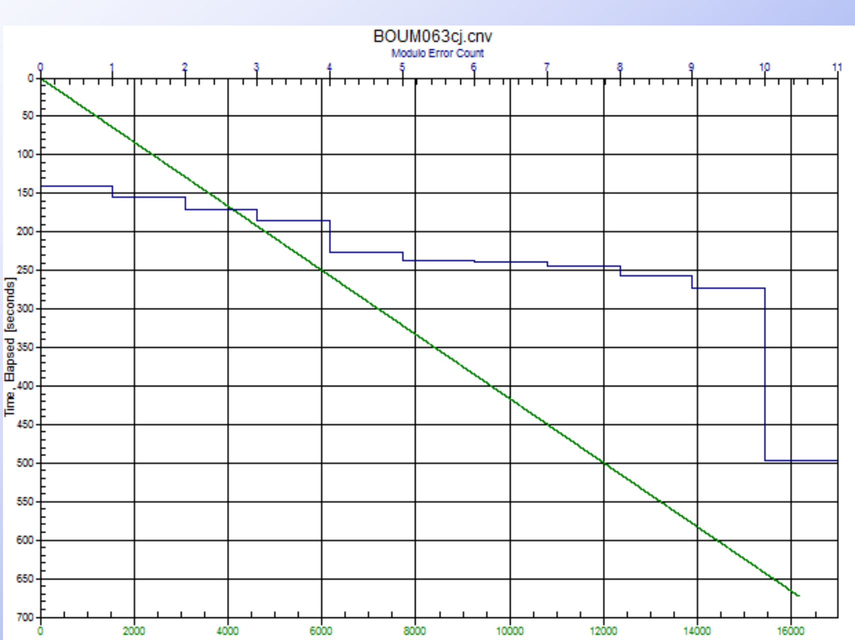
Plot to Identify Modulo Errors



Brief Overview of Data Processing for Use in Troubleshooting

- Sensor alignment, matching measurements of same water parcel
  - TC alignment completed real-time in SBE 11 Deck Unit
  - Post processing alignment for auxiliary sensors (i.e., DO)
- Correcting for underwater package-induced errors
  - LoopEdit
- Data editing and filtering (i.e. if modulo errors occur)
- Correcting for conductivity cell thermal mass
  - Why there is there a mismatch in salinity between up and down casts when T and C look spot on?

Description of Key SBEDataProcessing Modules

- DATCNV converts data from hexi-decimal to scientific units
- WILDEDIT or MEDIAN FILTER to remove outliers
- ALIGNCTD coordinates measurements of T, C and P on same parcel of water
- FILTER (optional) refines response time of mismatched sensors and smooths digital noise in Pressure data
- LOOPEDIT removes ship heave effects by marking scans “badflag” if the scan fails pressure reversal or minimum velocity tests
- CELLTM corrects cell thermal mass error for a given flow rate on the conductivity cell
- DERIVE takes the newly corrected independent variables (T, C, P, Oxvolts) and computes the dependent variables (Salinity, Density, Oxygen Concentration)
- BINAVG statistically averaging scheme for binning data into evenly space or interpolated bins
- SPLIT separates up and down casts

Recommended Default SBE 9 *plus* Data Processing Parameters

- DATCNV (Module 1)
  - Output up and downcasts of all parameters of interest. Only process on independent parameters (T,C,P, OXVOLTS, Modulo Errors etc.)
  - Output converted variables (salinity, DO concentration) if comparing to water samples
- ALIGNCTD (Module 3)
  - SBE 11 usually advances C +0.073 secs
  - Align DO and other sensor data to P and T accordingly in post processing
- FILTER (Module 2) only if continuous time series and no P outliers
  - Pressure only 0.15 secs
- LOOPEDIT (Module 5)
  - Only if ship heave a problem
  - Select minimum fall speed according to data
- CellThermalMass (Module 4)
  - ALWAYS
  - Alpha = 0.03 and Tau = 7 secs
- DERIVE (Module 6)
  - This is where you compute final Salinity, DO concentration, anything that is dependent on raw measured and now processed variables (like T, C, P)
- Bin Average (Module 7)
  - Do this AFTER running DERIVE

Options in DATCNV: Enabling Tau & Hysteresis Corrections for Oxygen

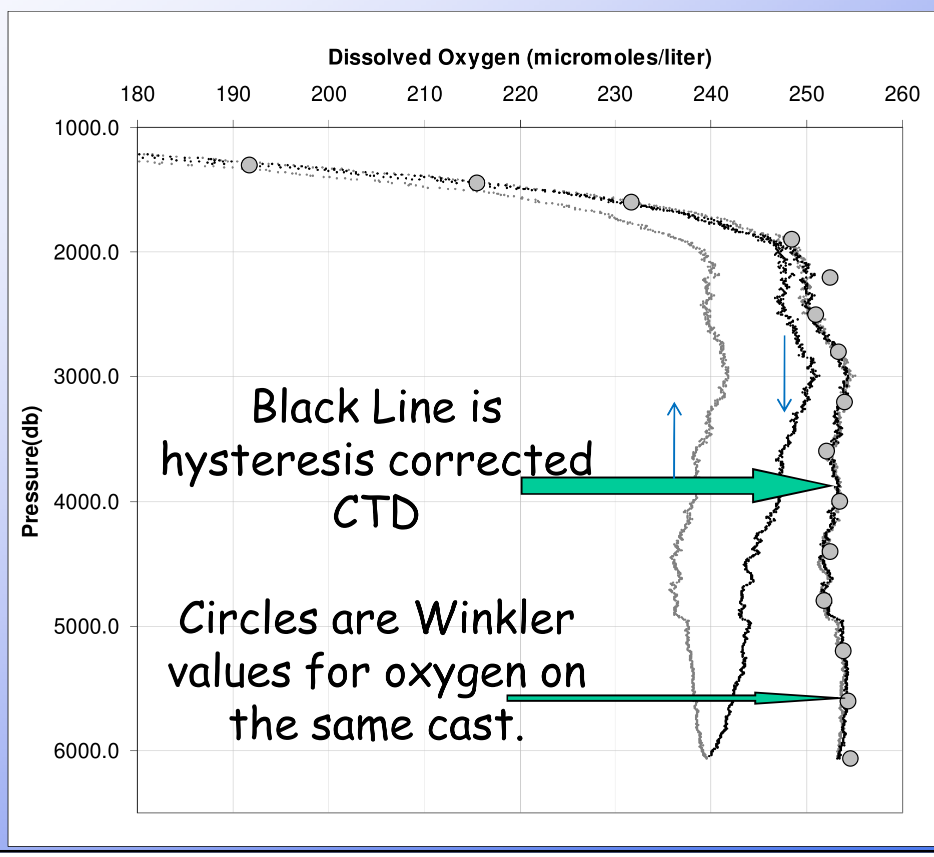
- Weather to enable or disable tau for oxygen
  - This term is introduced to sharpen the response of the sensor to rapid changes in oxygen concentration.
  - **SBE recommends keeping Tau enabled.**
- If working at depths > 1000 dbar, highly recommended to enable hysteresis correction
  - Apply to Oxvolts in DATCNV prior to correcting CTD to bottle samples
  - **SBE Recommends Keeping Hysteresis enabled**

Examples of Deep Ocean Hysteresis

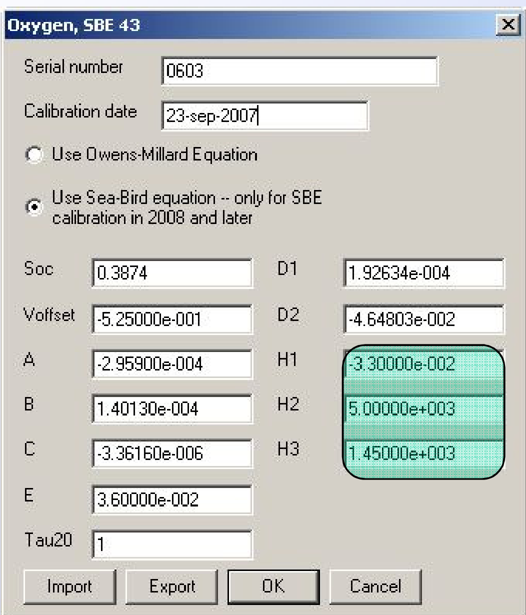
Uncorrected data shown left, with mismatched up and down casts

Corrected data shown right overlays Winkler values (not corrected to Winklers)

