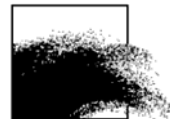


MANAGEMENT UNIT OF THE
NORTH SEA MATHEMATICAL MODELS

REMOTE SENSING AND
ECOSYSTEM MODELLING TEAM



Cruise Report - Belgica campaign B09-24 (15-18.09.2009)

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1 Introduction and participants

This report summarises scientific activities of all projects participating in *Belgica* cruise 2009/24. For a more detailed description and/or reports on the data or scientific analysis the reader is advised to contact the scientists concerned. The list of scientists participating in this cruise is given in Table 1.

Table 1. List of participants.

Name	Institution-Team	Project
RUDDICK Kevin	MUMM	BELCOLOUR-2
NEUKERMANS Griet	MUMM	BELCOLOUR-2
VAES Tom	MUMM (student)	BELCOLOUR-2
LOISEL Hubert	ULCO (guest MUMM)	guest
ASTORECA Rosa	ULB/ESA	BELCOLOUR-2
ROUSSEAU Véronique	ULB/ESA	AMORE-3
DENIS Kevin	UMH	AMORE-3
DOXARAN David	LOV	BELCOLOUR-2
SUYKENS Kim	ULg	BELCOLOUR-2
ELSA BRETON	ULCO (guest MUMM)	Guest
CABITRA ANDRADE DOS SANTOS Ines	ULB/ESA (student)	AMORE-3
BRIOSCHI Lorenzo	ULB/ESA (student)	AMORE-3
TOTAL aboard	12	

2 Campaign objectives

2.1 BELCOLOUR-2 : MUMM+ULB/ESA+ULg

The general objective of the BELSPO-funded BELCOLOUR-2 project is to improve the quality of existing optical remote sensing products for marine, coastal and inland waters based on new scientific knowledge and to develop new products (including partial pressure of CO₂ and primary production) for key applications such as aquaculture and air-sea CO₂ flux quantification. In addition to algorithm work and image processing BELCOLOUR-2 participates in seaborne cruises for the purposes of calibration of algorithms and for validation of the end products. The primary objectives of this campaign are making in-situ measurements simultaneous with satellite overpasses of MERIS (Medium Resolution Imaging Spectrometer) and MODIS (Moderate Resolution Imaging Spectrometer), measurements of a very detailed set of apparent and inherent optical properties (optical closure, characterisation of specific inherent optical properties for use in algorithm calibration/evaluation) and measurement of carbon-related parameters (partial pressure of CO₂, primary production).

The *Université Littoral Côte d'Opal* participates in this cruise through an *ad hoc* collaboration in optical property measurements. A student of the *Vrije Universiteit Brussel* participates in this cruise as part of an ECOMAMA Masters thesis collaboration with MUMM.

2.2 AMORE-3: ULB-ESA + UMH

The research project AMORE-3 seeks to contribute to the development of Sustainability Science for the management of coastal zones. In particular AMORE-3 address the dual control of changing human activity and climate on eutrophication processes in the Belgian coastal zone and the feedback effect of eutrophication on goods (newly-deployed offshore mussel farming) and services (atmospheric CO₂ absorption) provided by the Belgian coastal zone.

ULB-ESA objectives of the cruise are the study of phytoplankton ecophysiology and more particularly photoadaptation properties.

ULB-ESA + UMH has as objective testing the FlowCAM, a real-time digital imaging flow cytometry in field conditions, and more particularly the possibility for continuous measurements and real time analysis of natural phytoplankton communities present in spring in the Southern Bight of the North Sea.

2.3 ULCO-Phytoplankton

The objectives of this campaign were:

- to collect water samples of various hydrological properties and composed by various phytoplankton assemblages to study their influence on the spatial dynamics of nano- and micro detrital particles in the southern Bight of the North Sea.
- to collect various living solitary centric diatom species in order to cultivate them further in the laboratory (Laboratoire d'Océanologie et de Géosciences, Wimereux). These cultures will be used by Hubert Loisel to quantify the optical properties of various phytoplankton species.

