GLOBAL CHANGE 91

RV BELGICA CRUISE 91/16

PARTICIPATING LABORATORIES FROM :

ULB - MUMM - VUB - ULg

MUMM contribution

Computer logged oceanographic, navigational and meteorological data.

Hydrocarbons measurements.

VOLUME I : Report.

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1. INTRODUCTION.

The RV BELGICA cruise 91/16, from the 24th of June to the 10th of July 1991, is the third Belgian oceanographic campaign which took place as a contribution to the international program **Joint Global Ocean Flux Studies (JGOFS).** A preparatory campaign with the BELGICA took place in September 1989 (BELGICA campaign 89/21) and a second campaign took place in July 1990 (BELGICA campaign 90/18).

A summary of the objectives of the cruise is given in the cruise report "Rapport de mission du BELGICA 91/16 du 24 juin au 10 juillet 1991" (R. Wollast, Oct. 1991).

The BELGICA sailed from Zeebrugge on the 24th of June and arrived at the port of call Cork (Ireland) on the 3th of July. During the first part of the cruise, stations S01 to S12 have been sampled in the British Channel and the stations S13 to S19 in the Bay of Biscay. Stations 15 and 16 have been omitted due to bad weather conditions.

The BELGICA sailed again from Cork on the 6th of July. During the second part of the cruise stations 20 and 21 could not be sampled because of bad weather. The remaining stations 22 to 25 were sampled in the British Channel. The BELGICA arrived at Zeebrugge on the 10th of July.

Prof. R. Wollast was the principal scientist aboard the BELGICA for this cruise. The following laboratories have participated :

* Université Libre de Bruxelles (ULB) - Laboratoire d'Océanographie.
* Vrije Universiteit Brussel (VUB) - Laboratorium voor Analytische Scheikunde.
* Université de Liège (ULg) - Laboratoire d'Océanologie
* Ministry of Public Health and Environment - Management Unit of the North Sea and Scheldt Estuary Mathematical Model (MUMM).

MUMM was mainly charged with the automatic data acquisition and logging of oceanographic, meteorological and navigational data.

In addition to the data acquisition task, general assistance was offered in using the on board scientific instrumentation and related infrastructure, the 30l niskin bottle sampling, etc ...

Also samples for laboratory salinity measurements were taken, and these samples have been analyzed in MUMM's laboratory at Oostende.

The present report describes the computer logged oceanographic, meteorological and navigational data gathered during this cruise. Also the results of the laboratory salinity measurements are included.

2. COMPUTER LOGGED OCEANOGRAPHIC, NAVIGATIONAL AND METEOROLOGICAL DATA.

2.1. Navigational instrumentation

During this cruise, the data from the following navigational instruments connected to the shipborn computer system were logged by the so called Oceanographic Data Acquisition Software system "ODAS" :

* SHIPMATE RS4000 DECCA navigation system.
* NAVSTAR 602D DECCA navigation system.
  This 2 navigation systems have an accuracy of typically 50 to 400 meter, mostly depending on atmospheric conditions. In the centre of the Gulf of Biscay, the lack of a good DECCA coverage leads to errors of almost 1 nautical mile.
* Anshutz STD12 Gyro Compass.
* Raytheon DSN450 Doppler speed log and bathymetric depth.
* Atlas Deso 20 Scientific Echosounder.
  Both echosounders Raytheon and Atlas are shallow water echosounders, so no data is available at depths greater than 250-300m.

2.2. Oceanographic instrumentation

The seasurface temperature was measured continuously with a Rosemount temperature sensor installed at the inlet of the special seawater circuit situated at the bow of the vessel. However an irrecoverable instrument failure took place on the 30th of June.

A Sea-Bird SBE 19 Seacat CTD profiler was installed in the wet lab and connected to the special seawater circuit. The salinity was measured continuously using a personal computer with a dedicated software package from Sea-Bird. The specifications of this CTD profiler are found in table 1.

Parameter	Units	Range	Accuracy
TEMPERATURE	°C	-5 - +35	0.01 °C / 6 months
CONDUCTIVITY	S/m	0 - 7	0.001 S/m / month

Table 1. Sea-Bird SBE 19 Seacat specifications.

Salinity and density are calculated from conductivity, temperature and depth, in accordance to the 1978 Practical Salinity Scale from the IEEE Journal of Oceanic Engineering, January 1980.