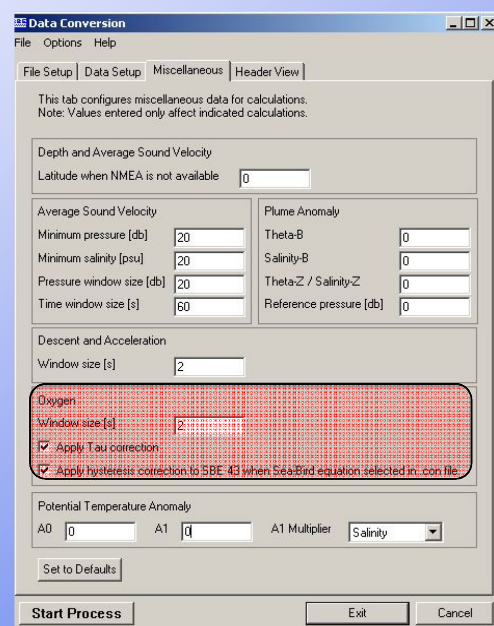
from Equatorial Atlantic



Dissolved O_2
Deep-Ocean Hysteresis



These must be in CON file
for Hysteresis Corrections to work



Check these boxes to enable
Tau and Hysteresis corrections

Activity: *Practice running Data Conversion on Raw Data File*

- Use the file C:*/Data/Module9/AlignC/Faroe.dat*
  - For the configuration file, use Faroe.con
  - Name your output file Faroe.cnv
  - Convert downcast only
  - Convert to quantities that stand alone:
    - Pressure, Digiquartz
    - Temperature,2 [ITS-90] -- (**secondary T**)
    - Conductivity,2 [S/m] -- (**secondary C**)
  - **Do not calculate parameters that are functions of P,T,C!**

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Gaps in Data and Modulo Errors

- The Modulo errors indicate that there is a gap in the time series
  - A minimum gap of 1 point
  - Because of the way the frequency counting works for the SBE 9+, this means that the point before and after will be affected
  - ***Gaps can be larger (multiple points)***
  - Modulo Error count only tells you when it occurred and how many times…not for how many scans.
  - The gaps are **not** filled in with error flags or NANs
- Requires user to identify the gap and size
- **Best to solve Modulo Error Cause Straight Away**

Tools for Looking for Size of Modulo Error Gaps

- Plot Modulo Error against time (select Time Elapsed (secs) in DATACNV
- In SEASAVE, select append a time stamp to every scan…this will help find the temporal period of a gap
- Output descent rate to help determine where and how big the gaps are

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- The header only tells you when there was a scan or set of scans dropped
- Need to examine data to see how big the gap is by looking at pressure and descent rate together
- Can plot pressure against time

- # name 11 = flC: Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
- # name 12 = par: PAR/Irradiance, Biospherical/Licor
- # name 13 = spar: SPAR/Surface Irradiance
- # name 14 = upoly0: Upoly 0, ISUS
- # name 15 = upoly1: Upoly 1, PVM5
- # name 16 = pumps: Pump Status
- # name 17 = modError: Modulo Error Count
- # name 18 = flag: 0.000e+00
- # span 0 = 1, 16160
- # span 1 = 0.000, 673.292
- # span 2 = -22881.363, 205.989
- # span 3 = 17.4167, 98.9762
- # span 4 = 17.4173, 48.9106
- # span 5 = 5.033530, 99.000000
- # span 6 = 5.039172, 71.595624
- # span 7 = 0.4872, 3.9915
- # span 8 = 0.00004, 5.28171
- # span 9 = 0.0257, 13.3417
- # span 10 = 3.5599, 99.3589
- # span 11 = 0.0095, 5.6517
- # span 12 = 1.0000e-12, 1.3885e+01
- # span 13 = 3.9976e+00, 7.9951e+00
- # span 14 = -7.0135105, 49.133926
- # span 15 = 0.0000000, 225.76313
- # span 16 = 1, 1
- # span 17 = 0, 11

Scan Secs Press T0 T1 C0 C1 OxVolt etc….

3534 147.208 123.004 17.4613 17.4613 5.046168 5.046238 3.0171 5.27707 0.6013 86.0424 0.1632 2.6525e-02 5.9963e+00 2.7570016 92.307692
1 1 0.000e+00

3535 147.250 123.057 17.4611 17.4611 5.046168 5.046203 3.0159 5.27708 0.6002 86.0674 0.1648 2.4784e-02 5.9963e+00 2.9550525 92.307692
1 1 0.000e+00

3536 147.292 123.057 17.4612 17.4609 99.000000 5.046203 3.0171 0.00004 0.6013 86.0424 0.1653 2.5363e-02 5.9963e+00 2.9220440 92.307692
1 1 0.000e+00

3537 147.333 123.169 17.4611 17.4611 99.000000 5.046274 3.0171 0.00004 0.6025 86.0173 0.1653 2.5363e-02 5.9963e+00 2.8890356 92.307692
1 1 0.000e+00

3538 147.375 -16829.813 17.4613 25.9087 27.476852 70.449079 1.6654 0.45796 4.1105 35.7855 5.6517 1.0000e-12 5.9963e+00 49.133926
1.7094017 1 1 0.000e+00

3539 147.417 -21176.759 98.9762 48.9106 5.033530 71.595624 1.6459 1.95460 4.1105 35.7855 5.6517 1.0000e-12 5.9963e+00 49.133926 1.7094017
1 1 0.000e+00

3540 147.458 205.989 17.4596 17.8598 5.046193 5.118893 3.0159 5.27829 0.6013 86.0424 0.1658 2.4784e-02 5.9963e+00 2.9220440 92.307692
1 1 0.000e+00

3541 147.500 123.282 17.4609 17.4608 5.046191 5.046314 3.0171 5.27709 0.6013 86.0424 0.1668 2.5363e-02 5.9963e+00 2.9220440 92.307692
1 1 0.000e+00

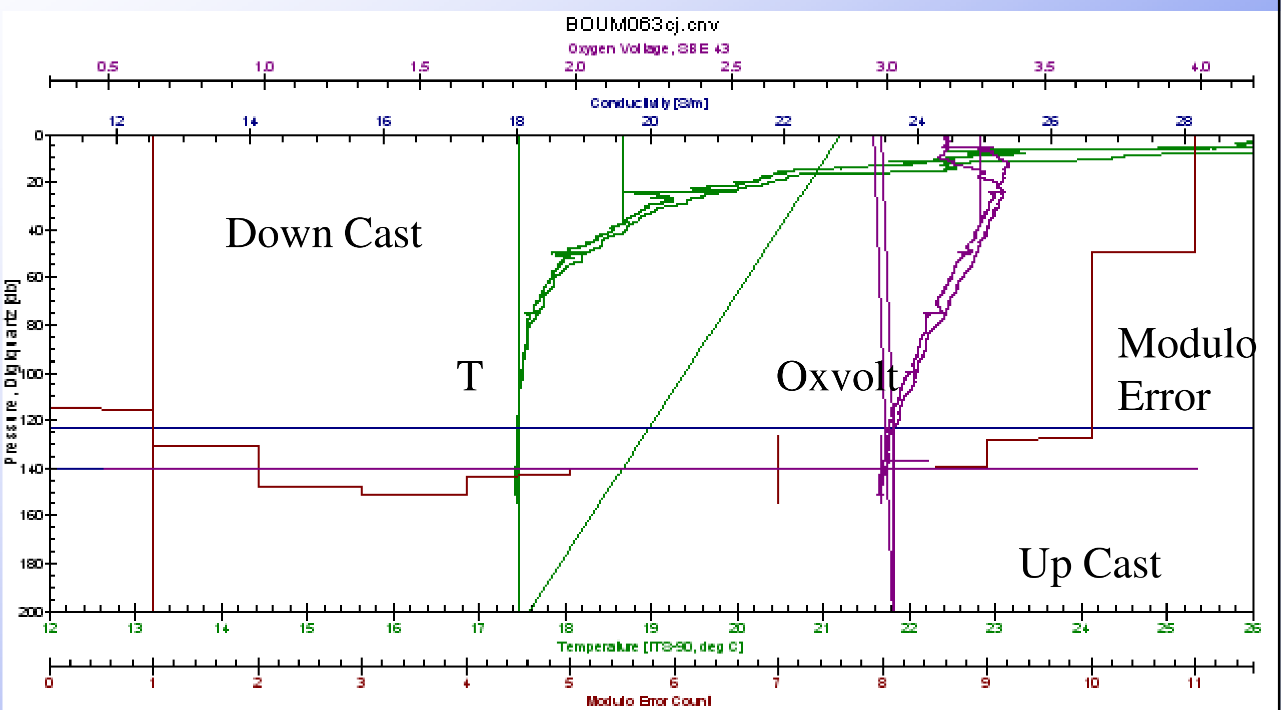
3542 147.542 123.387 17.4608 17.4608 5.046184 5.046239 3.0147 5.27710 0.6013 86.0424 0.1684 2.4784e-02 5.9963e+00 2.8890356 92.307692
1 1 0.000e+00

3543 147.583 123.387 17.4606 17.4606 5.046168 5.046163 3.0159 5.27712 0.6013 86.0424 0.1694 2.5363e-02 5.9963e+00 2.9220440 92.307692
1 1 0.000e+00

3544 147.625 123.447 17.4606 17.4602 5.046107 5.046279 3.0147 5.27714 0.6013 86.0424 0.1710 2.4207e-02 5.9963e+00 2.9220440 92.185592
1 1 0.000e+00