2.4 ULCO-Optics

The objectives of this campaign were:

- to quantify high frequency fluctuations of optical parameters in relation to turbulence
- to study the optical properties of suspended matter in the Southern North Sea

3 Summary of operations

3.1 Planned operations

The cruise plan was designed to allow:

- Daytime (8:00 – 18:30) optical measurements for the BELCOLOUR-2 project at a range of stations in Belgian waters, along the “Harwich transect” in UK waters and near the Scheldt estuary in Dutch waters and at arbitrary places at the time of satellite overpasses. An estimated 22 stations were planned.
- Simultaneous measurements of phytoplankton, including measurements using the FlowCAM, for the AMORE project at a subset of the BELCOLOUR-2 stations.
- Possible >4h cycle night-time measurement at a fixed station to quantify high frequency fluctuations of optical parameters in relation to turbulence.
- Possible continuous 6h day time measurement of optical properties of suspended matter, reflectance and concentration if cloudfree for SEVIRI TSM (Total Suspended Matter) validation.

3.2 Implementation of planned operations

Efficient working allowed the operations to be maximally implemented:

- 19 out of 22 planned stations were sampled for the BELCOLOUR-2 project,
- one 12h cycle night-time measurement was conducted at station 0924A from 14:00UTC on September 16th until 2:00UTC on September 17th.

However, due to continuous overcast skies no satellite match-ups were achieved and the SEVIRI TSM validation could not be conducted. On 3 stations the ULCO optics package was not deployed due to high wind and wave action.

An additional TSM filtration experiment was conducted on board on 3 water samples of very different turbidities, from the clear to the very turbid, to demonstrate the importance of filtration volume on the accuracy of the TSM concentration determination.

The objectives of the campaign were fulfilled for all teams onboard.

4 Overview of measurement stations

An inventory of samples collected is given in Table 2. Figure 1 maps the stations sampled during this campaign. At the WGAB station, no reflectance measurements were done (night time). On 3 stations the ULCO optics package was not deployed due to high wind and wave action.

Table 2. Sampling at each station.

Station	Date	Time (UTC)	Lat (° ' N)	Lon (° ' E)	Refl	water sample	CTD	Optics ULCO	Ulg	AMORE3
W04	15-Sep-2009	9:31	51°25.183'	3°15.181'	x	x	x	x	x	x
S03	15-Sep-2009	12:15	51°22.132'	3°43.852'	x	x	x	x	x	x
S01	15-Sep-2009	13:11	51°25.072'	3°34.076'	x	x	x	x	x	x
250	15-Sep-2009	15:14	51°32.206'	3°15.926'	x	x	x	x	x	x
W07	15-Sep-2009	16:34	51°34.932'	3°0.102'	x	x	x	x		x
W02	16-Sep-2009	6:33	51°13.354'	2°51.315'	x	x	x	x	x	x
W03	16-Sep-2009	7:23	51°10.657'	2°43.167'	x	x	x	x	x	x
0924A	16-Sep-2009	12:57	51°26.012'	3°28.47'	x	x	x	x	x	x
W09	17-Sep-2009	7:14	51°44.718'	2°41.609'	x	x	x		x	x
W10	17-Sep-2009	8:51	51°41.109'	2°25.219'	x	x	x		x	x
MH3	17-Sep-2009	10:44	51°44.526'	2°6.114'	x	x	x	x	x	x
MH4	17-Sep-2009	12:06	51°47.899'	1°52.867'	x	x	x		x	x
MH5	17-Sep-2009	13:38	51°50.954'	1°38.965'	x	x	x	x	x	x
MH6	17-Sep-2009	14:42	51°52.58'	1°31.14'	x	x	x	x	x	x
HARE	17-Sep-2009	16:05	51°55.017'	1°25.883'	x	x	x	x	x	x
WGAB	17-Sep-2009	21:31	51°57.630'	2°05.510'		x	x	x	x	x
702N	18-Sep-2009	6:09	51°23.861'	3°18.103'	x	x	x	x	x	x
700	18-Sep-2009	6:50	51°22.726'	3°12.676'	x	x	x	x	x	x
W01	18-Sep-2009	7:21	51°22.486'	3°11.588'	x	x	x	x	x	x