A Turner 111 fluorimeter, also connected to the special seawater circuit, was used to measure chlorophyll concentrations during the full campaign.

A Chelsea fluorimeter was installed to measure hydrocarbons at the water surface.

SCTD vertical profiles have been taken with the Sea-Bird SBE 9 CTD profiler. The specifications of this CTD profiling system are given in table 2.

Parameter	Units	Range	Accuracy (guaranteed)
DEPTH	m	0 - 3000	0.1 % of full scale range
TEMPERATURE	°C	-5 - +35	0.01 °C / 6 months
CONDUCTIVITY	S/m	0 - 6	0.001 S/m / month
DIS. OXYGEN	ml/l	0 - 15	0.1 ml/l / day
pH	pH	2 - 12	0.1 pH / day

Table 2. Sea-Bird SBE 9 specifications.

2.3. Meteorological instrumentation

Following parameters were measured by the Friedrichs meteorological station :

- windspeed
- winddirection
- airtemperature
- atmospheric pressure
- air humidity

In addition a solar radiation measuring device from Kipp & Zonen was installed.

The outputs of these sensors are analogous signals that are measured with the 4 ½ digit digital voltmeter incorporated in the ODAS system. Table 3 gives a review of the specifications of the meteo sensors.

Parameter	Units	Range	Precision
WIND SPEED	m/s	0 - 41	0.2
WIND DIRECTION	degrees	0 - 360	2
ATMOSPHERIC PRESSURE	mbar	950 - 1050	1.5
RELATIVE HUMIDITY	%	0 - 100	2.5
AIR TEMPERATURE	°C	-35 - +45	0.2
SOLAR RADIATION	Watt/m²	0 - 1000	10

Table 3. Meteo sensor specifications.

3. DATA ACQUISITION SYSTEM.

3.1. HP1000 - ODAS system.

A Hewlett Packard HP1000 minicomputer system with a HP6942 multiprogrammer and an HP3497A digital voltmeter subsystem were used to provide continuously logged data at the following intervals :

10 min. : navigational, meteorological and oceanographic data during the whole cruise.

01 min. : navigational data sea surface temperature and fluorescence during the full cruise.

1.0 sec. : solar radiation data (quantameter) during vertical profiles.

1.0 sec. : hydrocarbons measurements at the water surface.

The Oceanographic Data Acquisition System "ODAS" software package has been used for this purpose.

This ODAS software package was designed to interrogate the different subsystems, instruments and sensors installed, and to gather in real time several groups of parameters at different time intervals. The data are stored on Winchester disc while at the same time the data can be listed or plotted in real time or off line. Selected parameters can also be distributed in real time to the video monitors installed in the laboratories and on the bridge.

The data are transferred to the shore based data processing centre of MUMM situated at Oostende using the integral cartridge backup system of the Winchester drive.

At the shore station the data is stored on a identical HP1000 system, hence the same ODAS software package can be used for further processing.

Additionally the data stored in the internal ODAS format (binary) have been converted to ASCII for transportation to a PC MS-DOS or a UNIX system, using the KERMIT data transfer package.

3.2. SCTD - Horizontal profiling system.

The Sea-Bird SBE 19 Seacat profiler was installed in a reservoir connected to the special seawater circuit. The data was recorded continuously to obtain horizontal salinity profiles during the trajectories or time profiles at the fixed stations. The data, sampled twice a second, were averaged over a 1 minute interval in accordance with the acquisition rate of the sea surface temperature and the fluorescence. These data were stored on the harddisk of a portable personal computer. A graphical presentation of the data was available on the computer screen, while a hardcopy on matrixprinter was also possible. After the campaign these data were added to the HP1000 horizontal profile data.

3.3. SCTD - Vertical profiling system.

The vertical CTD profiles have been obtained with the Sea-Bird SBE 9 system installed on a General Oceanics Rosette sampler. The Sea-Bird SBE 9 measures the depth of the sensor package, water temperature, conductivity, pH and dissolved oxygen at a rate of 24 samples per second. These data were averaged in the Sea-Bird deck unit over a 0.5 sec. time interval.

