

# Data Quality Control

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# Introduction

## Background

The National Oceanography Centre has maintained a coastal observatory in Liverpool Bay since August 2002. The Irish Sea Observatory integrates (near) real-time measurements with coupled models into a pre-operational coastal prediction system whose results are displayed at <http://coastobs.pol.ac.uk>. The observing system collects in situ time series data of the water column on a 4-6 weekly basis, as well as daily instrumented ferry-box data, a shore-based HF radar system measuring surface currents and waves, coastal tide gauges, and visible and infra-red satellite data.

The key objectives of the Irish Sea Observatory are to better understand the role of the coastal ocean on the shelf sea system, to monitor and understand the impacts of natural and anthropogenic forcing of a shelf sea, and to provide the framework for research into the functioning of a shelf sea in a changing climate.

## Liverpool Bay Measurements

Liverpool Bay (*figure 1*) is a semi-enclosed shallow subsection of the eastern Irish Sea. Liverpool Bay is a coastal sea system with strong tidal mixing, occasional large storm surges and waves, freshwater input from the rivers Mersey, Dee, Ribble, Clwyd and Conwy, and stable and unstable stratification. The three dominant physical processes are the semi-diurnal tides, near-shore density gradients, and vertical stratification.

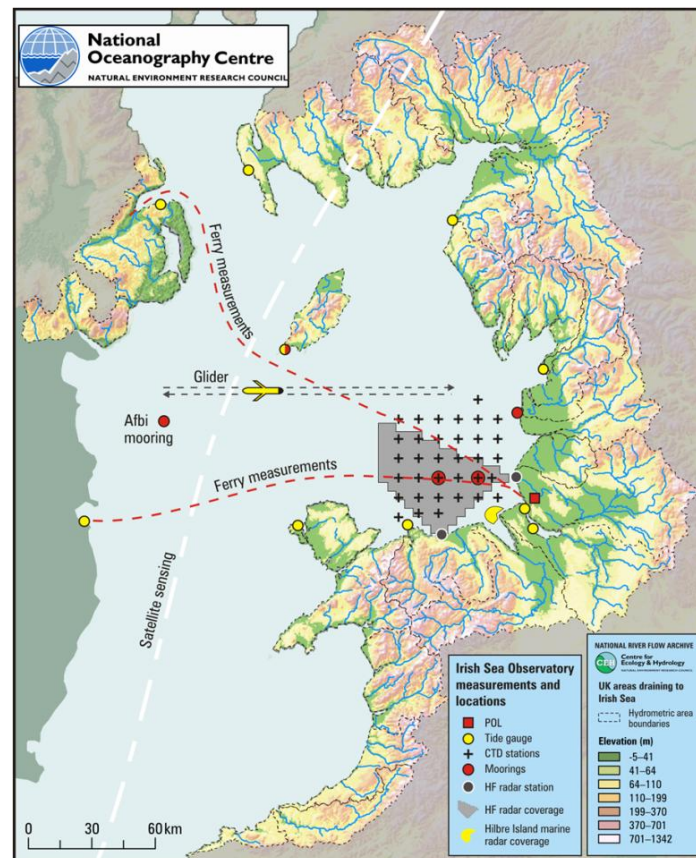


Figure 1: Irish Sea Monitoring System (left) Dots= tide gauges; dots with cross= moorings; dotted lined= possible ferry routes; shaded area= HF radar coverage; crosses= CTD, SPM, nutrients survey points; square= met station.

Two near-shore *in situ* moorings are continually maintained in Liverpool Bay. Site A, close to the mouth of the river Mersey at 53° 32' N, 3° 21.8' W was established in August 2002, with a mean water depth of 23.5m. A second site, Site B, was established at 53° 27' N, 3° 38.6' W in April 2005, where the mean water depth is 25.0m. In January 2010, Site B was moved to 53° 32.3' N, 3° 38.4' W. With a mean water depth of 36.8m, in a shipping separation zone.

Platform	Instrument	Specification	Observed Parameters
Bottom Frame	Sea-Bird SBE 16-plus	<a href="http://www.commtec.com/prods/mfgs/SBE/manuals_pdf/SBE16plusV2_rs232_002.pdf">http://www.commtec.com/prods/mfgs/SBE/manuals_pdf/SBE16plusV2_rs232_002.pdf</a>	Temperature, conductivity, pressure, turbidity
	ADCP	<a href="http://www.rdinstruments.com/monitor.aspx">http://www.rdinstruments.com/monitor.aspx</a>	Heading, pitch, roll, temperature, pressure
Moored	MicroCAT Seabird (5m and 10m depth)	<a href="http://www.seabird.com/products/moored.htm">http://www.seabird.com/products/moored.htm</a>	Temperature, conductivity, pressure
	Star Oddi- Starmon Mini (7.5m and 15m depth)	<a href="http://www.planet-ocean.co.uk/PDF/Starmon-mini.pdf">http://www.planet-ocean.co.uk/PDF/Starmon-mini.pdf</a>	Temperature
	VEMCO Minilogger (7.5m and 15m depth) until December 2008	<a href="http://www.vemco.com/products/dataloggers/index.php">http://www.vemco.com/products/dataloggers/index.php</a>	Temperature
Site A only	Aanderaa Oxygen Optode (bottom frame)	<a href="http://www.aadi.no/Aanderaa/Document%20Library/1/Data%20Sheets/Oxygen%20Optodes_3.pdf">http://www.aadi.no/Aanderaa/Document%20Library/1/Data%20Sheets/Oxygen%20Optodes_3.pdf</a>	Oxygen concentration, internal temperature and conductivity

**Table 1: Instrumented moorings in Liverpool Bay.** Data sets are from Liverpool Bay, Site A and B. Data available is from August 2002-

In addition to the long term coastal time series, a spatial survey is conducted on a 4-6 weekly basis. This is done during the ship surveys, taking measurements at 34 vertical profiles on a 5NM grid. The CTD measurements samples are SPM, bed sediment, total alkalinity and pH, meteorological measurements, and underway surface measurements including pCO<sub>2</sub>. The rosette sampler takes bottled water samples for nutrient analysis, salinity and chlorophyll.

## Aim

To study and analyse all COBS data from 2002-present, and to create new files containing the quality controlled data, as well as supporting documents justifying why adjustments to the data may or may not have been made.

# Raw Data

## Background

Raw data per cruise and the corresponding cruise reports can be accessed from <http://coastobs.pol.ac.uk/cobs/fixd/moorings.php>

Data are saved in separate files for each instrument, per cruise. The filenames of which correspond to the instrument used (*table 2*).

Abbreviation	Instrument
as	Aanderaa RCM 1/600Hz
mc	MicroCat 1/600Hz
mx	SeaBird SBE 16plus 1/600Hz
tp	Temperature Mini Logger
Bb	Teledyne ADCP

An example of a raw file is shown below (*figure 2*). It contains a header, which ends with a #. The header lists when the file was created, information about the instrument, the depth of the water column and the depth the instrument was placed, the start and end date and time, and the parameters measured. After the header, there will always be 7 or more columns of data. This is the data which goes through quality control. The first 7 columns in every file are always the same, no matter what the instrument is- year, month, day, hour, minute, second, temperature.

**Table 2: Instrument and Abbreviation.** The filenames begin with the abbreviations listed, followed by a 5-digit number, which corresponds to the instrument serial number, e.g. mc02081.01085ot (MicroCAT, sn02081).