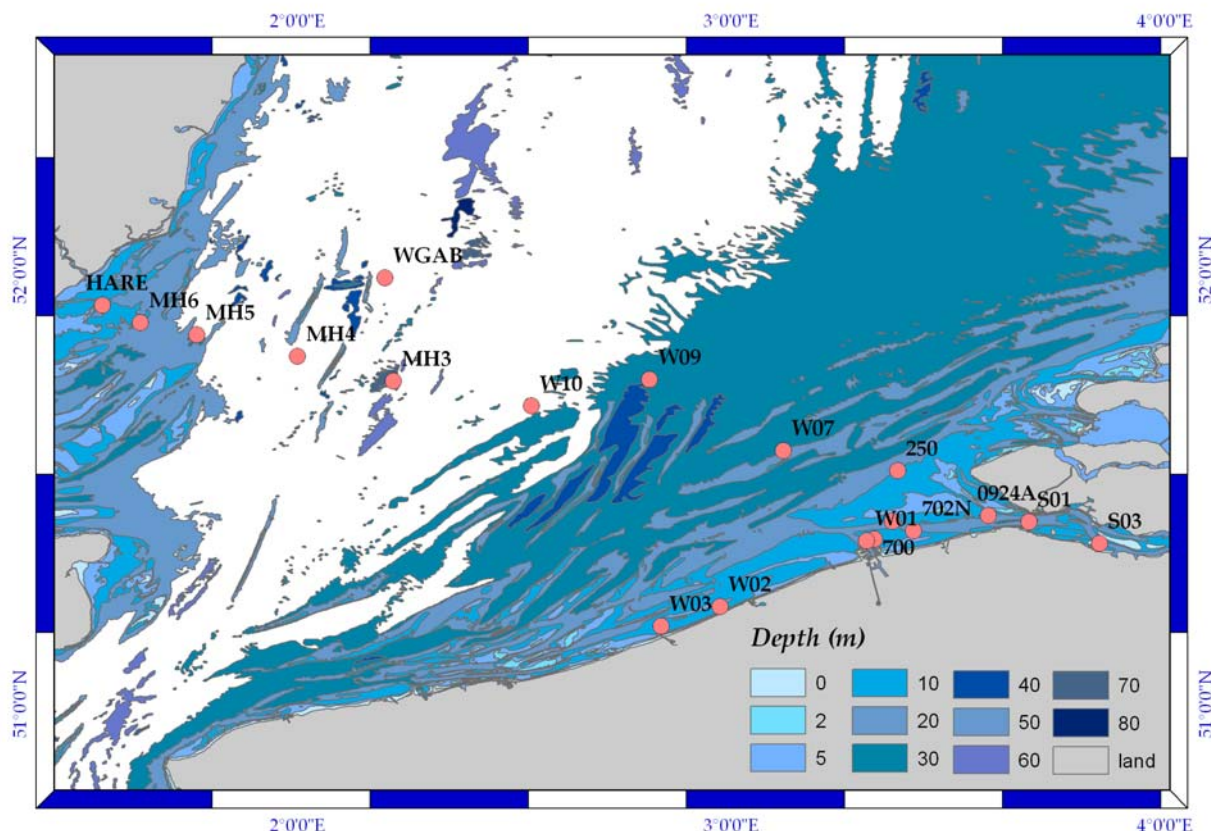


Figure 1. Overview of the stations sampled for BELCOLOUR-2 and AMORE-3. 12h cycle measurements were conducted at station 0924A.

4.1 BELCOLOUR-2

At 18 stations the following standard set of observations were made for the BELCOLOUR project:

- Above-water reflectance measurements with TriOS-RAMSES spectroradiometers (MUMM)
- Subjective description of sea/sky state (wave height, foam fraction coverage, cloud fraction, sun visibility, etc.) and sea/sky photos (MUMM)
- SeaCAT profile (SCTD+OBS+PAR) (MUMM+ULB/ESA)
- Niskin water sample (with CTD) at 0.5m depth for O₂, DIC and Total Alkalinity (ULg)
- Niskin/bucket water sample at -0.5 m for: suspended particulate matter concentration, chlorophyll-a and phaeopigments (MUMM filtration) and turbidity.
- Surface water samples with Niskin bottle and/or bucket for phytoplankton, non-algae particle and coloured dissolved organic matter (CDOM) absorption spectra, as well as chlorophyll a, HPLC pigments, suspended particulate matter and phytoplankton community composition (ULB/ESA-LOV)
- Optical package including hyperspectral absorption measurements and backscattering, particle size distribution with the LISST. Measurements near surface and along the water column (ULCO)
- Secchi depth (MUMM)
- Near infrared absorption (AC9) measurements

At the WGAB station, the above list of measurements were conducted except above-water reflectance (night time).