The averaged values were shown in real time on the PC display in a graphical way, allowing for an immediate decision of the water sampling depths. The Sea-Bird CTD software also allows to mark the SCTD data when water bottle samples are taken so that the SCTD and related parameters are known at the exact depth.

4. INVENTORY OF AUTOMATICALLY LOGGED NAVIGATIONAL, METEOROLOGICAL AND OCEANOGRAPHIC DATA.

All datafiles created during the BELGICA campaign 91/16 have been concatenated into the following data files :

Filename	Acquisition rate	Type of data	Duration
M21600	10'	navig. + meteo	Full campaign.
N31600 N31601	1'	position + oceano.	Full campaign.
N41600	0.5"	quantameter	Station 17 and 18.
N51600	0.5"	hydrocrabons	10 stations.
JG01.DAT JG02.DAT JG03.DAT JG05.DAT JG06.DAT JG07.DAT JG08.DAT JG09.DAT JG10.DAT JG11.DAT JG12.DAT JG13.DAT JG14.DAT	0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5" 0.5"	CTD vertical profile	CTD profiles at the Channel stations.
JG17.DAT to JG17g.DAT JG18.DAT to JG18e.DAT	0.5" 0.5" 0.5" 0.5" 0.5" 0.5"	CTD vertical profile	CTD profiles at the 24 hour stations in the Gulf of Biscay.
JG19.DAT JGsi.DAT JG22.DAT JG23.DAT JG24.DAT JG25.DAT	0.5" 0.5" 0.5" 0.5" 0.5" 0.5"	CTD vertical profile	CTD profiles at the Channel stations.

Table 4. Data file inventory.

These file names or derivatives occur on the different listings and plots.

5. REMARKS CONCERNING DATA ACQUISITION AND DATA VALIDITY.

5.1. Position registration.

During the whole GLOBAL CHANGE campaign, the DECCA chain based navigation systems (Shipmate RS4000 and NAVSTAR 602) were used as the primary positioning instruments. Only at the middle of the Gulf of Biscay bad reception occured, especially at night.

5.2. Salinity measurements.

5.2.1. Validation of the SCTD salinity measurements.

During the campaign vertical SCTD profiles have been taken with the SBE model 9 SCTD system. At different locations and multiple depths water samples have been taken to validate the salinity data of the SBE 9 system. The water samples have been analysed in MUMM's laboratory at Oostende with a Beckmann RB7 laboratory salinometer.

The Beckmann salinometer is calibrated using IAPSO standard seawater capsules obtained from the Institute of Oceanographic Sciences (UK).

The results have been compared with the Sea-Bird SBE 9 salinity measurements (see Table 5 and Figure 1).

Standard deviation	: 0.012 ppt.
Corrolation coefficient	: 0.998
Maximal error	: 0.043 ppt.

Campagne JGOFS 1991/16

	Station	Diepte (m)	Salinity Beckmann ppt	Salinity SBE9 ppt	Delta ppt
1	1	3	34.062	34.089	0.027
2	3	3	35.301	35.290	-0.011
3	5	3	35.217	35.202	-0.015
4	6	3	35.214	35.201	-0.013
5	7	3	35.090	35.081	-0.009
6	8	1	35.297	35.284	-0.013
7	9	3	35.251	35.236	-0.015
8	10	3	35.323	35.307	-0.016
9	11	3	35.338	35.321	-0.017
10	11	40	35.296	35.284	-0.012
11	12	5	35.334	35.317	-0.017
12	12	50	35.363	35.349	-0.014
13	13	3	35.408	35.386	-0.022
14	13	50	35.478	35.458	-0.020
15	17	20	35.590	35.577	-0.013
16	17	50	35.650	35.640	-0.010
17	17	50	35.598	35.602	0.004
18	17	10	35.619	35.617	-0.002
19	17	150	35.594	35.591	-0.003
20	17	200	35.592	35.588	-0.004
21	17	350	35.588	35.575	-0.013
22	17	500	35.532	35.521	-0.011
23	17	700	35.566	35.560	-0.006
24	18	5	35.462	35.446	-0.016
25	18	8	35.462	35.446	-0.016
26	18	10	35.462	35.446	-0.016
27	18	20	35.480	35.464	-0.016
28	18	30	35.494	35.479	-0.015
29	18	40	35.499	35.479	-0.020
30	18	50	35.539	35.508	-0.031
31	18	60	35.563	35.550	-0.013
32	18	80	35.563	35.552	-0.011
33	18	100	35.562	35.552	-0.010
34	18	120	35.562	35.552	-0.010
35	18	140	35.562	35.552	-0.010
36	19	8	35.166	35.153	-0.013
37	19	40	35.318	35.355	0.037
38	19	80	35.320	35.330	0.010
39	22	3	35.117	35.100	-0.017
40	22	20	35.124	35.112	-0.012
41	22	60	35.128	35.130	0.002
42	23	3	35.215	35.204	-0.011
43	23	20	35.219	35.205	-0.014
44	24	3	34.873	34.830	-0.043
45	25	5	35.128	35.121	-0.007
46	25	15	35.168	35.144	-0.024