1	Produced Tue Aug 31 10:57:27 BST 2010 ** Using Y2K Program **
2	=====
3	Input file : mc02081.01085ua
4	Meter type : mc (MicroCat)
5	Meter No. : 2081
6	Rig No. : 01085
7	First Scan : 26-01-2010 06:00:01
8	In water and settled : 26-01-2010 09:55:00
9	Release fired/start recovery : 17-03-2010 13:37:00
10	Last scan : 22-03-2010 15:00:00
11	Site name/Cruise No./Type : COA3/MA0210
12	Sample interval (secs) : 600.
13	Water depth (m) : 24.6
14	Meter depth below surface (m) : -5.0
15	Position Latitude/Longitude : 53 31.99N 03 21.72W
16	Read format : (f9.4,1x,f9.5,1x,i3,1x,a3,1x,i4,1x,3(1x,i2))
17	No of chans 1-Tem 2-Con 3-Prs : 2
18	Date/Time yyyy mm dd hh mm ss
19	Channel #01 F9.4 Deg(C) Temperature
20	Channel #02 F9.5 S/m Conductivity
21	Comment #1 None.
22	#
23	2010 01 26 10 00 01 5.2280 3.16275
24	2010 01 26 10 10 01 5.2856 3.17568
25	2010 01 26 10 20 01 5.2720 3.17316
26	2010 01 26 10 30 01 5.2353 3.16691
27	2010 01 26 10 40 01 5.2015 3.16059
28	2010 01 26 10 50 01 5.1459 3.15175
29	2010 01 26 11 00 01 4.9312 3.10820
30	2010 01 26 11 10 01 4.6939 3.05174
31	2010 01 26 11 20 01 4.9169 3.09677
32	2010 01 26 11 30 01 4.8254 3.07628
33	2010 01 26 11 40 01 4.6414 3.03314
34	2010 01 26 11 50 01 4.7845 3.07390
35	2010 01 26 12 00 01 4.8137 3.07905
36	2010 01 26 12 10 01 4.7672 3.06766
37	2010 01 26 12 20 01 4.9017 3.09692
38	2010 01 26 12 30 01 4.8864 3.09553
39	2010 01 26 12 40 01 4.8853 3.09524
40	2010 01 26 12 50 01 4.8584 3.08697
41	2010 01 26 13 00 01 4.8014 3.07949

**Figure 2: Raw Data File** An example raw file from MicroCAT02081, Cruise 66. UltraEdit or WordPad may be used to read these files, as the file extension is 'ot' rather than '.txt' or '.xls'. UltraEdit is preferred as it shows the line numbers and is easier to edit documents.

## Cataloguing

When a new set of cruise data is available on the Coastal Observatory Website, it is added to (i) Data\_Catalogue.xls, and (ii) Instrument\_List.xls.

### (i) Data\_Catalogue.xls

This document was created to catalogue all measurements and recorded data from 2002 to present cruises.

Coastal observatory: available data		
2010	Cruise number	73
	Cruise ID	ma4910
Data type	Cruise dates	05/12-08/12
Prince Madog	Underway data and surfmet	all available
CTD survey	Station profiles	21,24,33,32,25,20,13,9
Nutrients		available
Site A: ADCP, currents + waves	start	01/12/2010 12:30
	stop	12/01/2011 08:10
	near surface:	
CEFAS SmartBuoy	start	07/12/2010 13:06
	stop	12/01/2011 09:35
CT	5m depth: start	07/12/2010 13:06
	stop	12/01/2011 09:35
	7.5m Temperature logger: start	07/12/2010 13:06
	stop	12/01/2011 09:35
	10m depth: start	07/12/2010 13:06
	stop	12/01/2011 09:35
	15m depth Tlogger: start	07/12/2010 13:06
	stop	12/01/2011 09:35
	Bed-mounted: start	07/12/2010 12:30
	stop	12/01/2011 08:10
Oxygen data	Bed-mounted: start	07/12/2010 12:30
	stop	12/01/2011 08:10
Site B: ADCP, currents + waves:	start	07/12/2010 15:20
	stop	13/01/2011 08:20
	near surface:	
CEFAS SmartBuoy	start	07/12/2010 16:05
	stop	13/01/2011 15:17
CT	5m depth: start	07/12/2010 16:05
	stop	13/01/2011 15:17
	7.5m Temperature logger: start	07/12/2010 16:05
	stop	13/01/2011 15:17
	10m depth: start	07/12/2010 16:05
	stop	13/01/2011 15:17
	15m Temperature logger: start	07/12/2010 16:05
	stop	13/01/2011 15:17
	20m Temperature logger: start	07/12/2010 16:05
	stop	13/01/2011 15:17
	Bed-mounted: start	07/12/2010 15:20
	stop	13/01/2011 08:20
Meteorological data	Hilbre	
HF radar	currents	
	waves	
Ferry Box data	Liverpool Seaways	
Comments		During recovery, the weather station antenna was damaged. The weather station antenna was not repaired prior to deployment.

#### KEY:

as-Anderra RCM 1/600Hz (No velocity or direction)
mx-SeaBird 16-plus 1/600 Hz
mc-Microcat 1/600Hz
VEMCO Tlogger
Hilbre Met Data 2010
Met Data currently not available
mx-SeaBird 16-plus 1/600 Hz, additional sensor= Aanderra optode

**Figure 3: Data\_Catalogue** An example of one cruise from 2010. The key is located to the left, showing the colour-coding for each of the instruments and data available.

The table is designed to show:

- What data was collected for both Site A and Site B, i.e. ADCP, current and waves, and from the CEFAS SmartBuoy,
- The dates of each cruise,
- At what water depth the measurements were taken,
- What time the measurements began (when the instrument was in the water and settled),
- When the measurements stopped (when recovery started),
- The document has hyperlinks to link the cruise number to the corresponding cruise page on the Coastal Observatory Website.
- Which station profiles were visited,
- Any meteorological, HF Radar, or Ferry box data available for the same dates.
- Any key issues or problems encountered and written in the Cruise Reports are documented in the comments section at the bottom of each cruise.
- Years are shown on separate sheets, to make the catalogue easier to read.

The table is colour coded, and there is a key at the bottom of every tab explaining the various colours used. The different colours represent the various instruments used to record data.

To access the Cruise Reports or data files, registration is required to the Coastal Observatory Website.

## (ii) Instrument\_List.xls

This document was created to catalogue every instrument, on every cruise, at all depths, at both Site A and Site B. This document was produced to visually observe which instruments are being used, and to help discover trends in instrumental error.