Two FieldCAL calibrations at the beginning and the end of the campaign were made for all the MUMM spectroradiometers to allow an assessment of potential sensor drifts between measurements on this and previous or later cruises.

Partial pressure of CO₂ (pCO₂) was measured continuously during this cruise.

5 Problems and remarks concerning measurements, equipment and operations

- TriOS ACC suffered communication errors problems during cruise start fieldCal (abandoned), but otherwise functioned well.
- The Turner fluorometer gave strange readings at cruise start (pump off) and later did not communicate data to ODAS
- Ship Motorolas malfunctioned and were often not available in sufficient numbers for scientists (3).

6 Auxiliary hydro-meteo parameters

The ODAS auxiliary hydro-meteo data are available online at http://www.mumm.ac.be/Common/Belgica/Campaigns/Odas/od2008_10.dat

7 Team reports

Each team was asked to provide a brief report of the extent to which the cruise objectives of section 2 were fulfilled. These reports are reproduced in the following sub-sections.

7.1 BELCOLOUR-2

The data collected during this cruise meet most cruise objectives of BELCOLOUR-2 stated in section 2. An overview of the measurements is given by each research team under here.

7.1.1 MUMM

Due to continuous overcast skies no satellite match-ups were achieved and the SEVIRI TSM validation could not be conducted. An overview of the station metadata are given in table 7

Table 7. Metadata for the BELCOLOUR-2 samples taken by MUMM

Station	Date	Time (UTC)	Lat (° ' N)	Lon (° ' E)	Depth (m)	Wind (m/s)	PAR (w/m2)	SeaTemp (°C)	Sal (PSU)	Secchi (m)
W04	15-Sep-2009	9:31	51°25.183'	3°15.181'	14.8	8.8	143.0	17.5	33.452	1.10
S03	15-Sep-2009	12:15	51°22.132'	3°43.852'	12.0	7.2	158.0	17.7	29.171	1.00
S01	15-Sep-2009	13:11	51°25.072'	3°34.076'	21.9	7.5	618.0	17.6	31.969	1.60
250	15-Sep-2009	15:14	51°32.206'	3°15.926'	10.6	7.9	98.0	17.4	33.086	1.50
W07	15-Sep-2009	16:34	51°34.932'	3°0.102'	26.2	12.7	69.0	18.1	34.555	1.50
W02	16-Sep-2009	6:33	51°13.354'	2°51.315'	10.0	11.4	26.0	17.2	33.123	0.40
W03	16-Sep-2009	7:23	51°10.657'	2°43.167'	10.0	11.2	58.0	17.2	33.084	0.40
0924A	16-Sep-2009	12:57	51°26.012'	3°28.47'	16.1	12.6	189.0	17.4	32.704	1.00
W09	17-Sep-2009	7:14	51°44.718'	2°41.609'	37.0	9.8	98.0	17.7	34.870	6.00
W10	17-Sep-2009	8:51	51°41.109'	2°25.219'	43.0	10.9	109.0	34.9	34.910	5.00
MH3	17-Sep-2009	10:44	51°44.526'	2°6.114'	56.0	7.4	230.0	17.6	35.043	5.50
MH4	17-Sep-2009	12:06	51°47.899'	1°52.867'	27.8	11.1	218.0	17.6	35.012	1.80
MH5	17-Sep-2009	13:38	51°50.954'	1°38.965'	22.7	10.5	237.0	17.3	34.732	0.30
MH6	17-Sep-2009	14:42	51°52.58'	1°31.14'	15.7	11.0	180.0	16.8	34.592	0.40
HARE	17-Sep-2009	16:05	51°55.017'	1°25.883'	13.4	9.0	92.0	16.6	34.570	0.60
WGAB	17-Sep-2009	21:31	51°57.630'	2°05.510'		4.0	0.0	17.6	34.889	
702N	18-Sep-2009	6:09	51°23.861'	3°18.103'	10.6	5.8	67.0	17.0	32.204	0.20
700	18-Sep-2009	6:50	51°22.726'	3°12.676'	11.0	6.4	160.0	16.9	32.222	0.30
W01	18-Sep-2009	7:21	51°22.486'	3°11.588'	14.1	6.4	238.0	16.9	32.232	0.50

7.1.2ULB/ESA

The objectives of the campaign were to sample different types of water for IOPs measurements and to test the new instrument, the PAM fluorometer, for calculation of photosynthetic efficiency of phytoplankton. ¹⁴C radioactive incubations were performed in parallel in order to assess the photosynthetic capacity of phytoplankton to incorporate carbon. Both results (¹⁴C incubations vs PAM light curves) will be compared later. The objectives were fully fulfilled; measurements were carried out successfully and are listed in the Table below.

