Report of WP1 Workshop
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Introduction

The WP 1 group met for its 2. workshop in Lisbon on April 26, in connection with a WP2 workshop. Most of the time was dedicated to the planning of the important WP1 cruise, RRS Charles Darwin cruise 114, in July/August 1998. The meeting took place at the Instituto Superior Technico in Lisbon under the local organisation of Ramiro Neves. The among others, the following persons participated:

Toby Sherwin, Steve Groom, Ramiro Neves, Des Barton, Ian Joint, Søren Larsen, Sonia Batten, Paul Wassmann, Francisco Figueiras, Helena Galvao, Peter Burkill, Elaine Fileman, a representative for Michel Frankignoulle, Lei Chou, Andrew Hirst, Christian Wexels Riser, Steward Gibbs, Kalle Olli, Elisabeth Halvorsen, Klaus-Günther Barthel.

The meeting started at 09.00 with a general introduction and a presentation of important details regarding the cruise. A discussion was carried out regarding the various activities on the two legs of the cruise. After lunch, 3 groups were formed to discuss in greater detail the implications of the cruise outline with regard to their specific plans and the demands of the Technical Annex. These comments were presented in detail and at the end of the day the final outline of the both cruise schedules were presented before the meeting was terminated at about 18.00. Minor discussions and arrangements were made during the WP2 meeting which was carried out Monday to Tuesday.

WP1 Cruise Outline for RRS Charles Darwin cruise 114

The dates of the cruise are 29 July to 24 August. The ship will sail from the UK on 29 July and people and equipment will join the ship by boat transfer in the Ria of Vigo; there will also be a mid-cruise exchange of personnel. The groups which will participate on each leg of the cruise are shown in the table below.

Table 1. Cruise participation

Leg 1			**Leg 2**		
Institution	PI	Berths	Institution	PI	Berths
PML-a	Stuart Gibb (Chief Scientist)	1	PML-c (Chief Scientist)	Ian Joint	1
UITØ-a	Paul Wassmann	1	UITØ-a	Paul Wassmann	2
UITØ-b	Kurt Tande	1	UITØ-b	Kurt Tande	2
PML-b	Peter Burkill	1	PML-b	Peter Burkill	1
PML-c	Ian Joint	2	PML-c	Ian Joint	2
UWB-a	Toby Sherwin	2	UWB-a	Toby Sherwin	2
UWB-b	Des Barton	1	UWB-b	Des Barton	1
IIM	Paco Figueiras	3			
SAHFOS_	Sonia Batten	1			
UAL-a	Helena Galvao	1	UAL-a	Helena Galvao	1
ULg	M. Frankignoulle	1	Ulg	M. Frankignoulle	1
RVS Winch		1	RVS Winch		1
RVS Winch		1	RVS Winch		1
RVS Computing		1	RVS Computing		1
RVS CTD Technician		1	RVS CTD Technician		1
Total		18	Total		18

The cruise will investigate two regions. On Leg 1, the sampling will concentrate on the shelf in the vicinity of an upwelling. On Leg 2, sampling will target a filament and measurements will be made as the filament moves off shelf. In both experiments, extensive use will be made of satellite images which will be processed at the PML and transmitted to the ship. AVHRR sensors will provide temperature images up to 4 times daily and SeaWiFS should provide an image of chlorophyll distribution at about daily intervals. In addition, during Leg 1, sampling by the OMEX Work Package 2 cruise (Dr Antonio Bode Chief Scientist) will produce data over a wider spatial scale. Close contact will be maintained between the two ships. When the ships are sampling in the same area, samples will be exchanged for an intercalibration of temperature, salinity, phytoplankton pigments, DOC and phytoplankton production

Leg 1 Shelf Experiment

The aim of the experiment is to measure changes in biological activity in shelf waters in response to upwelling of nutrient-rich waters from the deep ocean onto the shelf. A particular emphasis of this experiment will be the measurement of phytoplankton processes, but measurements will also be made of microzooplankton, mesozooplankton and bacteria. In addition, analyses will be done or samples taken for phytoplankton pigments, dissolved organic carbon, dissolved CO2 and carbonate.