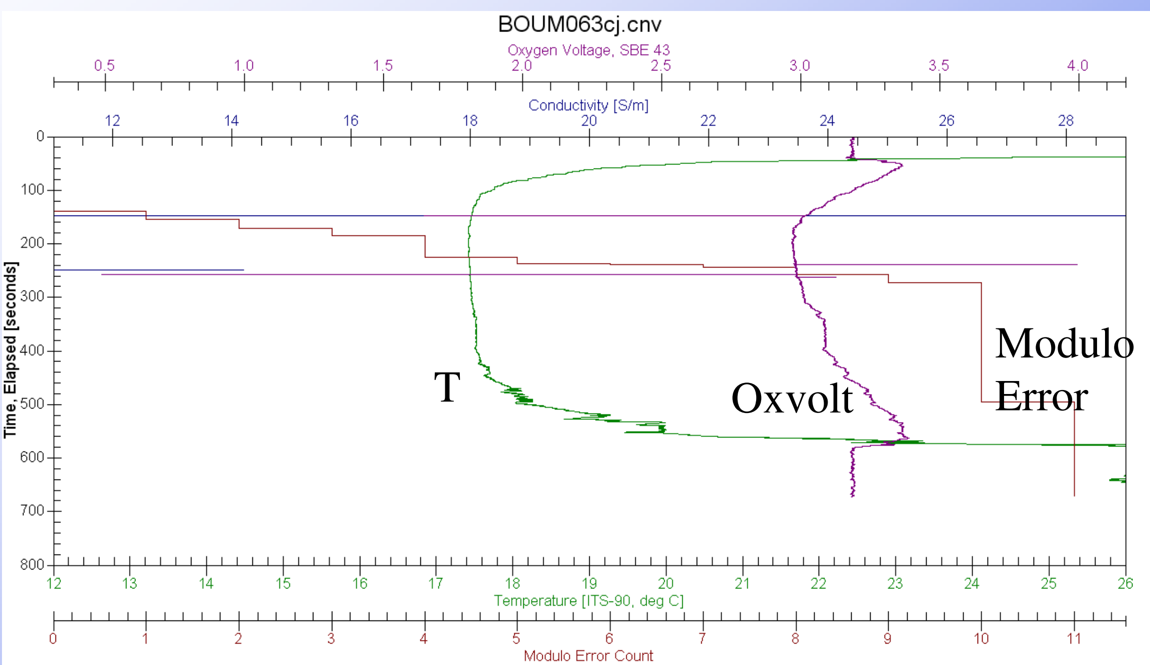
Depth Difference 123.282-123.169 = 0.113
For this Modulo Error assuming fall speed is 1 m/s
This would amount to about 3 scans lost (or 1 dropped scan)

Plot Modulo Error (11)
Can see if on both down and up cast



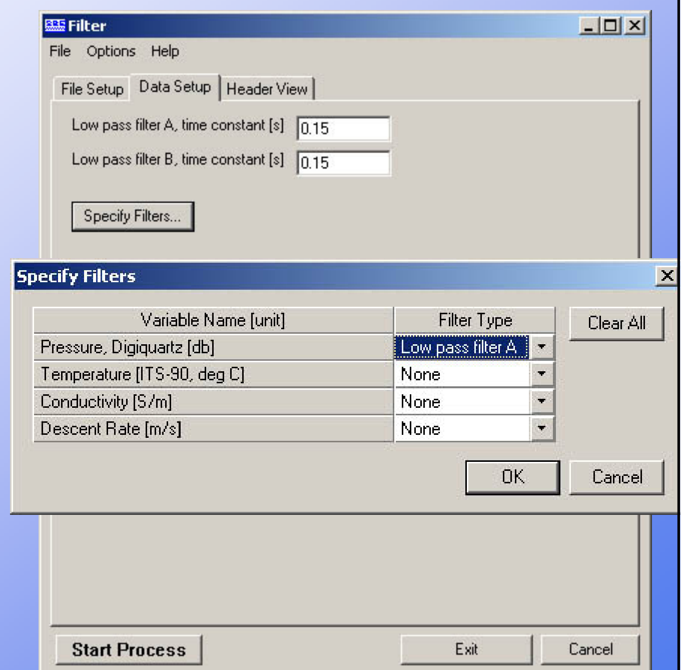
 1/14/2012

Plot against Time



Filtering Converted Data

- Filtering is used to remove digital noise from data (pressure mainly)
  - Need to do on P data prior to running LoopEdit
- Filtering can also be used to help match response times of critical paired sensors (T and C for computing S)
- **SBE 9*plus***
  - Filter **A** time constant 0.15 seconds for pressure to remove digital noise
  - No need to match response of T and C, already well matched by design



Derived Dependent Quantities vs. Raw Independent Quantities

- Salinity and Oxygen are computed quantities
  - Dependent variables
- For successful computation, inputs need to not only be accurately measure, AND accurately coordinated on a point in space, and secondarily coordinated in time response
  - Independent variables (T,C, P, OXVOLTS)
- If done incorrectly, this will have ripple effect in other computed quantities
  - density, buoyancy frequency, etc.

The Challenge: To get good salinity with only 10% of the signal

- The electrical measurement of conductivity
  - 90% of the signal from temperature
  - 10% from salinity based on the conducting ion content of seawater

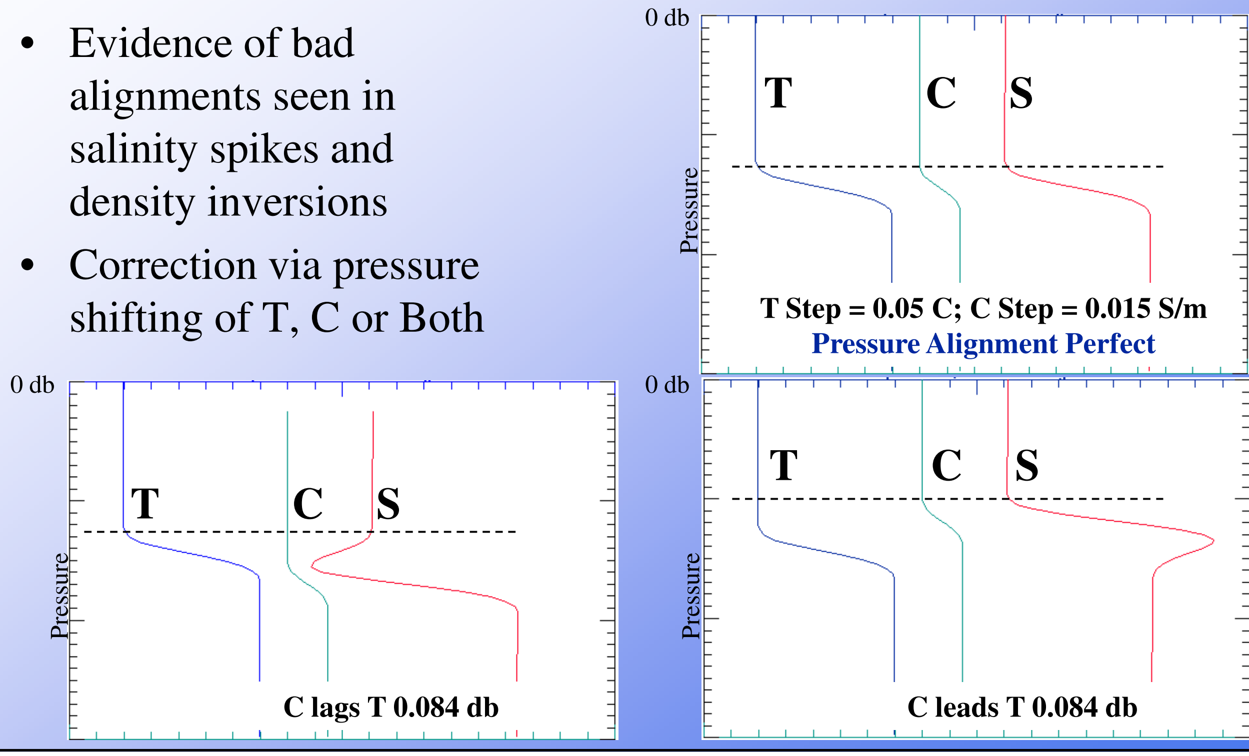
- 1% error in Temperature
  Causes 10% error in Salinity

Data Misalignment in CTD Data That Causes Salinity Spiking

1. Sensors (T and C) not seeing same water parcel
   – All SBE CTDs T and C are ducted and pumped, sensors do sample on the same water
2. Response time of sensors on the CTD package not well matched
   – On SBE 9+ T and C have well matched response times ~ 0.065 secs, by design
3. Travel time of water parcel through plumbing
   – This determined by pump speed and flow volume of the path between sensors which is known for SBE CTDs
      - Can advance for this in SBE 11 deck unit
      - Old SBE 11 units, only primary C values advanced
      - Newer models, both primary and secondary C values advanced