Date	Station	absorpt ion	HPLC	CDOM	Chl-a	SPM	ac9	PAM	Phyto
15/09	W04	3	2	1	1	1	2	1	1
	S03	3	2	1	1	1	2	1	1
	S01	3	2	1	1	1	2	1	1
	250	3	2	1	1	1	2	1	1
	W07	3	2	1	1	1	2	1	1
	W05	3	2	1	1	1	2	1	1
16/09	W02	3	2	1	1	1	2	1	1
	W03	3	2	1	1	1	2	1	1
	0924A	3	2	1	1	1	2	1	1
	0924B			1					
	0924C			1					
	0924D			1			1		
	0924E			1			1		
	0924F			1			1		
	0924G			1			1		
17/09	W09	3	2	1	1	1	2	1	1
	W10	3	2	1	1	1	2	1	1
	MH3	3	2	1	1	1	2	1	1
	MH4	3	2	1	1	1	2	1	1
	MH5	3	2	1	1	1	2	1	1
	MH6	3	2	1	1	1	2	1	1
	HARE	3	2	1	1	1	2	1	1
	WGAB	3	2	1	1	1	2	1	1
18/09	702N	3	2	1	1	1	2	1	1
	700	3	2	1	1	1	2	1	1

W01 3 2 1 1 1 2 1 1

Report by Rosa Astoreca.

7.1.3 ULg

The parameters sampled were Total Alkalinity (TA), Oxygen (O₂), pH, dissolved inorganic carbon (DIC) at each station and partial pressure of carbon dioxide (pCO₂) continuously during the whole campaign:

date:	stations:	parameters: TA O ₂ DIC pH			
15/09/09	W04	y	y	y	y
15/09/09	S03	y	y	y	y
15/09/09	S01	y	y	y	y
15/09/09	250	y	y	y	y
15/09/09	W07	n	n	n	n
15/09/09	W05	n	n	n	n
16/09/09	W02	y	y	y	y
16/09/09	W03	y	y	y	y
16/09/09	0924a	y	y	y	y
17/09/09	W07	y	y	y	y
17/09/09	W10	y	y	y	y
17/09/09	MH3	y	y	y	y
17/09/09	MH4	y	y	y	y
17/09/09	MH5	y	y	y	y
17/09/09	MH6	y	y	y	y
17/09/09	HARE	y	y	y	y
17/09/09	WGAB	y	y	y	y
18/09/09	702N	y	n	y	y
18/09/09	701	y	n	y	y
18/09/09	W01	y	n	y	y

All ULg instruments worked correctly and no samples were lost.

All objectives were achieved.

Report by Kim Suykens

7.2 AMORE FlowCAM report

7.2.1 Stations sampled

Only 10 stations were sampled with the updated FlowCAM during this cruise because of the bad weather: W04, S03, S01, 250, W07, W02, 0924A, MH3, MH4 and WGAB.

7.2.2 Goals

During this cruise, the following points have been evaluated :

- the behavior of the “updated” FlowCAM in real conditions
- the estimation of abundance in particle / mL (previously only relative abundance was provided)
- pumping of sea water directly in the FlowCAM and digitization of detected particles

7.2.3 Conclusions and limitations

FlowCAM behaviour:

The “updated” FlowCAM provides good quality images in real conditions when discrete samples are digitized but image quality decreases when sea water is pumped directly in the FlowCAM (more bad focused particles, first tests were performed during cruise 2009-06-16_20).

The image quality of the “updated” FlowCAM has changed, probably because of the new method to parametrize the background illumination.

Moreover, the same particle is sometimes detected more than one time by the FlowCAM because of the movements of the boat and the peristaltic pump.