Instrument	ma0711	ma0111	ma4910	ma3610	ma2910	ma2110	ma1710	ma1010	ma0510	ma0210	ma4709	ma3809	ma3309	ma2409
<b>MicroCAT SBE 37</b>														
mc02010	Site A (5m)									Site B (5m)				
mc02081								Site A (5m)		Site A (5m)		Site A (10m)		Site A (5m)
mc02506			Site B (5m)			Site B (5m)				Site B (10m)				
mc02991														
mc04966	Site B (5m)	Site A (5m)		Site B (10m)			Site A (5m)		Site A (5m)		Site A (10m)		Site A (10m)	
mc04998		Site B (5m)		Site A (10m)			Site A (10m)		Site B (10m)		Site B (10m)			
mc05433		Site B (10m)		Site B (5m)		Site A (5m)							Site B (10m)	
mc05434	Site A (10m)		Site B (10m)		Site A (10m)		Site B (5m)		Site A (10m)		Site A (5m)		Site B (5m)	
mc05790	Site B (10m)	Site A (10m)		Site A (5m)		Site A (10m)	Site A (10m)	Site A (10m)	Site A (10m)	Site A (10m)		Site B (10m)		Site A (10m)
mc05791			Site A (10m)			Site B (10m)	Site B (5m)					Site A (5m)		
mc05792			Site A (5m)		Site A (5m)		Site B (10m)		Site B (5m)		Site B (5m)		Site A (5m)	
mc05793								Site B (10m)				Site B (5m)		
<b>Seabird 16+</b>	ma0711	ma0111	ma4910	ma3610	ma2910	ma2110	ma1710	ma1010	ma0510	ma0210	ma4709	ma3809	ma3309	ma2409
ma04596						Site A								
ma04597		Site A		Site A										
ma04736			Site A		Site B		Site A		Site B		Site A		Site A	
ma04737		Site B		Site B		Site B	Site B	Site B	Site B	Site B	Site A		Site B	Site A
ma04738			Site B		Site A		Site B		Site A		Site B		Site B	
ma04848	Site A													
ma05309							Site A			Site A		Site B		Site B
ma05310	Site B													
<b>Star Oddi (Starmon mini)</b>	ma0711	ma0111	ma4910	ma3610	ma2910	ma2110	ma1710	ma1010	ma0510	ma0210	ma4709	ma3809	ma3309	ma2409
tp02836		Site A (7.5m)		Site A (7.5m)		Site A (7.5m)		Site A (7.5m)		Site A (7.5m)		Site A (7.5m)		
tp02837		Site A (15m)												
tp02838		Site B (7.5m)		Site A (15m)		Site A (15m)		Site A (15m)		Site A (15m)		Site A (15m)		Site A (7.5m)
tp02840	Site A (7.5m)		Site A (7.5m)			Site B (7.5m)		Site B (7.5m)						
tp02841	Site A (15m)		Site A (15m)		Site A (7.5m)		Site A (7.5m)		Site A (7.5m)		Site B (7.5m)		Site A (15m)	
tp02842	Site B (7.5m)		Site B (7.5m)		Site A (15m)		Site A (15m)		Site A (15m)		Site A (15m)		Site A (15m)	
tp02843							Site B (7.5m)		Site A (15m)		Site A (15m)		Site A (15m)	
tp02844									Site B (7.5m)		Site B (15m)		Site B (15m)	
tp02847														
tp02848	Site B (15m)		Site B (15m)			Site B (15m)		Site B (15m)						
tp02849		Site B (15m)		Site B (15m)			Site B (15m)			Site B (15m)		Site B (15m)		
tp02851	Site B (20m)		Site B (20m)											
tp02852		Site B (20m)		Site B (20m)					Site B (15m)		Site B (7.5m)		Site B (7.5m)	

**Figure 4: Instrument\_List** providing a visual representation of all of the instruments used since 2002, for both Site A and B. The CruiseID is shown at the top of every column, and the instruments and their serial numbers are at the start of every row.

Instrument	ma0711	ma0111
<b>MicroCAT SBE 37</b>		
mc02010	Site A (5m)	
mc02081		
mc02506		
mc02991		
mc04966	Site B (5m)	Site A (5m)
mc04998		Site B (5m)
mc05433		Site B (10m)
mc05434	Site A (10m)	
mc05790	Site B (10m)	Site A (10m)

**Figure 5: Instrument\_List** The Instrument\_Lists.xls zoomed in.

The instrument name is placed down the first column with a list of how many are in use, i.e. their serial numbers. The cruise numbers are listed in the first row of each new subsection, dedicated to each instrument. The cruise numbers are in descending order, moving left to right.

Each cruise has a number, and an ID, e.g. Cruise 51 is ma0708. The cruise ID comes from the ship, the Madog, where the last two digits represent the year, and the first two digits represent how many cruises it has been on in the year.

There is no key in this document as the colours do not represent anything; they are just used to highlight the different depths and Site A and Site B, which are clearly labelled. The other sheets in this document show the same information, just separated into one instrument per sheet. This is for easier viewing and understanding.

The first sheet of this document is a summary. It shows every instrument used since 2002, including the MicroCAT SBE 37 at 5m and 10m depth, the bedframe Seabird 16+, the Starmon Mini at 7.5m, 15m and 20m depth, the VEMCO-minlog-II-T at 7.5m, 11.5m and 15m (although no longer in use), the Aanderaa at 10m and at the seabed (although no longer in use). Also included on this page is the Aanderaa Oxygen Optode, which is attached to the bedframe Seabird 16+ (Cruise 51-present).



## Method

The raw data that comes directly from each instrument is processed into real numbers, and into a file format that has been consistently used since 2002, i.e. with the appropriate header and column ordering. As this is raw, the data may have errors, occurring from instrumental error or natural problems. Instrumental errors are usually either due to battery failure or consistent offsets.

Quality control of the moored data is done in two stages. The first involves comparing the temperature, conductivity, and salinity data from each instrument to the nearest CTD measurements taken at the same time. The second involves comparing all of the instruments from surface to bed per site and cruise, looking at temperature and salinity separately.

### (i) Checking against CTD measurements

CTD profiles are taken across the spatial grid in Liverpool Bay, at 34 or more stations. This section will be divided into stages, a step-by-step guide to quality controlled data from CTD measurement comparisons.

#### a) Loading in data

A MATLAB programme has been written to read in specified instrument data, and to compare it automatically with CTD data. To compare, the CTD measurements must be less than 1000m away from the instrument measurements, and must also match the deployment and recovery times (less than 3600 seconds). This is for reliability in the data, if the distance between the instrument and CTD is greater, it would not be fair to say the data from both sets should be similar as different processes may be occurring in each area. Similarly, if the CTD measurements were taken after recovery, or before deployment, and not during each, the meteorology may have changed leading to different values in the measured parameters.

This method of quality control analyses the temperature (°C), conductivity (S/m) and salinity data recorded from each instrument. Salinity is not directly measured by the instruments, but can be calculated by:

```
cnldr=10*conductivity/sw_c3515;  
salinity=sw_salt(cnldr,temperature,pressure);
```

Figure 6 shows how the data is plotted, using `checkplot(datout,all_data)`.

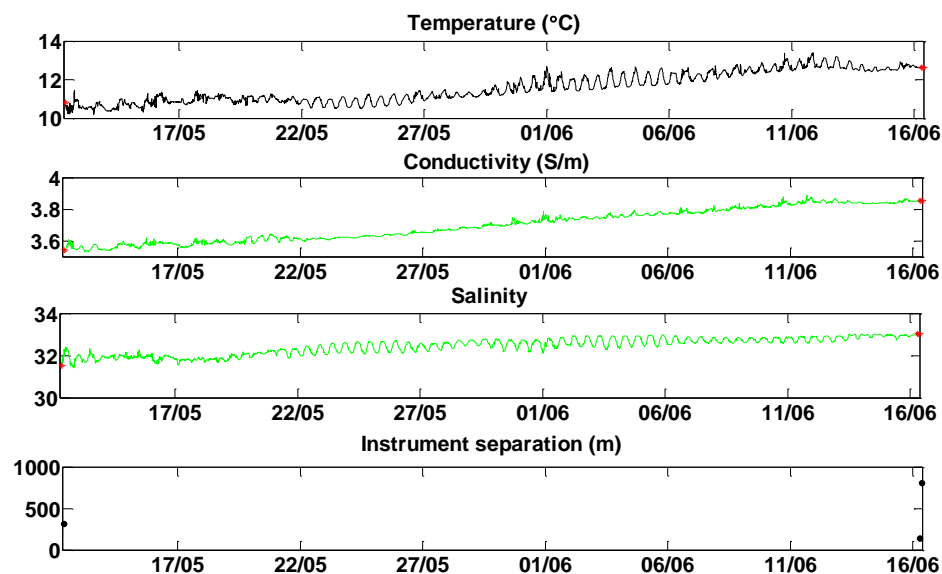


Figure 6: Checking against CTD measurements example plot.