The experimental design will involve the release of an Argos drifting buoy on the shelf which will then be followed for 2-3 days. Water and plankton samples will be taken throughout the day and night to measure changes in plankton biomass and activity. In addition, there will be repeat measurements of the physical structure of the water column using CTDs and ADCP on a small grid of stations round the Argos buoy. Turbulence measurements will be made with the turbulence probe FLY. The daily timetable of sampling activities is shown in Table 2.

Table 2 Sampling activities on each of the 2-3 days following an Argos drifting buoy on Leg 1 of the cruise.

Time	Duration (h)	Activity	Partners
00.00	0.5	CTD/faecal	UITØ
00.30	1	MOCNESS	UITØ
01.00		MOCNESS	
01.30			
02.00			
02.30			
03.00	0.5	GO-FLO	PML-b
03.30	1.5	CTD/rosette	PML-a/c, IIM. UAG
04.00		CTD/rosette	
04.30		CTD/rosette	
05.00	1	Rig Deployment	
05.30		Rig Deployment	
06.00	1	MOCNESS	UITØ
06.30		MOCNESS	
07.00			
07.30			
08.00			
08.30			
09.00	0.5	CTD/spectroradiometer	IIM
09.30	3	FLY transect	UWB
10.00		FLY transect	
10.30		FLY transect	
11.00		FLY transect	
11.30		FLY transect	
12.00		FLYtransect	
12.30	0.5	Apsteinnet	PML-b
13.00	1	MOCNESS	UITØ

13.30		MOCNESS	
14.00	1	CTD/faecal	UITØ
14.30		CTD/spectroradiometer	IIM
15.00	3	FLY transect	UWB
15.30		FLY transect	
16.00		FLY transect	
16.30		FLY transect	
17.00		FLY transect	
17.30		FLY transect	
18.00	1	MOCNESS	UITØ
18.30		MOCNESS	
19.00			
19.30	1	Rig Recovery	PML-c
20.00		Rig Recovery	
20.30		**FLY Possible**	**UWB**
21.00		**FLY Possible**	
21.30		**FLY Possible**	
22.00		**FLY Possible**	
22.30		**FLY Possible**	
23.00		**FLY Possible**	
23.30			

Bold: This sampling will be done if ship works 24h

It will probably not be possible to follow the buoy for more than 2 to 3 days since it will either drift off the shelf or will be close to the shore. The buoy will, therefore, be recovered and returned to the original station position. One day will then be spent in sampling over a tidal cycle at the original station position; this will provide information on the spatial distribution of plankton and of the physical structure on the shelf..

After sampling this transect for one day, the Argos buoy will be re deployed and the experimental cycle will continue with another 2-3 days following an Argos buoy, with a lateral survey after 3 days. This cycle could be done 3 times during Leg 1. At the end of Leg 1, there will be a change of personnel (by boat transfer in the Ria of Vigo so maximising the time spent at sea during the cruise).

Leg 2 - Filament Experiment

The aim of the Filament Experiment is to track a body of water as it is transported away from the shelf in a filament (N.B. filaments usually form every few weeks when there is strong upwelling but the presence of a filament cannot be guaranteed during Leg 2. In this case, the objectives of the cruise will change in response to the conditions prevailing and the study will focus on either an upwelling or relaxation condition). The emphasis of this Leg of the cruise is on mesozooplankton grazing, but measurements will continue of all parameters measured on Leg 1.

The water mass will be marked with 4 or 5 Argos drifting buoys which will be deployed at the shelf break. Sampling will continue as the Argos buoys are followed over a 7-10 day period. The daily sampling schedule is shown in Table 3.

Table 3 Sampling activities on each day following an Argos drifting buoy on Leg 2 of the cruise in the study of a filament.