Automatic recognition:

The implementation of automatic recognition in near real time (each 15 seconds) in the Zoo/PhytoImage assistant is now functional and will be released with the version 2 of the software (Fig. 1), for each test, the process was done without any problem or bug.

Moreover, the estimation of abundance in particles per mL is now available in Zoo/PhytoImage and graphs of the evolution of abundance can be provided (Fig. 2). This new graphical presentation will be very useful to detect changes in communities along transects in the Belgian coastal zone.

The system is currently able to compare real abundances (new), relative abundances, size spectra and relative biomass for the total sample or by groups automatically recognized by Zoo/PhytoImage.

The particles detected by the updated FlowCAM are not well recognized by the previous classifiers (created using images from the FlowCAM before the update), probably because of the different image quality.

A systematic gray scale calibration is now done before each digitization. This step should decrease variations in image quality from one digitization to an other and thus increase recognition rates. Moreover, new samples have been digitized to provide new images in order to create new classifiers able to recognize particles digitized with the updated FlowCAM.

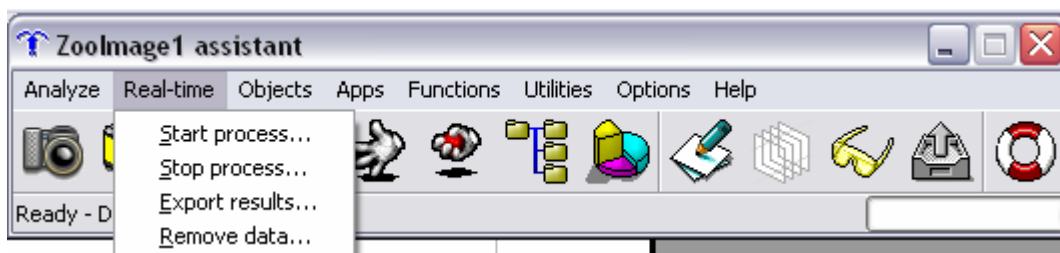


Figure 1: Implementation of the real time analysis in the Zoo/PhytoImage assistant. The user can now uses the menu to perform a real time analysis of FlowCAM experiment.

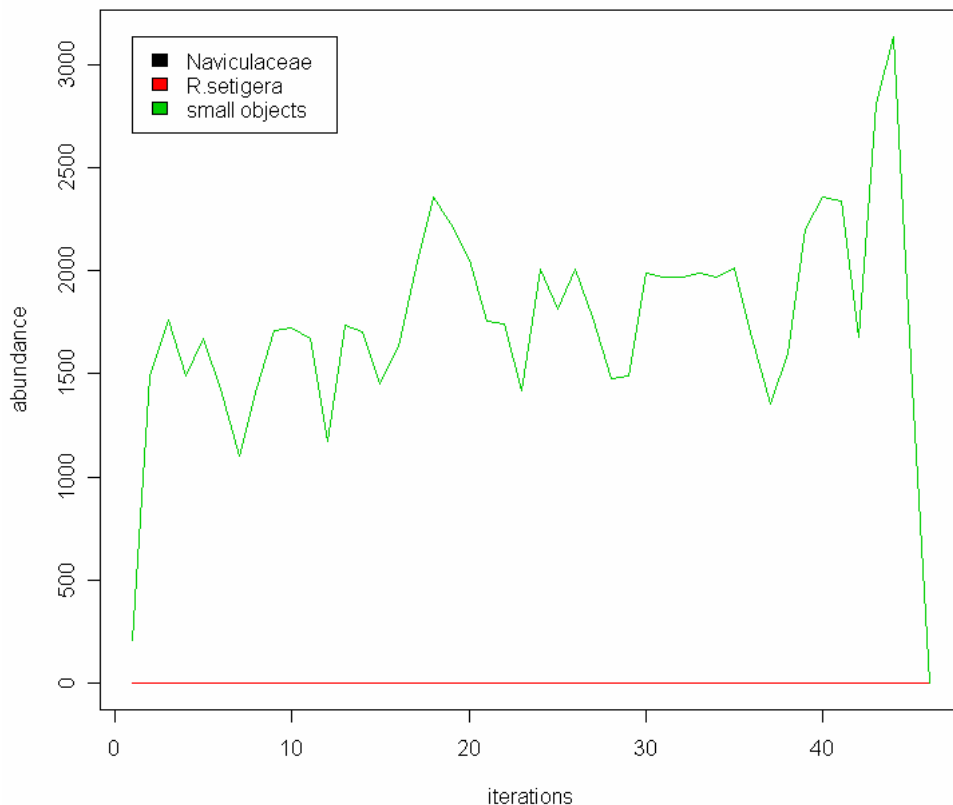


Figure 2 : new graphical presentation of the evolution of abundance (particles / mL) for 3 groups recognized by Zoo/PhytoImage at S01 station.