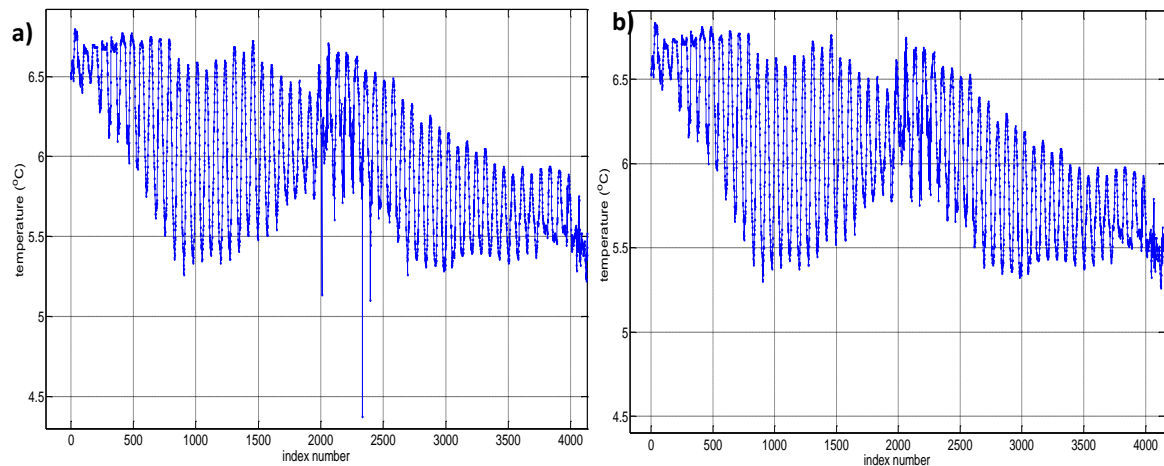
The figure is divided into subplots, to show each parameter clearly. The red dots in the top three subplots indicate the CTD measurements. There are only a few of these measurements at deployment and recovery as

the programme looks for the nearest CTD measurements to the location of the instrument measurements. Instrument separation is the distance in metres between the instrument (e.g. the MicroCAT, Minilogger or Seabird 16+) and the CTD.

To begin with, these plots are analysed for any obvious spikes in the instrument data, offsets between the CTD measurements and instrument data, and drifts in the instrument data.

### b) Identifying Spikes

Data is classified as a spike if it does not follow the same trend as the rest of the data, for instance, one or two points that are significantly higher or lower than the other values.



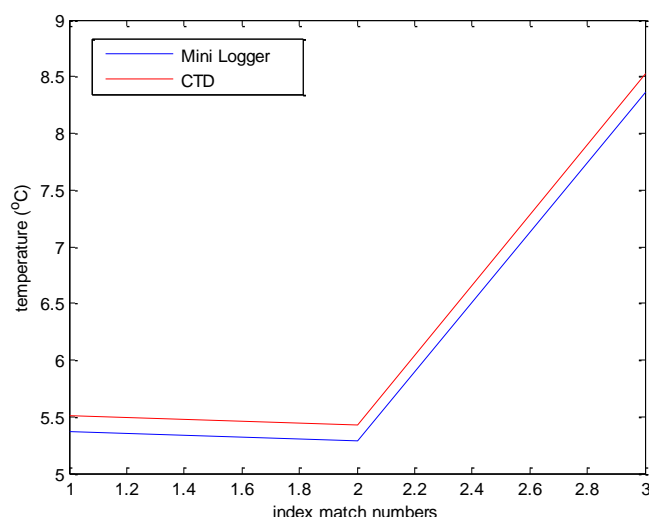
**Figure 7: Identifying Spikes** a) data with spikes, b) data with spikes removed. Data from a Star Oddi Temperature Mini Logger (serial number to02849). at Site B. Cruise 66 (26<sup>th</sup>-28<sup>th</sup> January 2010).

If the initially created plots show spikes, a new plot is created with just the parameter on the y-axis. The date is not set on the x-axis for this plot as the index numbers of the spikes are required later. A simple zoom in on the figure allows the user to locate the index numbers for the spiked data. These numbers are noted, and then converted to a NaN (not a number). A new file is created with NaNs in replace of the index numbers that had spiked data.

### c) Identifying Offsets

An offset is when the instrument data is continuously higher or lower than the CTD measurements at deployment and recovery. If this appears to be the case from the initial checking with CTD measurements plot, a new plot is created. To see the extent of the offset, the CTD measurements are plotted, with their index numbers, along with the instrument match points.

According to the specifications of all instruments, conductivity should be accurate to 0.001S/m and temperature should be accurate to 0.01°C. Salinity should also be accurate to 0.001. If the difference between the instrument data and CTD measurements is larger than these accuracy boundaries (either plus or minus), the data is nudged by this amount.



**Figure 8: Identifying Offsets:** Plot the CTD measurement match points along with the instrument match points

This example (*figure 8*) is from the Star Oddi Temperature Mini Logger (serial number tp02842), at Site A, Cruise 67 (17<sup>th</sup>-18<sup>th</sup> March 2010). There are three index numbers that match, one at deployment, and two at recovery.

The mean offset in this example is -0.1447°C. A new file is created with temperature values adjusted by +0.1447°C.

In some situations, the offset might be greater at deployment compared to recovery, or vice versa. In this case, the minimum offset at deployment or recovery would be used rather than a mean.

#### d) Identifying Drifts

A drift is different to an offset. An offset has a similar difference at deployment and recovery between the instrument data and CTD measurements. A drift is often where the data is good for a period of time, and then gradually shows an offset towards recovery. This gradual offset usually becomes larger towards recovery.