Time	Duration (h)	Activity	Partners
00.00	0.5	CTD/faecal	UITØ
00.30	1	Plankton nets	UITØ
01.00		Plankton nets	
01.30			
02.00			
02.30			
03.00	0.5	GO-FLO	PML-b

03.30	1.5	CTD/rosette	PML-a/c, IIM. UAG
04.00		CTD/rosette	
04.30		CTD/rosette	
05.00	1	Rig Deployment	PML-c
05.30		Rig Deployment	
06.00	1	Plankton nets	UITØ
06.30		Plankton nets	
07.00			
07.30			
08.00			
08.30			
09.00	0.5	CTD	PML-c
09.30	3	FLY transect	UWB
10.00		FLY transect	
10.30		FLY transect	
11.00		FLY transect	
11.30		FLY transect	
12.00		FLYtransect	
12.30	0.5	Apstein net	PML-b
13.00	1	Plankton nets	UITØ
13.30		Plankton nets	
14.00	1	CTD/faecal	UITØ
14.30		CTD	PML-c
15.00	3	FLY transect	UWB
15.30		FLY transect	
16.00		FLY transect	
16.30		FLY transect	
17.00		FLY transect	
17.30		FLY transect	
18.00	1	Plankton nets	UITØ
18.30		Plankton nets	
19.00			
19.30	1	Rig Recovery	
20.00		Rig Recovery	
20.30		**FLY Possible**	**UWB**
21.00		**FLY Possible**	
21.30		**FLY Possible**	
22.00		**FLY Possible**	
22.30		**FLY Possible**	
23.00		**FLY Possible**	
23.30			

Bold: This sampling will be done if ship works 24h.

As in Leg 1, there will be small scale surveys around the Argos buoy using CTD and FLY which will last for about 3h each survey.

After 4 or 5 days, this routine sampling will be changed for one day when an intensive CTD and FLY survey will be done. As in Leg 1, the aim is to place the daily measurements into a better spatial context; therefore, a transect will be sampled across the main Argos drift. Sampling on the original schedule will be resumed on the day after the CTD/FLY transect. At the end of the experimental period, the Argos buoys will be recovered and there will be a boat transfer of personnel and equipment in the Ria of Vigo.

STABLE deployment

On passage from the UK, before the beginning of Leg 1, STABLE will be deployed as the ship crosses the Iberian shelf. At the end of Leg 2, after the exchange of personnel and equipment, the ship will recover STABLE on passage from Vigo to the UK.

WP1 Physical oceanography and remote sensing activities for RRS Charles Darwin cruise 114

This summary covers the role played by UWB-a, UWB-b and NSS in the cruise. The overall aim of the physics partners is to define and quantify, as far as possible, the important physical variables contributing to the exchange of material at the Iberian shelf break in summer. The constraints of the sampling programme mean that this will be done by making measurements of physical features on the shelf and in the ocean - measurements at the shelf break itself will not be specifically targeted. We intend to examine how water circulates vertically on the shelf, and vertically and horizontally in the ocean. These processes are essentially determined by mixing from tidal phenomena on the shelf and by filament related structures in the ocean.

Leg 1: On the shelf

The deployment position of the sediment trap will be determined by reference to the proximity of an offshore filament and non-linear internal waves. Information about the location of these phenomena, from AVHRR SST, SeaWiFs ocean colour and SAR, will be relayed to the ship by NSS during the cruise. If required an Argos drifter will be attached to the drifting sediment trap to assist in its location. During the two to three day deployment of the sediment trap UWB-a will conduct CTD/ADCP sections for up to three hours on a line normal to the coast passing through the trap. These sections may sometimes be augmented/replaced by measurements with the FLY turbulence probe by UWB-b. One of the main objectives of this work will be to determine the surface to bottom temperature difference and vertically averaged temperature across the shelf as an indicator of the strength of upwelling. Temporal variations in these quantities may become apparent and may be related to the variations in the wind field. Detailed interpretation of individual profiles may be complicated by the presence of non-linear internal waves, and both the baroclinic and barotropic components of the tide. The drifting nature of the sediment trap experiment may make it difficult to interpret its results in relation to the local physics. (As an aside, and because of this, we suggest that the sediment traps be moored.) In an attempt to overcome some of the temporal variability in this work, 24 hour stations will be worked on three occasions, when the traps are lifted. These will be conducted by deploying a small lightweight moored buoy with thermistors attached, to act as a marker and to measure internal wave activity, and maintaining the ship in the close vicinity of this buoy whilst conducting and a series of CTD and FLY measurements. Ideally these measurements will be made at a location which is representative of the positions last occupied by the drifting trap.