Pumping and image quality:

The pumping system (composed by two peristaltic pumps) was not tested during this cruise because of the bad weather. Anyway, the previous cruise showed that improvements must be done in order to have a good image quality during pumping. These first tests were encouraging, pumping sea water directly in the FlowCAM is now possible.

7.2.4 Challenges and improvements

Optimize image quality for the continuous pumping system (work in progress but not possible to test during this cruise because of the bad weather).

Improve the training sets using new images of contrasted stations in order to better recognize particles detected by the updated FlowCAM (work in progress).

Improve the biomass calculation especially for colonial groups (work in progress).

Develop a system of 'semi-automatic' recognition to improve recognition of particles by Zoo/PhytoImage (work in progress).

Develop a system to eliminate particles detected more than one time based on their similarity (to do).

Report by Kevin Denis

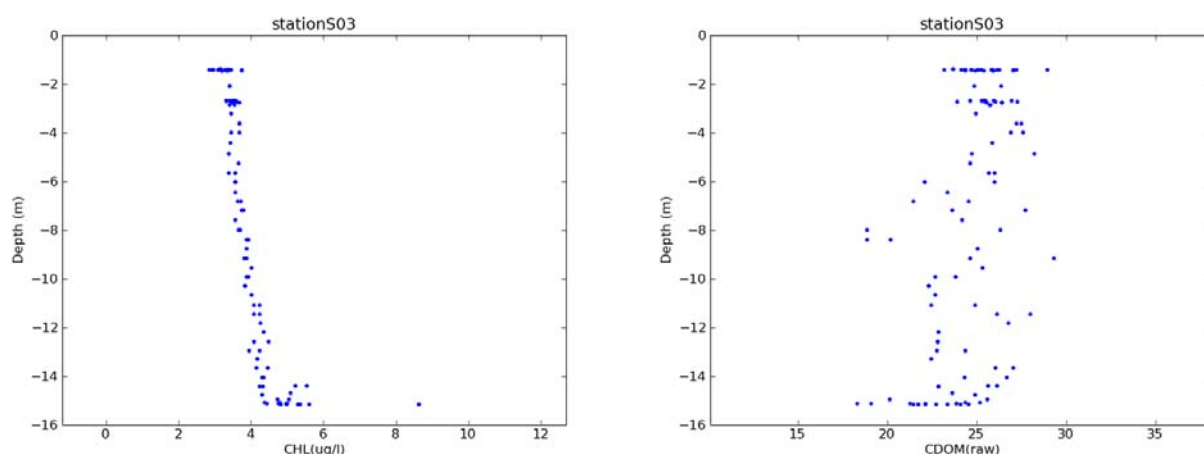
7.3 ULCO-Phytoplankton

This mission was a success since it allowed me to collect water samples at all sampled stations (a total of 20 stations) and at one station (O924A) located at the entrance of the Scheldt estuary during 12 hours with a hourly frequency. In addition, a total of 15 living solitary centric species were microscopically isolated. It should be noted that microscope observations allowed too detection of a toxic raphidophyceae (*Heterosigma akashiwo*, identification made by V. Rousseau), mainly concentrated in coastal English waters (stations MH5, MH6, Hare, and Wgab). Attempts will be made to cultivate them to calibrate further the Belgian Flowcam and study optic properties of this toxic flagellate.