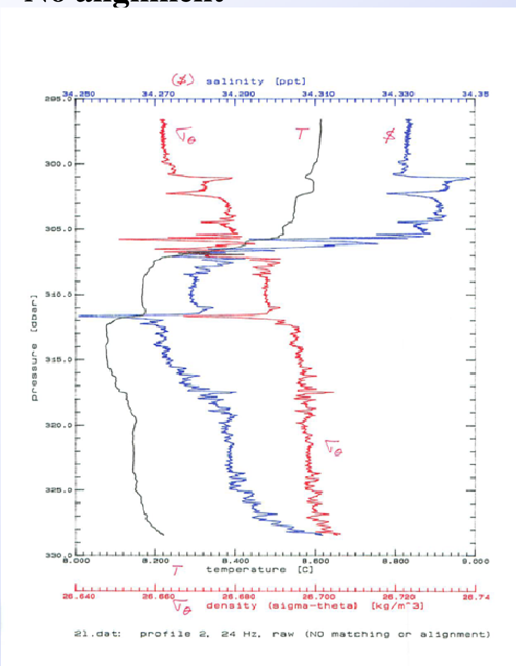
Examples of Lags and Leads in T and C Alignment and Effect on Computed Salinity

- Evidence of bad alignments seen in salinity spikes and density inversions
- Correction via pressure shifting of T, C or Both

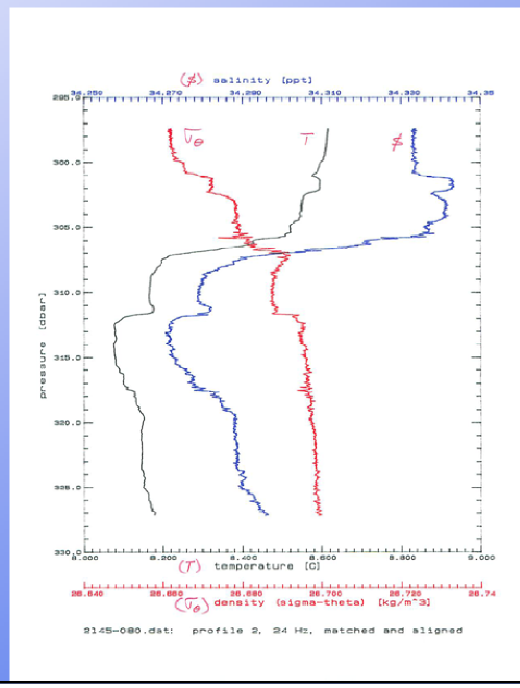


Example of how the TC Duct Helps Alignment of T and C Data

SBE 9+ Ducted Data (Raw Data) No alignment

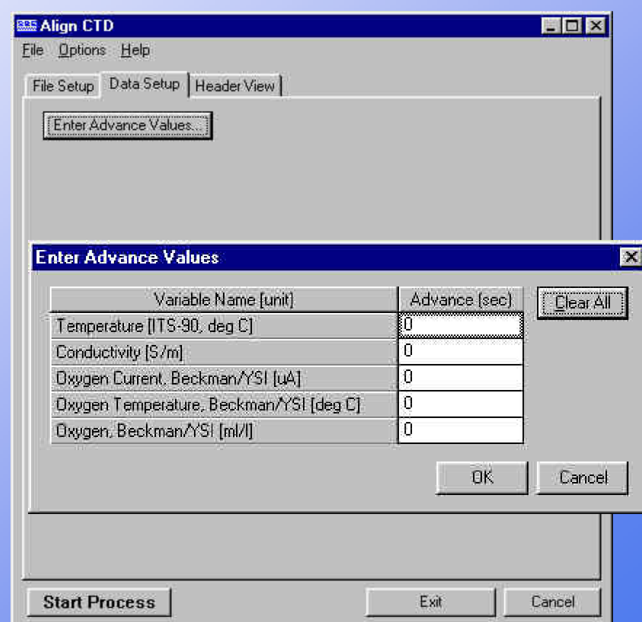


SBE 9+ Ducted Data Aligned Data

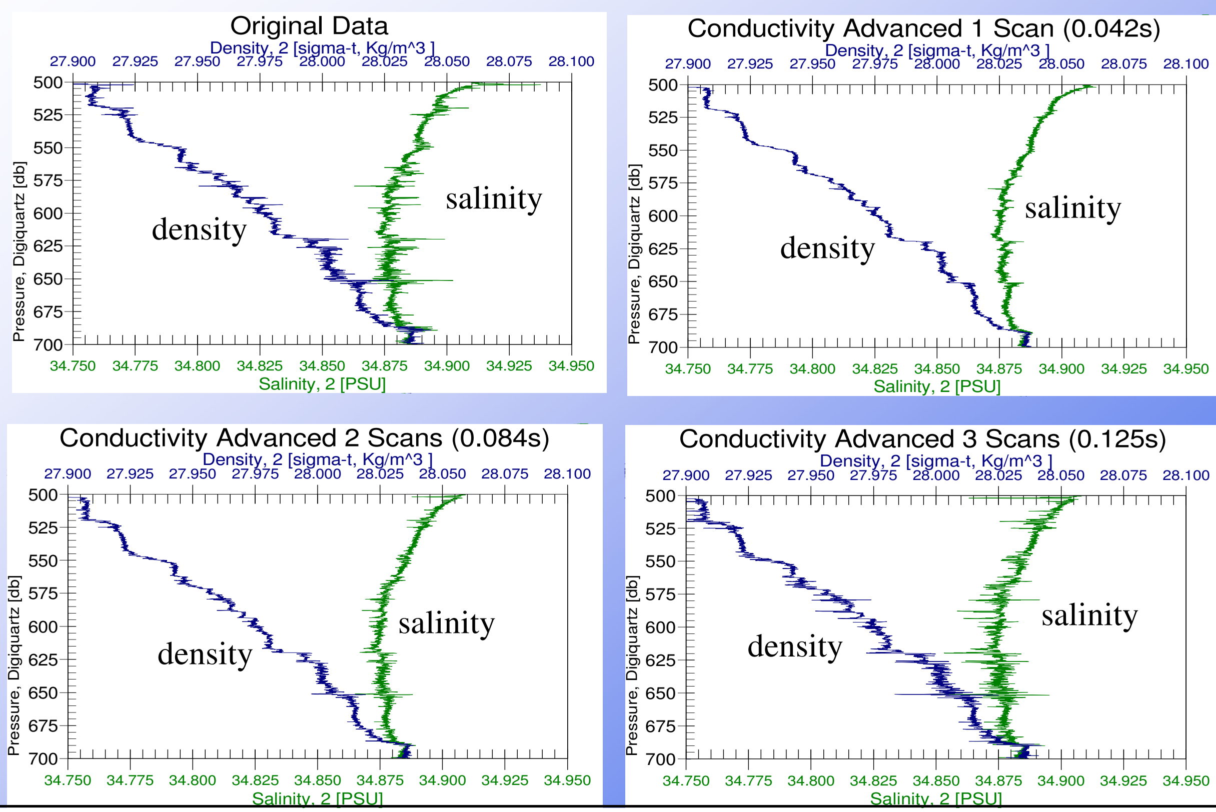


Manipulating Data to Remove Misalignment Post Processing

- **An alignment on T and C is done automatically in the 11*plus***
- 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



Example of Different Alignments of T and C



Dissolved O_2 Alignment

- Sensor time constant ~ 2 - 5 secs
  - temperature dependent
- Plumbing delay from T and C < 2 secs, depending on location of sensor in flow path
- For SBE 9+, Advance OXVOLTS (not concentration)
  typically ~ 3- 4 seconds total

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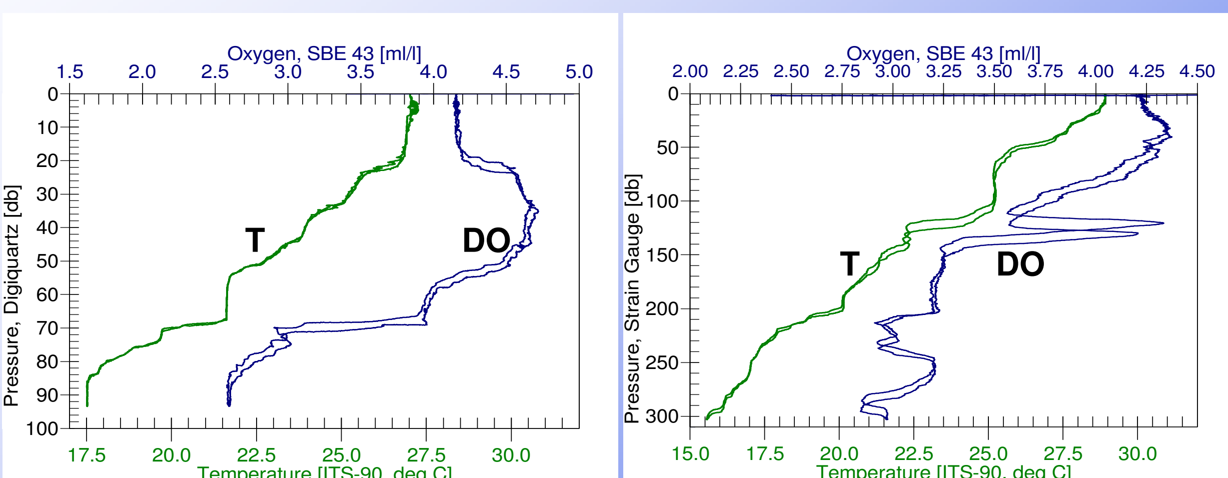
Mismatch down-up Cast Data in Dissolved Oxygen Profiles That Might Not be Alignment Issue