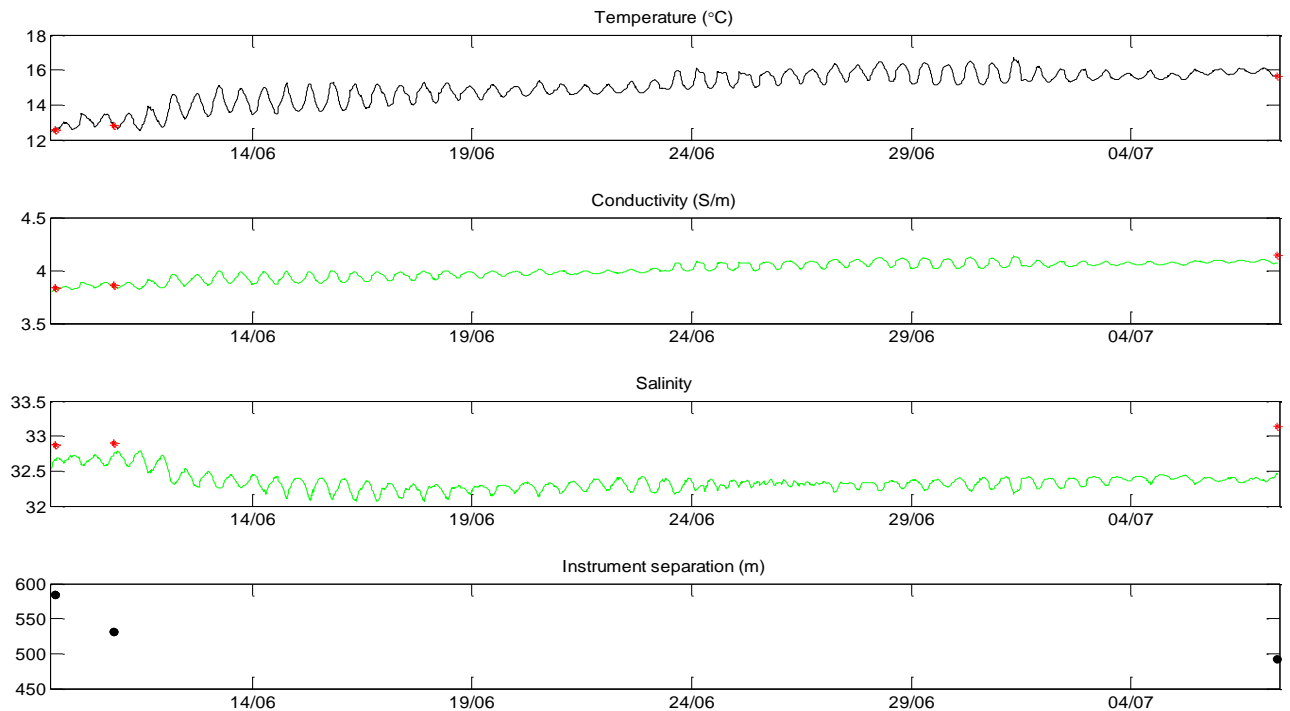
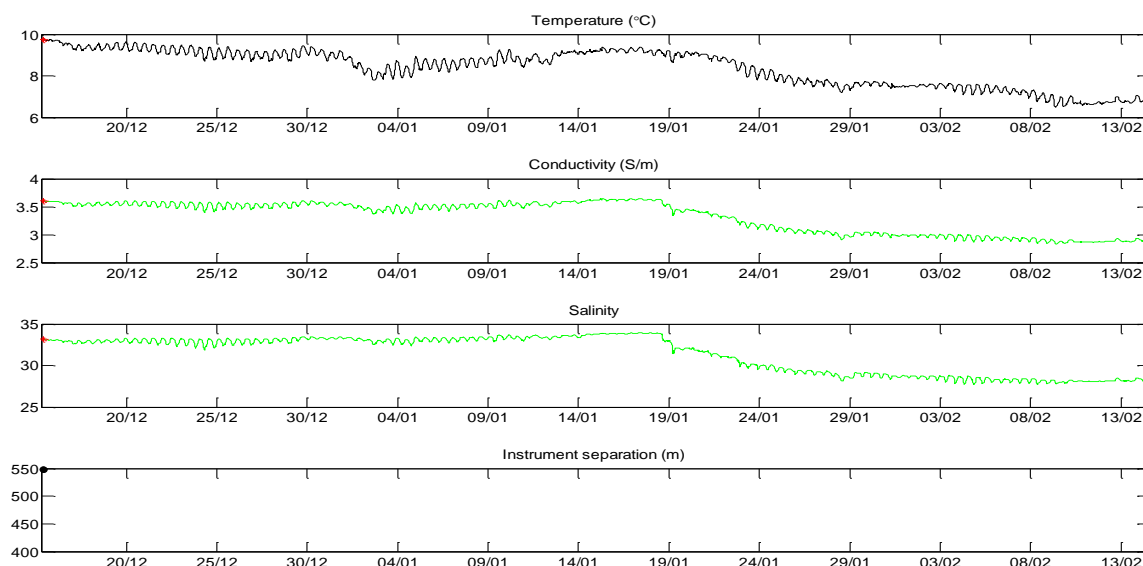


Figure 9: Identifying Drifts example plot.

The data used in this example (*figure 9*) is from the bed frame Seabird 16+, at Site A (serial number mx04736), Cruise 60 (9<sup>th</sup>-10<sup>th</sup> June 2010). Conductivity looks good at deployment compared to the CTD measurements, but there is a large offset at recovery. As salinity is calculated from temperature and conductivity, the drift is emphasised. In salinity, there also appears to be an offset at deployment. In this example, the whole of conductivity and salinity have been flagged in the Quality Control Document, which suggests not using the conductivity and salinity data from this instrument.

### e) Identifying Step Changes

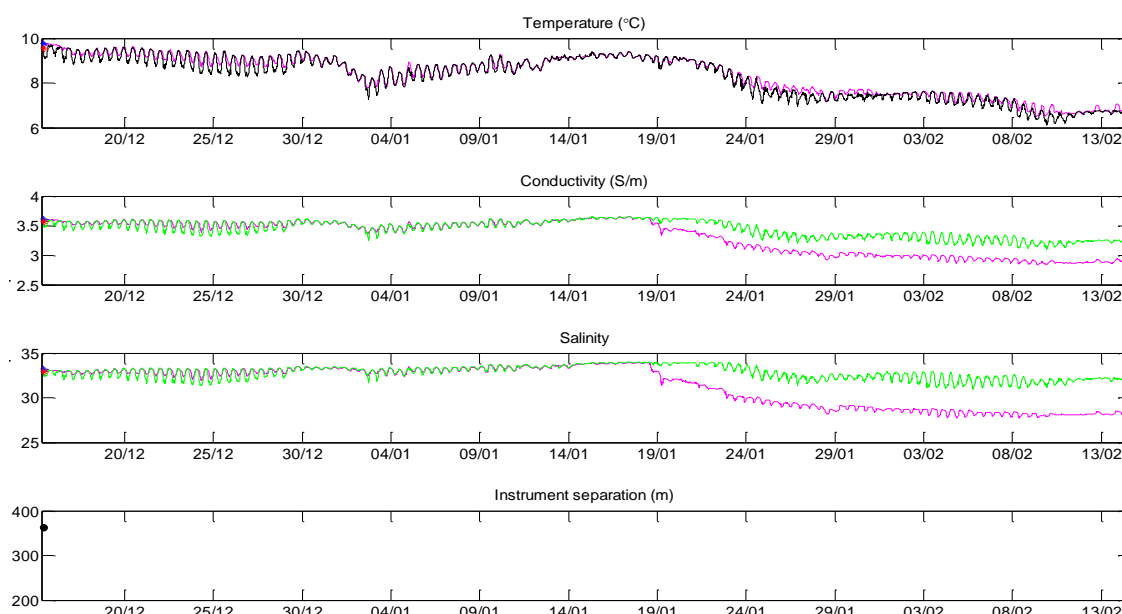
A step change is similar to a drift, only more noticeable and could happen mid-cruise. The likely cause of a step change is battery failure of the instrument, which should be added to the comments section in the Data Catalogue. To check battery failure has been noted, or if there were any other problems found during a cruise, such as fouling, the Cruise Reports should be referred to.



**Figure 10: Identifying Step Changes** example plot.

In this example (*figure 10*), data is from the bed frame Seabird 16+ (serial number mx04597), at Site A, Cruise 41 (13<sup>th</sup>-15<sup>th</sup> December 2006). Temperature looks good, and matches the nearby CTD measurements. Conductivity and salinity look good until approximately 19<sup>th</sup> January 2007, after which there is a clear step change. Temperature also appears to decrease towards recovery, but this decrease is also seen in the nearby CTD measurement.