Maximal error	-0.043
Mean error	-0.011
Standard deviation	0.012
R squared	0.998

Table 5. Data Sea-Bird SBE 9 versus Beckmann RB7 salinometer.

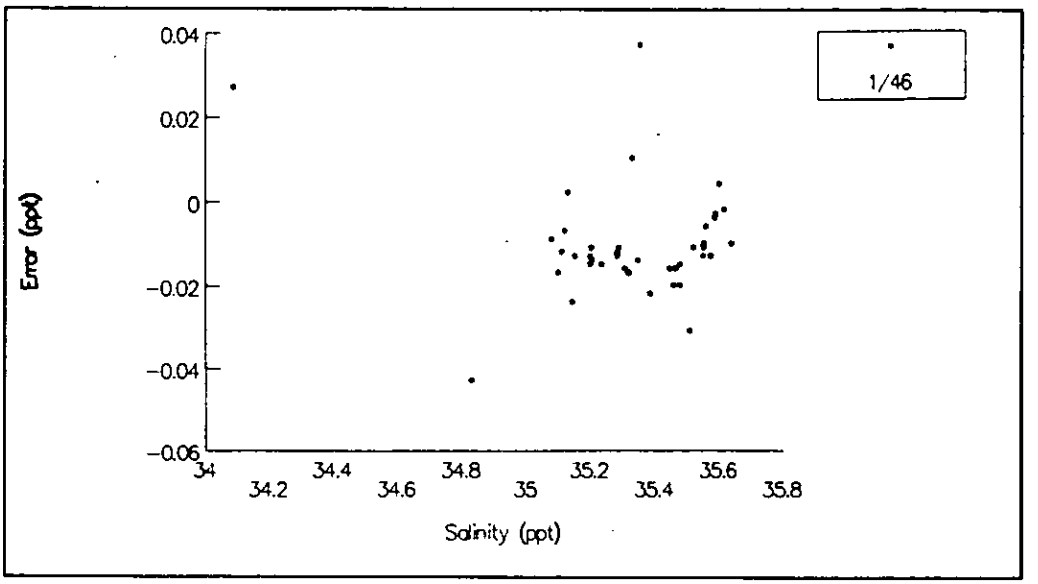

Figure 1. Error Sea-Bird SBE 9 versus Beckmann RB7 salinometer.

5.2.2. Salinity spiking of the SCTD measurements.

In order to improve the performance of the salinity measurements, the Sea-Bird SBE 9 has a Temperature and Conductivity (TC) duct with an inertia-balanced pump flow.

The salinity spiking alignment computer program has been applied on the SCTD data (sampling speed 12 samples per second) to minimize the salinity spiking.
See also "JGOFS 90, RV BELGICA cruise 90/18, MUMM contribution Volume I : Report, J. Backers, A. Pollentier.".

5.3. Dissolved oxygen.

The Sea-Bird SBE 9 is equipped with a Dissolved Oxygen sensor model SBE 13. This dissolved oxygen sensor is a "Beckmann" polarographic type which produces an oxygen-dependent electrical current and incorporates a thermistor for determination of the membrane temperature. The computation of dissolved oxygen is made arithmetically according to the methods outlined by Owens and Millard.

The DO sensor has not been recalibrated at sea. However the data have been corrected using the oxygen measurements from the Laboratoire d'Océanographie - Ulg (Winkler method). A mean deviation of +4.4 % for the stations 1 to 12, and a mean deviation of -3.08 % for the stations 18 to 25 has been observed. The data in the Appendices to this report are corrected for these deviations. Figure 4 shows the deviation at -10 m before and after correction using the ULg DO-data.