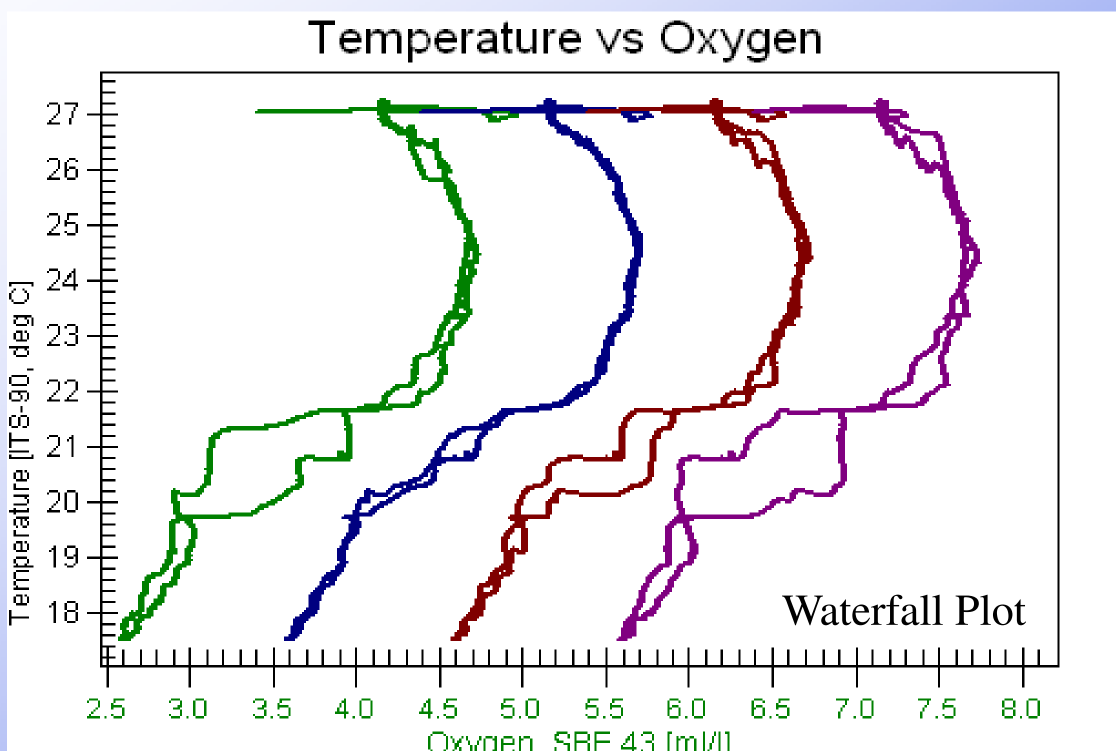
This mismatch is likely due to Transit time **alignment issue** in DO sample with respect to T and P

Notice the mismatch is in T and DO Taken near Gulf Stream. **Probably boat drift**

Activity: Align DO Data

- *Data Conversion*:
  - Use C:\Data\Module9\AlignDO\GulfMex.dat and GulfMex.con
  - Convert upcast and downcast
  - Output P, T, S, and Oxygen Voltage SBE 43
- *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* :
  - De-select *Sort input files* in Options menu, and then select input files in order (GulfMexD.cnv, GulfMexA2D.cnv, GulfMexA4D.cnv, and GulfMexA6D.cnv)
  - Overlay plot of T (17 to 28) vs Oxygen (2.5 to 8.0), with 1.0 offset for oxygen

Dissolved Oxygen Advanced 0, 2, 4, 6 Seconds Relative to Pressure



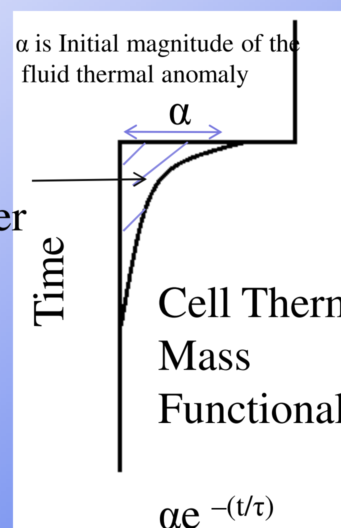
Effect of Conductivity Cell Thermal Mass on Computed Salinity Values

- 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
- All conductivity cells experience this
  - SBE can correct for it, because of controlled flow

Thermal mass errors scale with the velocity of the flow through the cell

- **α parameter scales the amplitude of the error ~3% of ΔT for SBE 9+**
  - **1˚C => 0.03 psu**
  - **α varies as V^{-1}**
  - Will be slightly different for different pump flow speeds
- τ = Relaxation time of response
  - Less flow dependent Tau varies as $V^{-1/2}$

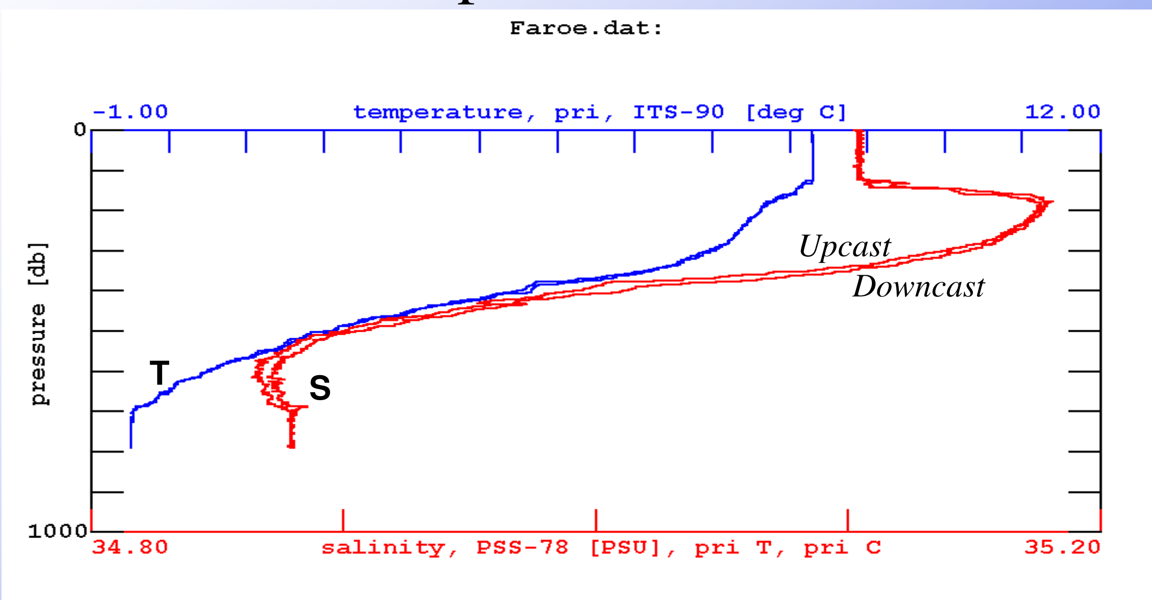
$\int \alpha e^{-(t/\tau)}$ = heat loss (area under curve)



Temperature Step 1˚ C

V is the flow speed

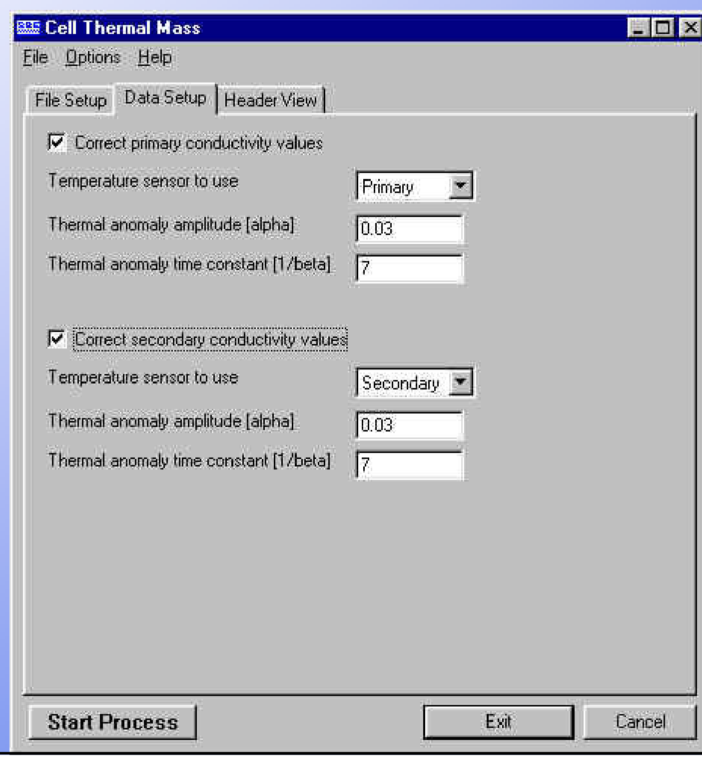
Cell Thermal Mass Example Observed as Mismatch Between Up and Down Casts