To check this step change in conductivity and salinity is not a natural event, data from the 10metre MicroCAT (serial number mc04498) at the same site was plotted on the same figure, to see if this had a similar trend. The water column in Liverpool Bay is generally well mixed, so a similar temperature and salinity pattern would be expected at a 10m depth and the bottom (maximum of 25m depth).



**Figure 11: Step Change, bed frame and 10m MicroCAT** example plot.

The step change is only seen in the bed frame, suggesting this data should be used with caution. Unlike the data that previously had a drift in and so the whole data set for conductivity and salinity was flagged, some of this data is still good, and therefore can be used. In this situation, a new file was created where conductivity and salinity after the 18<sup>th</sup> January 2007 were converted to NaNs.

## f) Adjusting Files

If during the quality control method with CTD measurements, an offset, step change, or spike was found, the data is adjusted in MATLAB, and a new file is created using the `make_adjusted_file` function. If a drift is found, a caution is noted in the Quality Control Excel file and the reason for the caution.

When a new file is created, a new line is automatically written into the first line of the data file. This stays the same for each file that is adjusted using nearby CTD measurements, to inform the data user if an adjustment to the file has been made, and whom by. It also states which quality control document to refer for more details.

```
Corrected by alexew using nearby CTD measurements. See MooringQC.xls for details
Produced Wed Jul  2 14:59:24 BST 2008 ** Using Y2K Program **
=====
original file contained offset in temperature of +0.0370degC.
new file created with all temperature values +0.0370degC.
=====
Input file           : tp06027.01027ua
Meter type           : tp (Mini Logger)
Meter No.            : 6027
Rig No.              : 01027
First Scan           : 13-03-2008 08:00:00
In water and settled  : 14-03-2008 10:51:00
Release fired/start recovery : 16-04-2008 10:42:00
Last scan            : 16-04-2008 14:50:00
Site name/Cruise No./Type : COA3/MA0708
Sample interval (secs) : 600.
Water depth (m)       : 20.3
Meter depth below surface (m) : -15.0
Position Latitude/Longitude : 53 32.02N 03 21.49W
Date/Time  yyyy mm dd hh mm ss
Channel #01 F6.2 Deg(C) Temperature
#
2008 3 14 11  0  0 7.223000
2008 3 14 11 10  0 7.213000
2008 3 14 11 20  0 7.213000
2008 3 14 11 30  0 7.213000
2008 3 14 11 40  0 7.213000
2008 3 14 11 50  0 7.203000
2008 3 14 12  0  0 7.203000
2008 3 14 12 10  0 7.173000
2008 3 14 12 20  0 7.183000
2008 3 14 12 30  0 7.183000
2008 3 14 12 40  0 7.163000
2008 3 14 12 50  0 7.153000
2008 3 14 13  0  0 7.173000
2008 3 14 13 10  0 7.163000
2008 3 14 13 20  0 7.173000
2008 3 14 13 30  0 7.163000
2008 3 14 13 40  0 7.163000
2008 3 14 13 50  0 7.163000
```

Figure 12: Adjusted Data File example plot

In the header is a section separated with double lines, stating what was found during the quality control process, for instance, an offset, or spikes. The following line in the same section states any adjustments to the data within the file. The original file is never overwritten.

## (ii) Checking Against Other Instruments at Depth

The second stage of the quality control process occurs after the data has been checked with matching CTD data. This process involves the comparison of temperature and salinity from all instruments from Site A together and all instruments from Site B together, per cruise. For instance, temperature data at Site A would be compared from the 5m and 10m MicroCATs, the 7.5m and 15m Thermistors, and the Seabird 16+ Bottom Frame.

In more recent cruises, there are two Bottom Frames at Site A. This is because the oxygen sensor is attached to one. The temperature and salinity data are obtained from the Bottom Frame that does not have the oxygen sensor attached. This is because temperature and conductivity have been calibrated on this frame, but not on the one with the oxygen sensor.

The Matlab function used for this process is 'plotting.m'. To begin with, the user must manually enter the following commands into the Command Window:

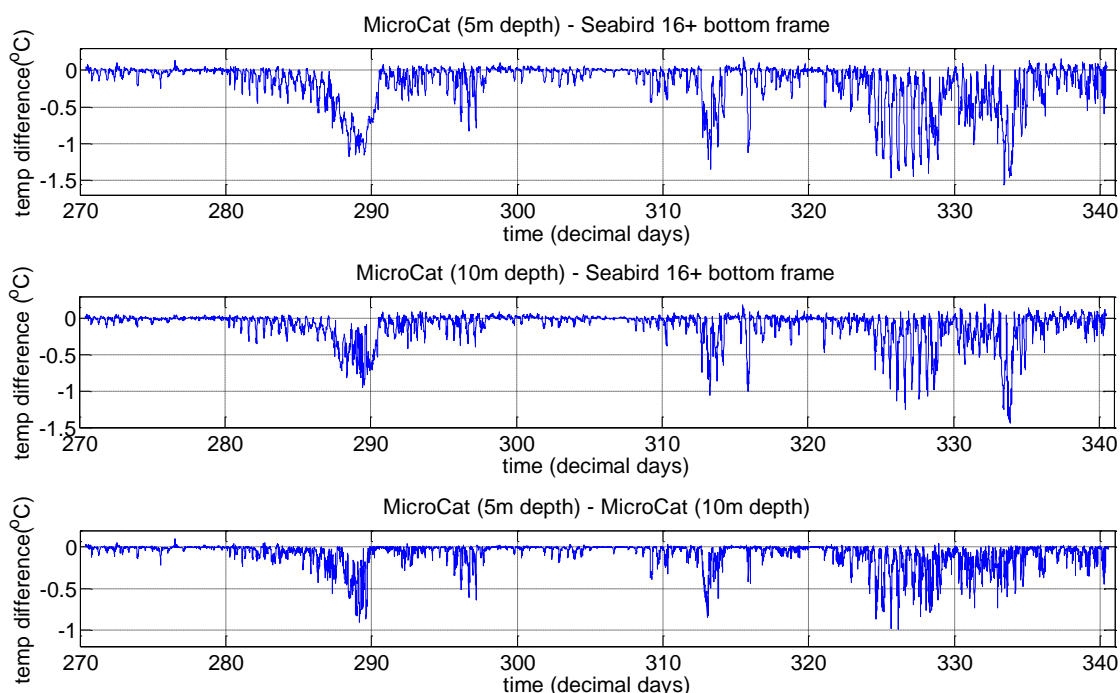
```
a) M_dir='N:\data' % calling the mother directory where the data is stored
b) ext='.csv' % only want to look at comma separated CTD files
c) [all_data,CTD]=alexread_csv_files; % creates a structured array of all of the
CTD
data
d) instr='N:\data\ma0210_moorings\mc05790.01085ot' % calling the filename to be
read
into MATLAB
e) [datout]=Check_instruments_with_CTD(all_data,instr,1000,3600); % produces an
array
of the instrument
data
```

The user needs to create a new datout variable for each instrument. This is done by repeating (d) and (e), but changing the [datout] variable name each time.

```
%datout = MicroCAT 5m depth
%datout2 = Seabird 16+ bottom frame
%datout3 = MicroCAT 10m depth
%datout4 = Thermistor 7.5m depth
%datout5 = Thermistor 15m depth
```