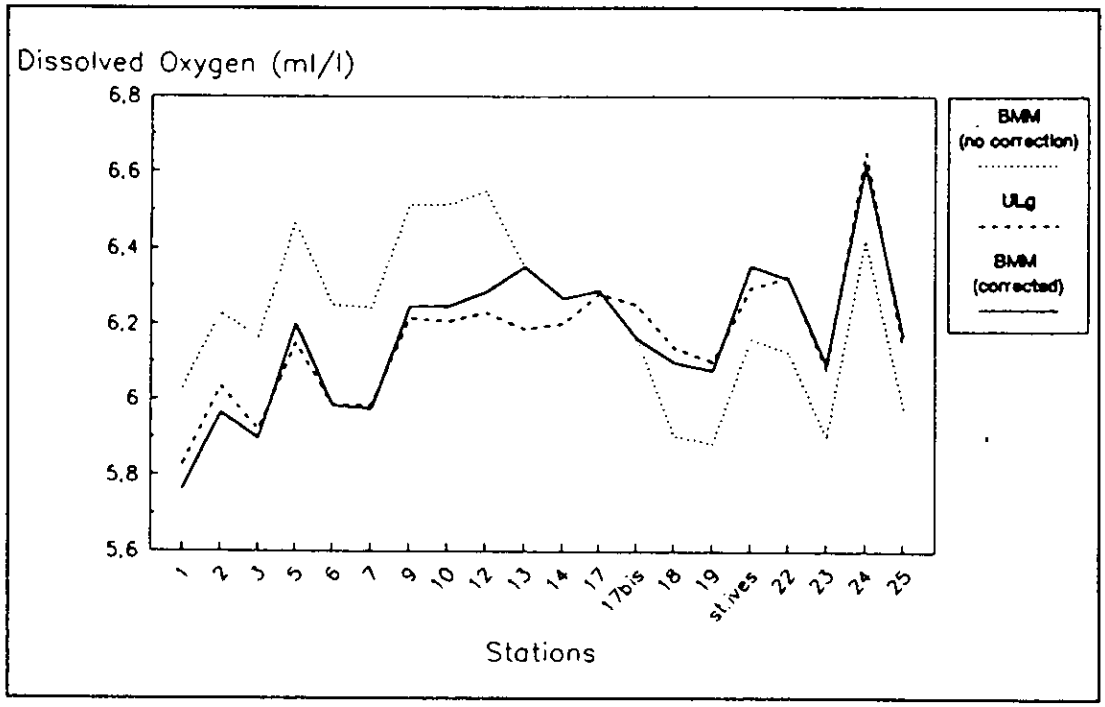

Figure 4. % Deviation between DO data ULg and MUMM, before and after correction.

5.4. pH sensor.

Sea-Bird Electronics, Inc. specifies a long term drift of 1 % per day for the pH sensor. The pH measurements performed with the SBE 9 pH sensor show a drift of about 0.25 % per day (see Figure 5.). The data in the Appendices to this report has been corrected for this drift.