Removing the Effect of Conductivity Cell Thermal Mass

Corrects Conductivity BEFORE computing Salinity

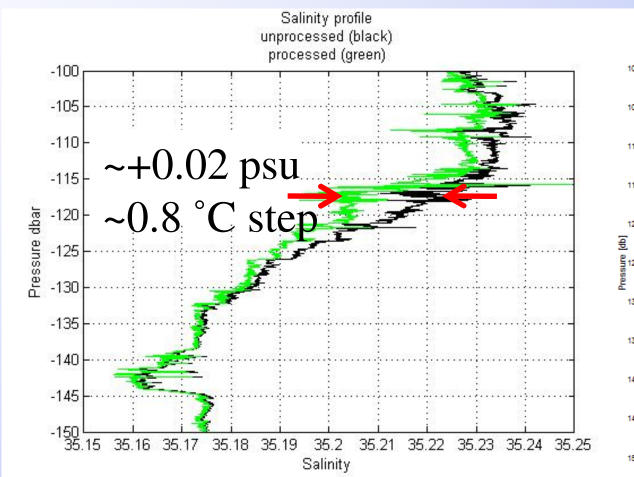
Again, SBE recommends default settings for starters



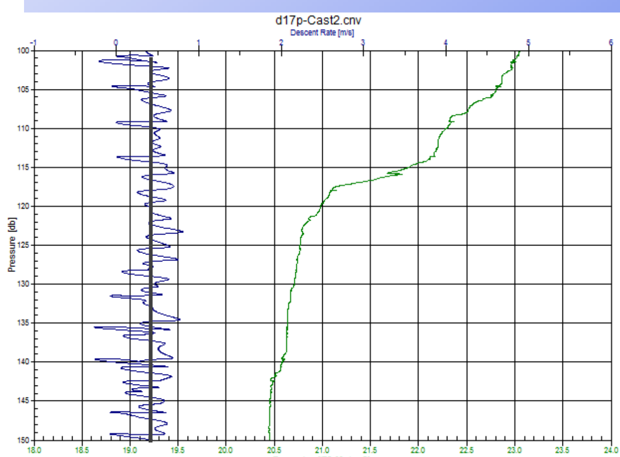
SBE 9+ Salinity with and without CTM

Green Salinity processed with CTM correction

Black Salinity unprocessed



Corresponding Temperature (green) and descent rate (blue)



Note: Downcast only, Data not LoopEdited

Dz/dt ~ 0.40 m/s

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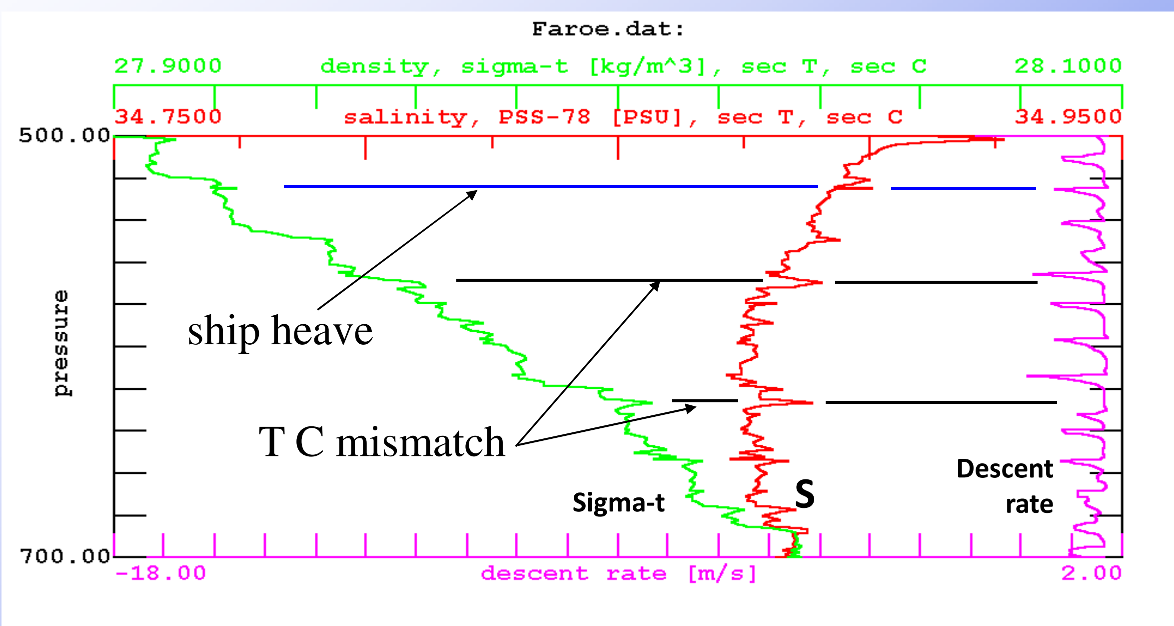
Editing non-Oceanic, Deployment Related Signals

- Ship Heave
  - Flag scan lines of data where yo yo-ing of the CTD occurred during deployment using
  - SBEDataProcessing module LoopEdit
- Edit outliers using WildEdit or MedianFilter

Distinguishing between Ship Heave or TC Alignment



Plotting dz/dt (descent rate computed in DATCNV or DERIVE helps)

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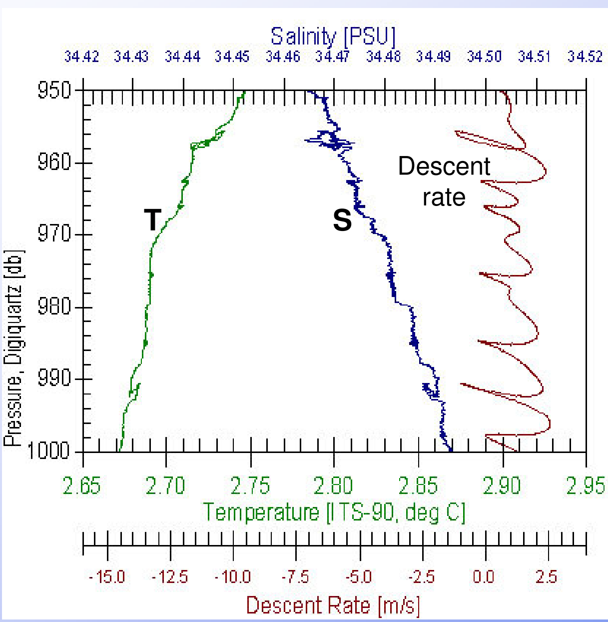
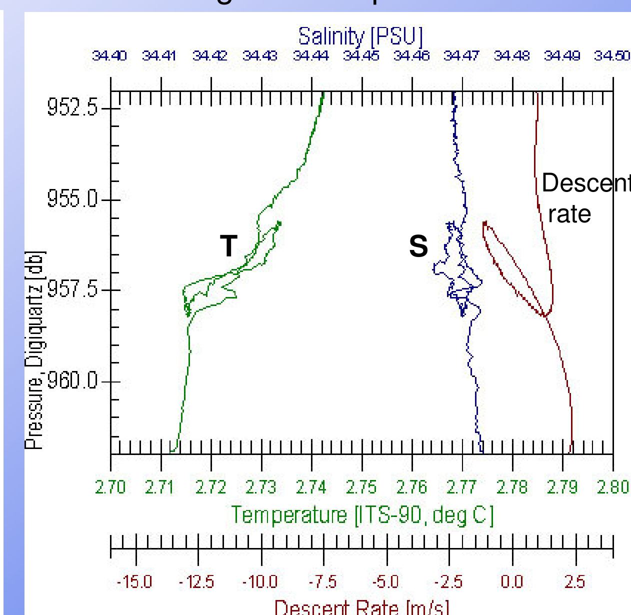
Ship Heave Effects

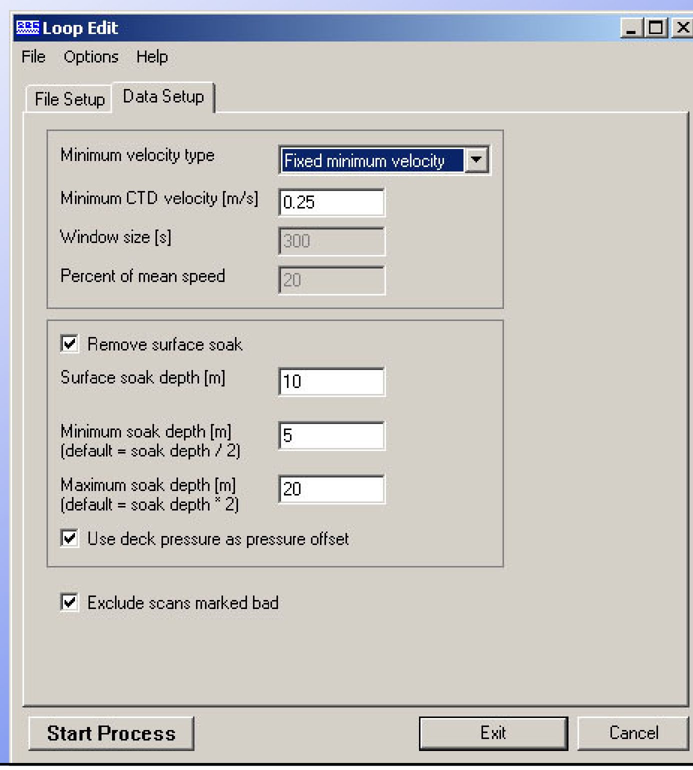


Enlargement of plot at left



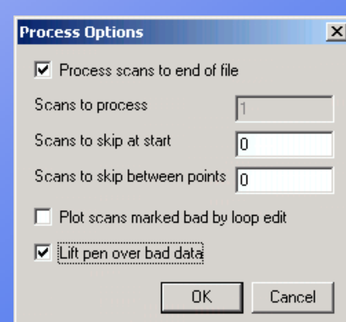
Removing Package-Induced Data Artifacts

- Data errors introduced this way must be omitted; there is no *fix*
- *Loop Edit* FLAGS Scan Lines with pressure loops caused by ship heave