## a) Temperature

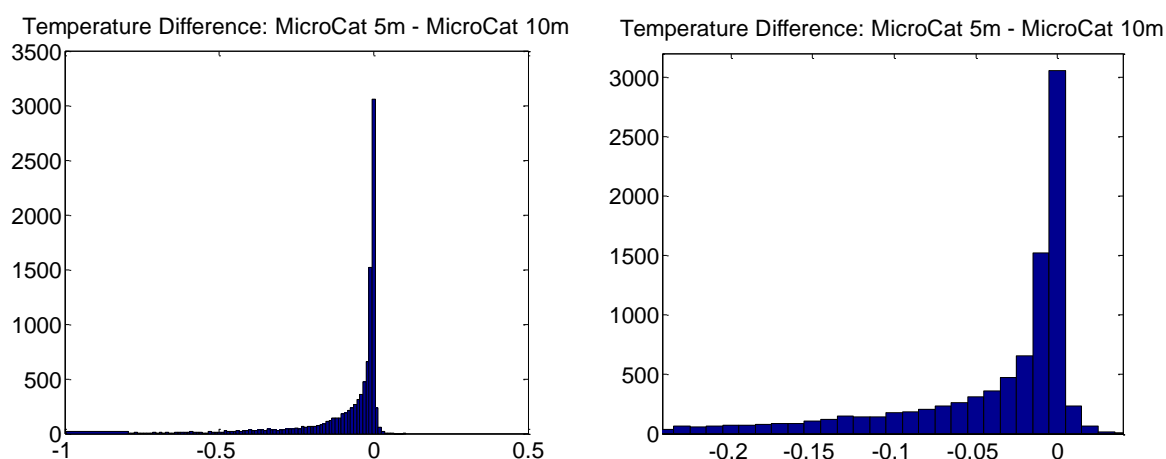
The first plot to be produced is the temperature difference for both MicroCATs and the Seabird 16+ bottom frame. This helps to visually observe any offset in the data.



**Figure 13: Temperature Difference Plot** example plot from Cruise 72, Cruise ID ma3610

Temperature should not vary greatly in a well-mixed, shallow, shelf sea environment, with a maximum of 25m depth. This said, most of the data points in the plot above should lie at 0, with the exception of periods of stratification, for instance when the sun warms the surface. If most of the data points are higher or lower than 0, i.e. if a horizontal line was drawn through the majority of the points and it was not at 0, then an offset in one of the two instruments is present. It is often easy to determine an offset immediately if it is in just one instrument, however it is not always that simple.

Histograms of the temperature difference plots are produced to find the exact offset value.



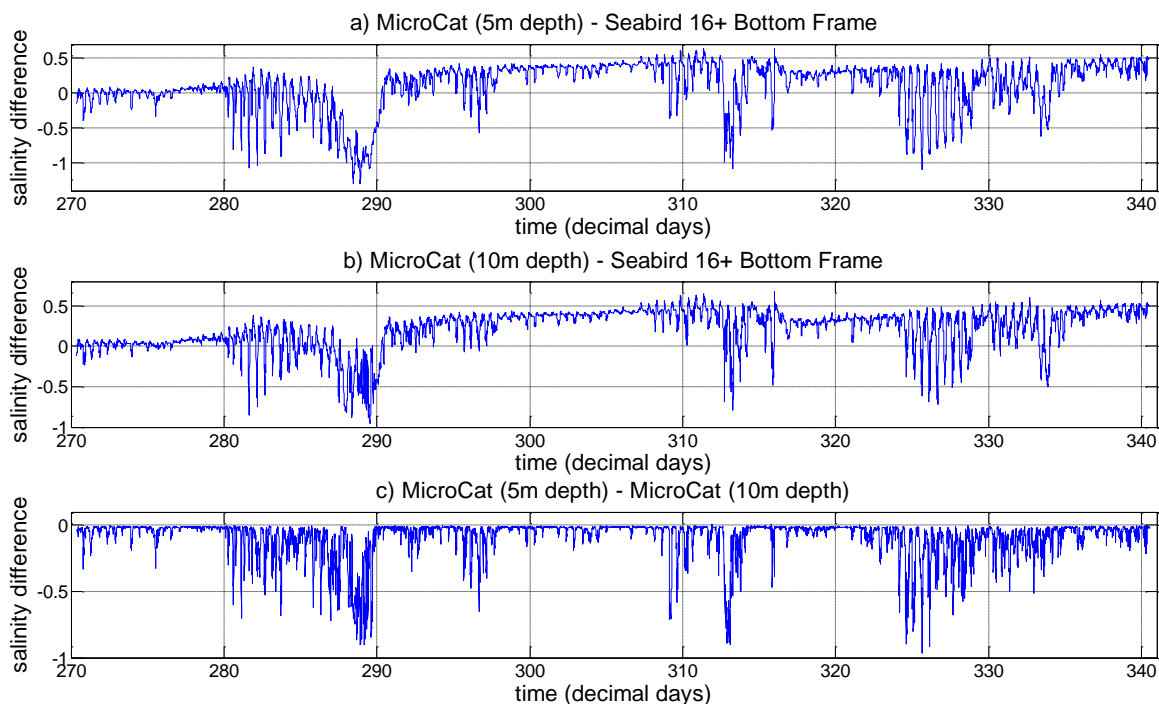
**Figure 14: Temperature Difference Histograms** Cruise 72, Cruise ID ma3610, to the right is the same image zoomed in to accurately read the offset.

The highest peak in the histogram represents the most common value for the difference between the two variables. If most of the values lie at 0 (*figure 14*), there is no offset between the two instruments.