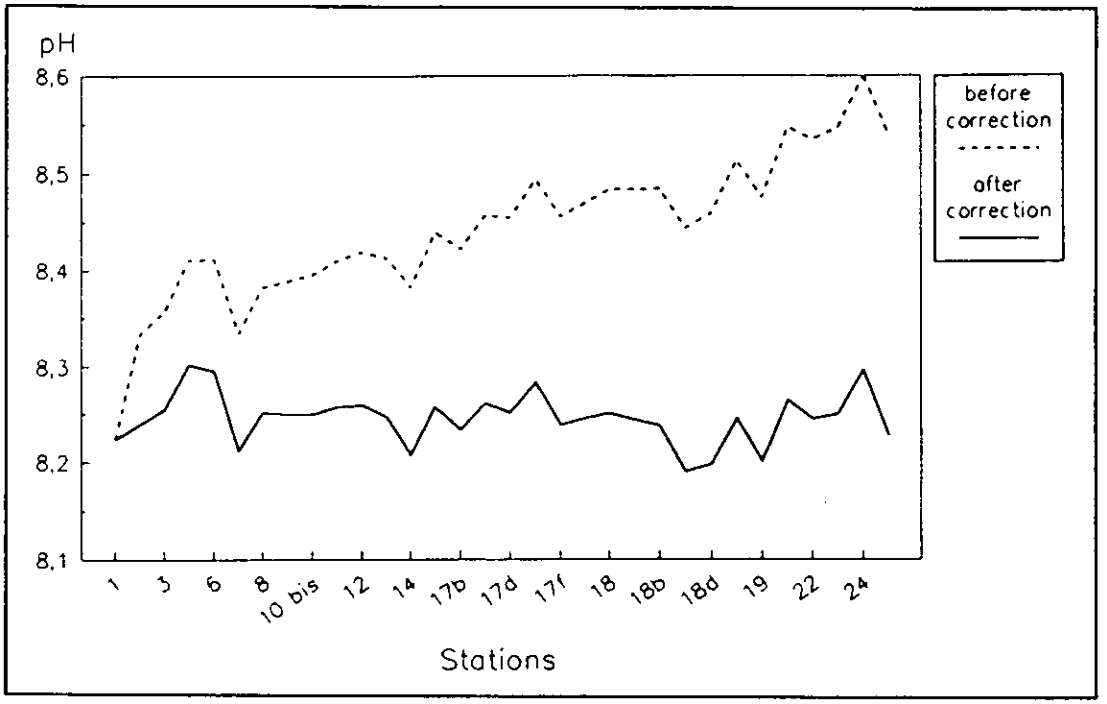

Figure 5. pH values at -3m before and after correction.

5.5. Temperature data.

As mentioned in par. 2.2, the Rosemount temperature sensor broke down on the 30th of June. From then on, the listings and plots (see Appendices Volume II) contain the SBE 19 SCTD-temperature data. The latter has been corrected for the warming up of the seawater in the special seawater circuit. An analysis of the temperature data obtained during the first 6 days of the campaign with the Rosemount sensor and the SBE 19 SCTD showed a warming up of 0.323 °C with a standard deviation of 0.04 °C.

5.6. Data validity.

One of the features of the ODAS package is that it verifies all subsystems, instruments and parameters interrogated.

To each parameter value, subsequently logged in the ODAS files, one byte is added to take into account these data validity checks.

The validity is also shown on the data listings (see Volume II: Appendices) and transferred to the ASCII files. The following code is used :

Code	Meaning
M	Malfunction of a subsystem.
U	No update of the data since the previous logged value.
V	Data not valid (e.g. test on data string format failed).
D	Range error of the DVM subsystem.
R	Lower/upper range test.
G	Gradient test.
=	Not used.
S	Suspected data indication given by e.g. a positioning system.

6. REVIEW OF LISTINGS AND PLOTS.

All listings and plots of the RV BELGICA GLOBAL CHANGE 91/16 campaign are compiled in "VOLUME II : Appendices". A review of the contents of this volume is given in supra.

Appendix 1. Plot with station annotations and list of positions.

Table 1. Station positions.

Figure 1. Station positions on chart.

Appendix 2. Position data and meteorological data during the complete campaign.

Listing 1. Navigational data every 30 minutes.

Figure 2. Trackplot of the complete campaign.

Listing 2. Meteorological data every hour.

Figure 3 & 4. Graphplot showing airtemperature, atm. pressure, solar radition, windspeed and -direction.

Appendix 3. Horizontal profiles.

Listing 3. Oceanographic data, listed every 30 minutes.

Figure 5 & 6. Graphplot showing seatemperature and fluorescence during horizontal profiling.

Figure 7 & 8. Graphplot showing salinity and density (sigma Θ) during horizontal profiling.

Appendix 4. Vertical profiles with SCTD.

Tables 2 to 33. Tables giving the values of the oceanographic parameters at the SCTD water sampling points.

Figure 9 to 39. Vertical profiles of temperature, salinity and density

Figure 40 to 70. Vertical profiles of pH and dissolved oxygen.

Appendix 5. Vertical profiles of incident light (quantameter).

Figure 71 to 75. Graphplot of incident light vs. depth and listing of incident light, 1 value per meter

Appendix 6. Hydrocarbons measurements.

Table 34. Table giving the hydrocarbons measurements.

Figure 76. Chartplot showing the Chelsea fluorimeter hydrocarbons measurements.