Leg 2: In a filament

A search will be made for a filament using the ship borne thermo-salinograph in conjunction with the latest AVHRR and SeaWiFs images relayed to the ship by NSS. A cluster of 4 Argos drifters drogued at 15 m depth will then deployed by UWB-a over the shelf edge in the root of the filament in an initial area of about 5 km2. One of these drifters may contain a light sensing package. During the next 7 to 10 days the buoys will be used to tag a water mass moving with the filament. About twice a day, for about 4 hours, the ship will make sorties away from the 'centre' of the drogues to conduct a series of CTD/ADCP and FLY sections down to about 300 m in order to establish the context and scale of the drifter movement. Usually the ship will move to a station about 10 km away across the direction of flow and make measurements at about 2 km intervals back to the centre. Occasionally she will make a similar set of measurements along the flow to a distance of nominally 20 km. One day will be set aside for a longer section (about 50 km wide) across the flow in order to gain insight into the larger scale of the filament/eddy structure. At other times UWB-b will deploy the FLY - which is not limited in its times of activity in quite the same way as the CTD - on an opportunistic basis to map the turbulence and density field in as much detail as possible. At the end of the leg the Argos drifters will be recovered.

Remote Sensing Support

NSS will be processing AVHRR and SeaWiFS satellite imagery continuously prior to and during the cruise, to provide the latest surface locations of upwelling and filaments. Around 5 AVHRR images of the OMEX II-II region are received every day, and processed into navigated SST maps and infrared radiance images (for viewing fine-scale structures and clouds). Additional SST products include daily, three-daily, weekly and monthly composite images to provide a synoptic view of the region, contour

maps, and front maps. One SeaWiFS image of the region is also received each day, and processed into a chlorophyll map and a pseudo- true colour image (for viewing sediments and other coloured dissolved or particulate material). All data will be made available within two hours of acquisition, and disseminated to OMEX partners prior to the cruise via the remote sensing web site (http://www.npm.ac.uk/rsdas/omex/), and then during the cruise via Inmarsat transmissions once a day, or more frequently if required. The normal two week embargo on SeaWiFS data will be relaxed one week prior to the cruise, though OMEX scientists must register by post with NASA in order to access any SeaWiFS data via the web site.

WP1 Chemical Oceanography Activities for RRS Charles Darwin cruise 114
Partners: IIM, PML, ULg

Objectives: Description and understanding of the variability and dynamics of inorganic carbon and nutrients on the shallow shelf and across the shelf edge during an upwelling/relaxation cycle off the Galician coast. This study is closely related to the investigation of the dynamics of production, degradation and export of organic matter carried out by other partners.

Methodology: The description of inorganic carbon and nutrient availability will be carried out in the surface layer (0 to -300 m) during quasi-Lagrangian ship-drift experiments covering the shallow shelf and a cross shelf filament. IIM will carry out 5 nutrient analysis (NH4, NO2, NO3, HPO4, SiO2): samples will be frozen to -20 ºC for later analysis in the laboratory using an autoanalyser with colorimetric detection. PML will also sample these parameters for intercalibration purposes. ULg will determine the partial pressure of CO2 (pCO2) using both direct (underway subsurface samples) and indirect methods (discrete vertical samples). The direct method consists in the equilibration of seawater with air and then the measurement of pCO2 using an Infra-red analyser. The indirect method relies on the calculation of pCO2 and DIC from Total Alkalinity (electro-titration) and pH (combined electrode) measurements. Dissolved oxygen will also be determined using the Winkler method and a polarographic electrode.

Status of research: Chemical oceanography activities will start during the first WP1 cruise that will be carried out aboard the *RRS Charles Darwin* from the 29th July to 24th August 1998 (cruise CD114).

Basic sampling strategy of chemical oceanography parameters during the CD114 cruise:
Sampling strategy of chemical oceanography parameters is similar for both legs of the CD114 cruise, detailed in section “Basic sampling scheme for legs 1 and 2“. Discrete vertical samples of nutrients and inorganic carbon will be taken at three “biological stations” (pre-dawn, 9-10 am and 2-3 pm) were primary and secondary production will also be investigated. These stations will be chosen near the deployed drifting buoy. Discrete vertical samples will also be taken during the “survey mode” of the “filament experiment” and during the “tidal cycle study” of the “shelf experiment”. Underway measurements of pCO2, pH and O2 in subsurface water will be carried out through out the cruise.