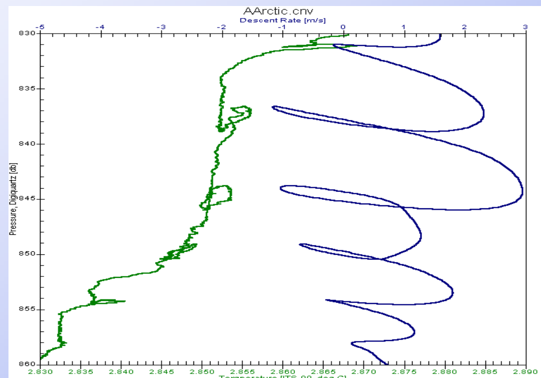


Activity: Remove Loops

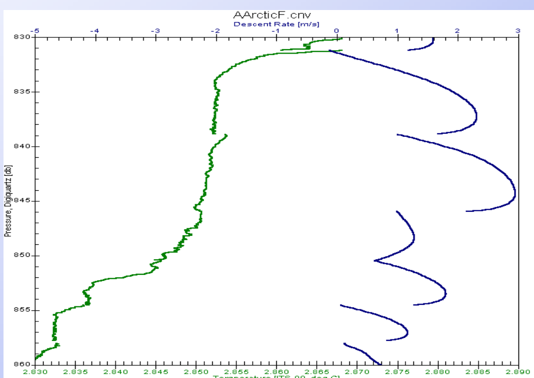
- *Data Conversion*:
  - Use C:\Data\Module9\Loop\AArctic.dat and .con
  - Downcast only
  - Time, pressure, temperature, and descent rate
- *Filter*: Filter Pressure with time constant 0.15 seconds
  - Use same file name for output file, AArctic.cnv
- *Loop Edit*: **Un**check *Remove surface soak* and *Exclude scans marked bad*. Run two times --
  - Name append *P*, percent mean speed, 300 sec window, 20% mean speed
  - Name append *F*, fixed minimum velocity, 0.25 m/sec
- *Sea Plot*: Click *Plot Setup* tab, click *Process options* button, and check *Lift pen over bad data*. Plot each file separately.
  - Y axis Pressure (830 to 860 db)
  - X axis 1 Temperature (2.83 to 2.89 °C)
  - X axis 2 Descent rate (-5 to 3 m/sec)



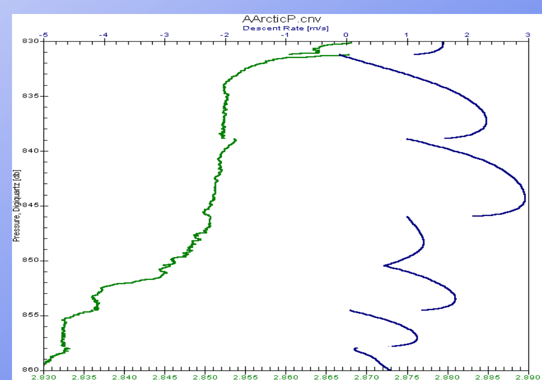
Removing Package-Induced Data Artifacts, Loop Edit



Original



Edit by fixed speed (.25m/s)



Edit by % mean speed (20%)

DERIVE
Dependent Variables

- Dependent Variables
  - Salinity, density, dissolved oxygen concentrations, oxygen saturation, etc.
- Once DERIVE is run on data, should not reprocess on derived variables
  - Do NOT align on oxygen concentration, salinity etc.
- In DERIVE, you will have the same options as in DATCNV for oxygen, except hysteresis correction.
  - Deep Ocean Hysteresis needs to be done on the OXVOLTS (raw oxygen output)

Bin Averaging

- Reduces size of a data set by statistically estimating data values at even intervals (e.g., every meter or 10 meters)
- Can work in depth (meters), pressure (decibars), time, or by scan
- Can bin average upcast, downcast, or both
  - If bin averaging upcast and downcast, keeps upcast bins and downcast bins separate
- The surface bin is treated separately

Bin Average: Output Data

```
# binavg_bintype = meters
# binavg_binsize = 1
# binavg_excl_bad_scans = yes
# binavg_skipover = 0
# binavg_surface_bin = no, min = 0.000, max = 5.000, value = 2.500
# file_type = ascii
*END*
     1.000    24.9124    35.2455      100  0.0000e+00
     2.000    24.9582    35.2463       90  0.0000e+00
     3.000    25.0029    35.2477       36  0.0000e+00
```

Data Processing Tips

- Best data is collected at highest rate instrument is capable of
- Data should not be *reprocessed*
  - *Do not run align on data that is already aligned!*
  - *Do not align or filter derived variables (salinity)*
- Calculation of derived parameters and bin averaging should be done last

Assess Quality of data by comparing to other standards

- Quality assessment using redundant measurements or unreasonable data signals
  - Primary and secondary sensors
  - Water samples - (Salinity and DO)
  - Other sensors (moored and CTD)
  - Match to historic TS relationships
  - TS reproducibility
  - Look for density inversions or unusual steps in data

Sensor Tracking and *In-Situ* Validation Techniques

- Obtain specific types of CTD data for diagnostic checks of data quality (covered later)
  - Turn CTD on deck with pumps off to take on-deck pressure readings before using CTD
    - Barometer checks prior to cruises
    - Tracking pressure sensor drift
  - Collect high quality water samples for in-field sensor drift tracking
  - Collect clean (continuous) down-profiles (no stops) to perform salinity spiking corrections
  - Periodically collect clean down-up casts (no stops) to evaluate cell thermal mass correction parameters

Module 7:
Care and Maintenance

Pre-cruise inspections/checks of the equipment
Spare parts and tools
Care and maintenance during cruise and between casts
Post-cruise equipment maintenance

Sea-Bird Electronics, Inc.
Newport, OR Feb. 2012
Carol D. Janzen, Ph.D. Physical Oceanography
David Murphy, M.S. Electrical Engineering and Oceanography

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Pre-Cruise Equipment Checks

- Helps to prevent *last minute* problems that can delay or impact a cruise
- Especially important if you are not the *sole* user of the equipment
- Should be done as soon before the cruise as is reasonably possible

What should be checked? (Recommendations)

- All connectors and cabling
- All hardware/fasteners, mount clamps, and blocks
- Ferrites – Inductive Modem parts
- Instrument plumbing
- Pressure ports / plumbing
- Battery compartment(s) and batteries

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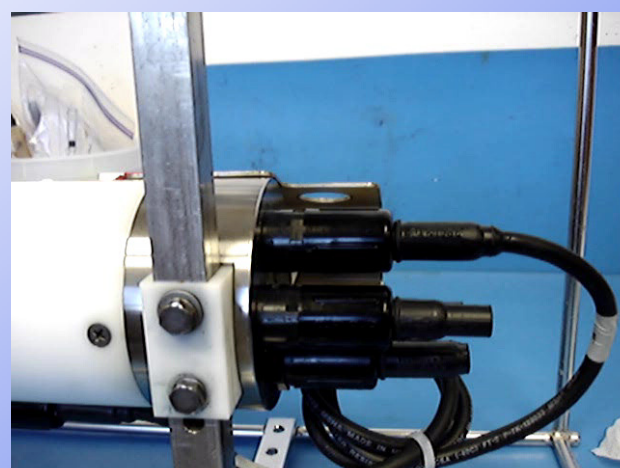
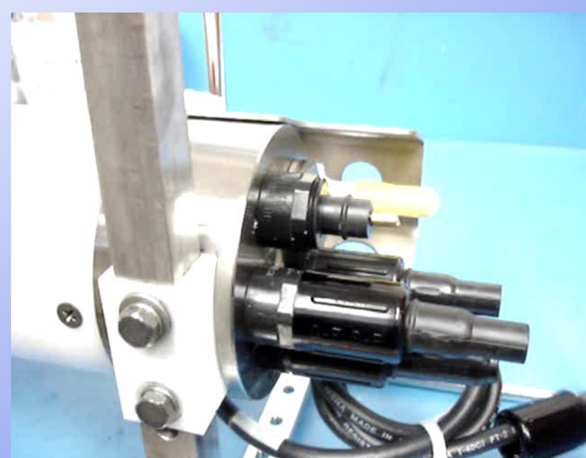
Check Connectors

- Disconnect each cable or dummy plug one at a time.
  - Inspect each exposed connector for corroded or damaged pins.
  - Make sure the connector isn't loose.