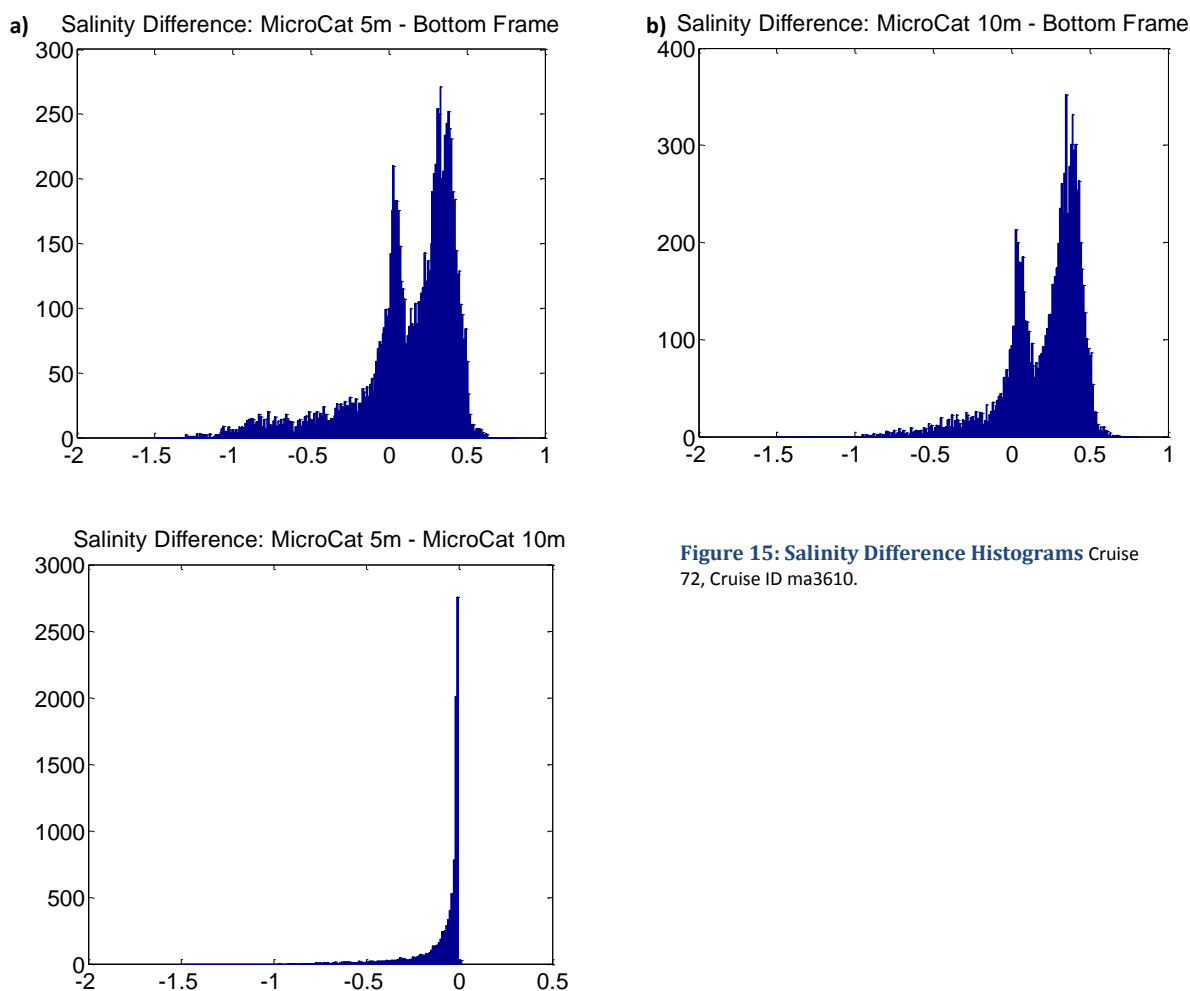
## b) Salinity

The second plot produced is the difference in salinity for both MicroCATs and the Seabird 16+ bottom frame.



**Figure 14: Salinity Difference Plot** example plot from Cruise 72, Cruise ID ma3610.

Figure 14 is a good example of a data set that was flagged. At a first glance, it would appear the top two subplots have a drift from deployment all the way through to recovery, the last subplot however looks okay, although there may be an offset, there is not a drift.



**Figure 15: Salinity Difference Histograms** Cruise 72, Cruise ID ma3610.

There is an offset in salinity between 5m and 10m MicroCATs of -0.01. When comparing all plots together, it would appear the drift is only in the Seabird 16+ Bottom Frame as it is not seen in histogram (c). In this example, no adjustment was made to the 5m or 10m MicroCAT, but a caution was noted as one has an offset of -0.01, but it is unclear which. For the Bottom Frame, it has been recommended to not use the salinity data, and thus also the conductivity data. This is because salinity is calculated from temperature, pressure and conductivity. If salinity data is poor quality, but temperature is good, the conductivity must also be poor. This can be checked by producing the same plots for just conductivity.

### c) Adjusting Files

If during the quality control method that compares the individual parameters with each instrument at depth, an offset, or drift is identified, the data is adjusted in MATLAB, and a new file is created using the `make_adjusted_file` function. If a drift is found, a caution is noted in the Quality Control Excel file and the reason for the caution.

When a new file is created, a new line is automatically written into the first line of the data file. This stays the same for each file that is adjusted using all instruments at depth, to inform the data user if an adjustment to the file has been made, and whom by. It also states which quality control document to refer for more details.

```
Corrected by alexew. See MooringQC_histograms.xls for details
Produced Tue Dec 21 09:14:07 GMT 2010 ** Using Y2K Program **
=====
New file created with salinity (column 5) added.
By comparing with all instruments at depth, an offset of 0.01degC was found in temperature,
and 0.04 in salinity. Corrected file with all temperature data -0.01degC and all salinity data +0.04.
=====
Input file           : mx04737.01111ua
Meter type          : mx (Seabird 16 Plus)
Meter No.           : 4737
Rig No.             : 01111
First Scan          : 28-09-2010 06:00:03
In water and settled : 29-09-2010 07:50:00
Release fired/start recovery : 07-12-2010 14:29:26
Last scan           : 09-12-2010 11:40:03
Site name/Cruise No./Type : COB1/MA3610
Sample interval (secs) : 600.
Water depth (m)      : 34.0
Meter height above sea bed (m) : 0.5
Position Latitude/Longitude : 53 32.41N 03 38.50W
Read format          : (f8.4,1x,f9.5,1x,f9.3,1x,f7.4,26x,2x,i2,1x,a3,1x,i4,1x,3(1x,i2))
Chans 1-Tem 2-Con 3-Pre : 4
Date/Time  yyyy mm dd hh mm ss
Channel #01 F9.4 Deg(C) Temperature
Channel #02 F9.5 S/m Conductivity
Channel #03 F9.3 db Pressure
Channel #04 F9.4 FTU Turbidity # Additional sensor, Seapoint turbidity sensor No. 10537, 0-5V range 0-125 FTU
Channel #05 F8.6 Salinity
Comment #1 None.
#
2010 9 29 7 50 3 15.345700 4.116970 34.567000 0.805000 33.135306
2010 9 29 8 0 3 15.355400 4.118340 34.559000 0.862500 33.139428
2010 9 29 8 10 3 15.353300 4.116530 34.565000 0.775000 33.124955
2010 9 29 8 20 3 15.357300 4.119670 34.589000 0.905000 33.149748
2010 9 29 8 30 3 15.358500 4.120660 34.626000 0.890000 33.157604
2010 9 29 8 40 3 15.359200 4.121470 34.680000 1.022500 33.164261
2010 9 29 8 50 3 15.360000 4.122030 34.762000 0.905000 33.168579
2010 9 29 9 0 3 15.360400 4.122650 34.865000 1.062500 33.173765
2010 9 29 9 10 3 15.360800 4.123000 34.984000 0.957500 33.176523
2010 9 29 9 20 3 15.360900 4.123270 35.126000 0.910000 33.178807
2010 9 29 9 30 3 15.361300 4.123780 35.278000 1.057500 33.182987
2010 9 29 9 40 3 15.361900 4.125350 35.452000 1.050000 33.196501
2010 9 29 9 50 3 15.362600 4.126960 35.643000 1.095000 33.210284
2010 9 29 10 0 3 15.362700 4.127790 35.856000 0.925000 33.217566
2010 9 29 10 10 3 15.363700 4.129300 36.080000 0.970000 33.230185
2010 9 29 10 20 3 15.363400 4.130900 36.313000 0.980000 33.244708
2010 9 29 10 30 3 15.362400 4.132760 36.555000 1.097500 33.262155
2010 9 29 10 40 3 15.361600 4.134070 36.803000 1.122500 33.274494
2010 9 29 10 50 3 15.361300 4.134180 37.059000 1.167500 33.275637
2010 9 29 11 0 3 15.361400 4.134210 37.317000 1.195000 33.275723
2010 9 29 11 10 3 15.359500 4.135220 37.570000 1.492500 33.286300
2010 9 29 11 20 3 15.357300 4.136420 37.824000 1.365000 33.298838
```

**Figure 16: Adjusted Data File** Cruise 72, Cruise ID ma3610, Site B, Seabird 16+ Bottom Frame.

During this stage, all files from the Seabird 16+ Bottom frame and both MicroCATs have a new column added for salinity. Even if a MicroCAT or Seabird 16+ data file does not need adjusting from the quality control, a new file is still created for the new column.