Phytoplankton activities on RRS Charles Darwin cruise 114
Partners: PML-a, PML-c, IIM

Phytoplankton biomass (IIM, PML-a)
Objectives:
To evaluate the role of short-time phytoplankton species succession and the corresponding suspended organic matter concentration on primary production. The information obtained with this technique will be complemented with that obtained from HPLC-chemotaxonomy, particularly for those small-size phytoplankton groups which are poorly identified with light microscopy.

To map the distribution of phytoplankton assemblages.

To provide basic information to other investigations conducted during the cruise programme.

Methodology:
Phytoplankton and suspended matter retained on GF/F filters will be collected from a range of depths through the water column during the two drifter experiments. Preserved phytoplankton samples will be counted at the laboratory by inverted microscope. Suspended matter will be analysed for particulate organic carbon (POC), and nitrogen (PON) using a CHN analyser. See below (Phytoplankton pigments) for a more detailed explanation of HPLC methodology.

Phytoplankton pigments (PML-a)
Objectives:
To investigate the evolution of chlorophyll and carotenoid pigment signatures during drifter experiments conducted across the NW Iberian shelf break in order to understand the dynamics of plankton production and associated organic matter transformation in relation to the hydrography of the region.

To undertake surface pigment and mapping for ground truthing remotely sensed ocean colour satellite data.

Methodology: Seawater samples will be collected from CTD on station and from the non toxic supply during survey periods. Phytoplankton will be harvested by filtration onto GF/F filters. Samples will be preserved in liquid nitrogen and returned to the lab for analysis.

In the lab pigments will be extracted from the filters with the aid of ultrasonication. Extracts will be centrifuged and filtered through Teflon syringe filters to remove debris. Extracts will then be analysed for a range of chlorophyll, carotenoids and phaeopigments by reverse phase HPLC. Pigments and phaeopigments will be detected by absorbance using diode array detection (at 440 and 667 nm respectively) and quantified using an internal standard methodology.

Primary and new production (PML-c)
Objectives:
To investigate phytoplankton production in different size fractions and its variability during upwelling/downwelling cycles and along filaments.

To determine the utilisation of nitrate, ammonia and phosphate by phytoplankton assemblages and to estimate new production.

To determine the assimilation stochiometry of the main nutrient elements: carbon, nitrogen and phosphorous.

To produce a budget for nitrogen during Lagrangian experiments.

Methodology: Primary production will be measured during the two legs of the cruise by in situ incubations at 10 depths. Samples will be incubated for 24 hours with 14C and then fractionated through 5µm, 2µm and 0.2µm pore size filters to determine the production of micro-, nano- and picophytoplankton. The same experimental protocol will be used to measure phosphate uptake but using the radioisotope 33P.

New production will be assessed by measuring the assimilation of 15N nitrate and 15N ammonium; these experiments will not be size fractionated. In some experiments, the uptake of nitrate and ammonium will be measured directly in short-term incubations by measuring the change in ambient concentrations using analytical methods with nanomolar sensitivity.

Nitrification, ammonium regeneration and denitrification (PML-c)
Objectives:
To assess the importance of nitrification and ammonia regeneration. To produce, in combination with nitrate and ammonium uptake, a budget for nitrogen.

Methodology: Nitrification rate will be measured using allylthiourea inhibition of 14C fixation and ammonium regeneration rates will be assessed by 15N isotope dilution experiments. Some preliminary experiments will also be done to investigate nitrogen fixation. Samples will be screened for the presence of nif-H genes and incubations used to assess the level of acetylene reduction and 15N2 fixation; these experiments will be done on water enriched with iron and in which the oxygen concentration is deliberately reduced. The aim of the experiment will be to attempt to detect nitrogen fixation under optimum condition, rather than to obtain estimates of the actual N2 fixation rates. Since there are increasing numbers of reports of the presence of organisms with nitrogen fixing genes, it is important to know if the genes are expressing functional enzymes. If the enzymes can be detected in natural assemblages, the next step will be to attempt to quantify the actual rates of N2 fixation in natural populations.