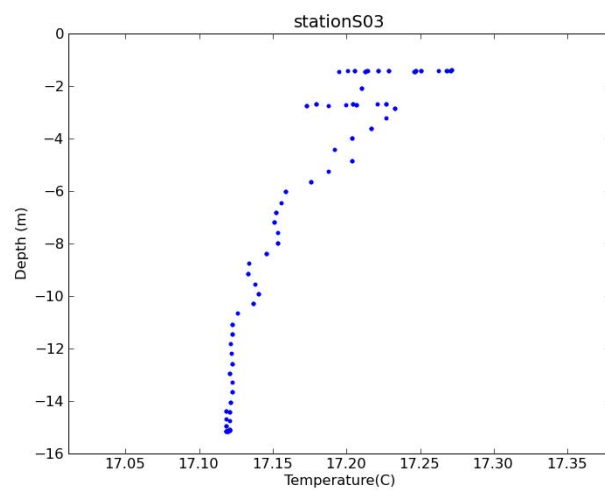
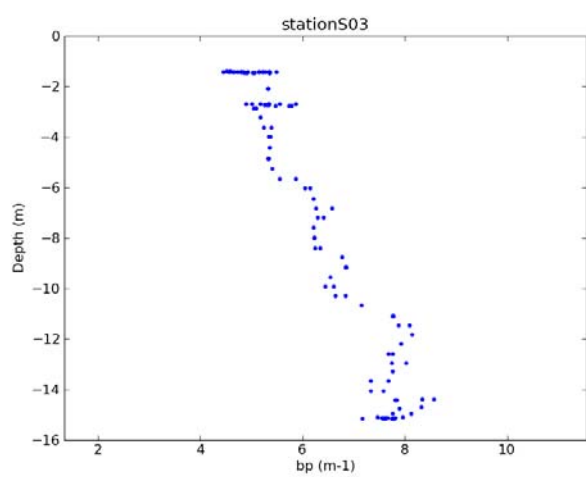
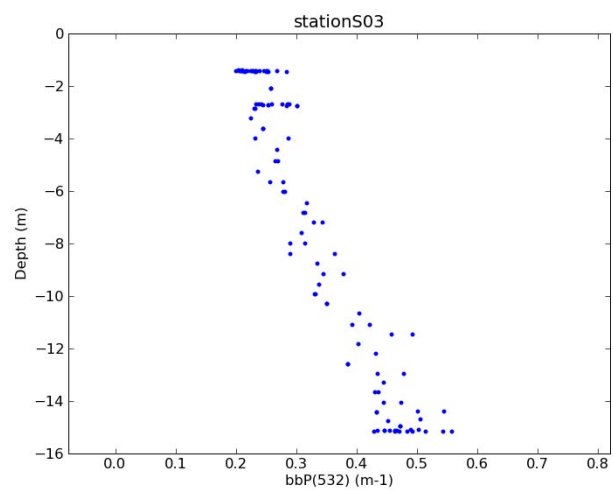
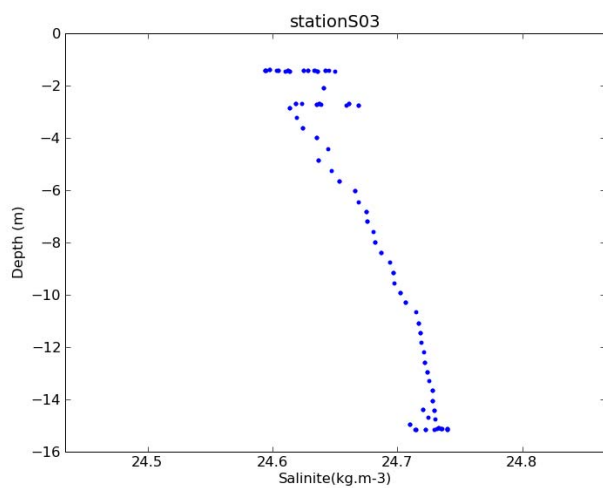
Report by Elsa Breton

7.4 ULCO-Optics

ULCO recorded fluorescence-CDOM-temperature-salinity (CTD), absorption-scattering-attenuation



(WetLabs AC-S), backscattering (Wetlabs BB9). An example of vertical profiles of the recorded parameters is given in the attached figure for Station S03. The current speed and direction (ADV) was recorded with an ADV during 13h of measurements at station 0924A. All instruments functioned well and no problems were encountered.



All objectives have thus been met.

Report by Hubert Loisel

COLOPHON

This report was issued by MUMM in October 2009.

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 ☐ revised version of document
 ☐ confidential

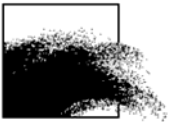
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