Check Cabling

- Inspect each cable boot or dummy plug for corrosion.
- Check the cable for cracks and abrasions in its outer jacket.



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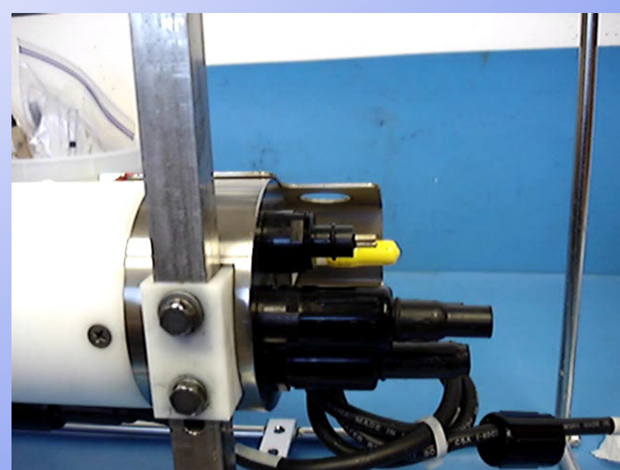
Re-Install Cables and Dummy Plugs

- Clean and re-lubricate connector boots, dummy plugs, and connectors.
  - Clean with Kimwipes or other lint free cloth or wipe.
  - SBE recommends Dow Corning® DC4 for lubrication.
- Never use petroleum-based products.

Proper Installation Technique

- Clean and very lightly lubricate the connector body and cable boot with DC4.
- Align the pins and press the connector boot onto the connector.
- *Burp* the connector to remove any trapped air.



Check the External Hardware

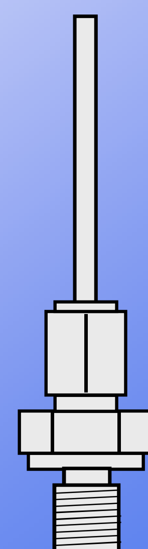
- Check that all external hardware, mounting bolts, mount straps, and cage clamps are tight.
  - Check for cracked mounting blocks.
- Check for corrosion damage to the hardware.
- Check the condition of the installed anodes.
  - Replace as necessary.
- Verify there are no dissimilar metals in contact with each other.
  - Look for mounting straps touching the cage or housing.

Inspect the Instrument's Plumbing

- Plumbing should be clean and free of salt and biological deposits.
  - Clean/replace as necessary.
- Ensure the hole in the air bleed valve is open.
  - Use a piece of 26 awg wire.
- Make sure all plumbing connections are properly tie-wrapped.
  - DO NOT tie-wrap to the conductivity cell.
- Examine the conductivity cell for damage.

Instruments with Pressure

- Verify that the pressure port is adequately filled with oil and that the pressure port is not blocked by salt build-up.
  - Re-fill as required.



Verify the Functionality

- Establish communications with the instrument.
- If possible, use the same computer that will be used on the cruise.
- Verify you have the most recent calibration coefficients
  - Check for both electronic and hard copies.

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Record Some Data

- Log and check some data.
- A clean garbage can full of water is a good way to do this, but it can also be done in air.
- Verify the recorded values seem reasonable.

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Prepare the Instrument for Shipping

- Make sure the instrument is dry.
  - See App Note 2D for conductivity cell care.
  - See App Note 64 for dissolved oxygen sensor care.
- If the instrument is equipped with a magnetic switch, place a piece of electrical tape across it in the OFF position.
- Verify all dummy plugs have been re-installed.
- Package the instrument for shipping.

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Tools & Spare Parts

Some factors in deciding what spares you need or want to take on a cruise:

- Your level of expertise / What level of service are you comfortable with?
- The duration of the cruise/transit time.
- The size / type of the vessel.
  - Is it a dedicated research vessel with well-equipped lab facilities?
  - Is it a vessel of opportunity with few if any facilities?
- Remoteness of the research area.
  - Will you have reliable and timely communications?
  - Is it possible to receive shipments of parts and material?

Tools

- Box and open-ended wrench set
- Allan wrench set
- Assorted screwdrivers
- Nut-drivers
- Cutters
- Pliers
- Crescent wrench (medium)
- Soldering iron (A small butane iron is good)
- Hand-held multimeter

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Spare Parts

- O-rings
- Tygon® tubing
- Set(s) of cables
- Full set(s) of spare dummy plugs
- Mount straps / blocks
- Water sampler latch assembly
- Deck Unit fuses
- Pump parts (thrust washers & O-ring)
- Air bleed valve
- Connectors
- Back-up sensors or CTD (if possible)

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Materials

- Spare batteries
- 1 L pre-mixed Triton X-100 solution, 0.1%
- 500 mL pre-mixed Triton X-100 solution, 1% - 2%
- 1 L pre-mixed Bleach solution, 500 – 1,000 ppm
- Several liters of DI Water
- T/C backfilling syringe(s)
- Oil backfilling kit
- Kimwipes or other lint-free wipes
- Parker Super O Lube
- DC4
- Blue Moly
- LocTite® (or equivalent)
- Solder
- Electrical tape
- Air bleed valve cleaning wire
- Assorted tie-wraps
- Hard copies of Calibration Sheets
- Copy of the instrument's manual
- Short *test* cable (real-time instruments)
- Small plastic pail

Instrument Care and Maintenance During the Cruise

- Keep the instrument as protected as possible during transit.
- If it must be stored on deck, out of the crate, during transit:
  - Avoid ship exhausts (main propulsion, galley vents, and compartment vents).
  - Avoid salt spray if possible.
  - Avoid prolonged UV exposure.
  - A cover for the CTD can be a good investment.

First Cast of the Day

- Wet the conductivity cell in accordance with Application Note 2D, approximately 1 hour before the cast.
- Before taking the first cast:
  - Verify all cables and dummy plugs are installed.
  - Verify all plumbing is properly connected.
  - Remember to remove the soaker tube from the conductivity cell, covers from PAR sensors, pH bottles, etc.
    - Making a checklist that includes all sensors in your configuration can help prevent things from being overlooked.

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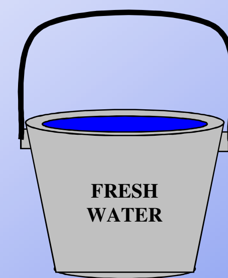
After / Between Casts



- Rinse the equipment thoroughly with fresh water.
  - On some vessels the amount of fresh water available for wash-down may be restricted; if so, use as much as the Ship’s Master will allow.
  - Even a bucket full of fresh water is better than no wash-down at all.
- Rinse and store the conductivity cell in accordance with Application Note 2D.
- Rinse and store the dissolved oxygen sensor in accordance with Application Note 64.

SBE 32 Carousel Water Sampler Care

- Proper care and maintenance of the latch assemblies will help ensure reliable operation.
  - Never use any lubricants on the latches.
  - The latches are water lubricated.
  - Wash the latches thoroughly between casts.
  - Depending on the time between casts, store the latches in a bucket of fresh water.
  - Removing the latches also permits proper washing of the actuator magnets.

Flooded Instruments

- While instrument flooding is rare, it does happen from time to time.
- A flooded instrument can be under extreme pressure.
- If you suspect an instrument has flooded, use extreme caution.
  - Point the instrument's end cap(s) in a safe direction.
  - **If applicable**, loosen the end cap hardware (1/2 turn for each screw/bolt). If the end cap *followed* the hardware out, the instrument may be under pressure.

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Releasing the Pressure

- If the instrument is pressurized, the pressure can be released by *backing off* one of the installed I/O connectors several turns.
- This will break the connector's O-ring seal and allow the instrument to vent.
  - Look for signs of internal pressure
    - *Hissing*
    - Leaking water

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What to Do with the Instrument if Flooded

- Pour out any water inside the housing.
- Return the instrument to SBE for evaluation.
- Advise Sea-Bird of possible flood, we don’t want to get hurt!

Post-Cruise Maintenance

- Profiling instruments
  - Soak the instruments in a clean garbage can full of fresh water. This will help remove / dilute all salt water that may be trapped in gaps and crevices.
    - Install loops of Tygon® tubing on the conductivity cell and dissolved oxygen sensor to protect them.
    - Remove locking sleeves from the cables to allow flushing.
  - Soaking in fresh water especially applies to Carousel Water Samplers.
    - Actuator magnets need thorough cleaning.
    - Latches can be washed in a dishwasher.

After Cleaning

- Allow the instrument to dry.
- Open the battery compartment and remove any exhausted batteries.
  - If the instrument is going to be stored for an extended period, do not replace the batteries.
- Follow all storage guidelines for any installed sensors and for the conductivity cell.
- Store the instrument in a clean, dry environment.