Profiles will also be examined for the presence of nitrous oxide. Although we are not able to measure denitrification in natural assemblages, we feel that information on N2O concentrations may give an approximate estimate of the magnitude of likely denitrification in the region.

Photosynthesis-Irradiance parameters (IIM)
Objectives: To characterise the photosynthetic response of the phytoplankton as function of the underwater light field, nutrient availability and phytoplankton composition.

To estimate the short time scale variability on photosynthetic parameters and carbon-specific growth rates as induced by upwelling-downwelling cycles.

To estimate daily water column primary production and compare the results with those obtained by 24 hours in situ incubations.

Methodology: Photosynthesis-irradiance parameters will be determined during Leg 1 by 14C uptake in lineal incubators with controlled light quantity and quality. Diel cycles of photosynthesis-irradiance parameters will also be performed. Surface and downwelling irradiance will be measured by spectral light sensors during photoperiod. Spectral phytoplankton absorption coefficients will be determined by spectrophotometry on suspended matter collected on GF/F filters.

Water column primary production will be integrated starting from bio-optical variables above. Time integrated primary production will be done at 1 hour intervals. Phytoplankton carbon content estimated from phytoplankton biovolumes will be used in combination with primary production rates to estimate carbon-specific growth rates; carbon:chlorophyll ratios will be also assayed.

Dissolved organic carbon (IIM)
Objectives: To estimate the importance of dissolved organic carbon (DOC) to the total carbon budget during exchange processes (filament) and upwelling-downwelling cycles. During Leg 1, samples will be exchanged with PML-a to further the intercalibration exercise.

Methodology: Samples for DOC determinations will be taken during both Legs. Samples will be filtered through GF/F filters and analysed by high temperature catalytic oxidation (HTOC) in the laboratory.

WP1 Zooplankton Activities for RRS Charles Darwin cruise 114
During a meeting in Paris in November 1997 a zooplankton group was established within WP1, to facilitate planning of fieldwork, integration and optimal use of resources and ship time. The group met again in April in Lisbon to discuss in more detail a work schedule for the first WP1 cruise, Charles Darwin 114, in August later this year. Although some zooplankton work will be carried out during Leg 1 it is agreed that the focus for zooplankton cruise activities would be Leg 2. A daily sampling regime was formulated fir each leg of the cruise and integration of data was discussed. The following

table summarises the work schedule to be carried out. An essential part in this cruise schedule is the need for an overlap in assistance among the participants.

Leg 1: zooplankton personnel 2

Microzooplankton grazing (PML)
Microzooplankton biomass (PML)
Zooplankton abundance & biomass MOCNESS & WP-2 nets (UITO)
Mesozooplankton grazing (gut content & gut evacuation) (UITO & SOC))
Faecal pellet production (UITO)
Mesozooplankton carnivory (SAHFOS)

Leg 2: zooplankton personnel 5

Microzooplankton grazing (PML)
Microzooplankton biomass (PML)
Zooplankton abundance & biomass MOCNESS & WP-2 nets (UITO)
Mesozooplankton grazing (gut content & gut evacuation) (UITO & SOC))
Faecal pellet production (UITO)
Mesozooplankton carnivory (SAHFOS)
Mesozooplankton (SOC)

WP1 vertical export activities for RRS Charles Darwin cruise 114

The goal of the vertical flux group in WP1 is to investigate the short-term variability in quantity and quality of particle fluxes from the euphotic zone on a daily basis. Drifting sediment traps will be used at 2-4 depths on the shelf or in filaments. POC/PON, Transparent Exopolymer Particles (TEP), faecal pellets and microplankton will be quantified. Also, for vertical export important particles types such as faecal pellet and TEP in the water column, will be quantified along the daily drifts. The results will be related to equivalent ones from the pelagic system in the overlying waters in order to calculate daily loss rates and specific sinking rates for each particles category.

The vertical flux group decided that the activities during Leg 1 and 2 should be devoted to the following activities, according to the Technical Annex:

Leg 1: 1 scientist

Short term vertical flux measurements
Suspended faecal pellets
Transparent exopolymeric particles in the water column and the sediment traps

Leg 2: 2 scientists

Short term vertical flux measurements
Suspended faecal pellets
Variability in zooplankton faecal pellet production
Transparent exopolymeric particles in the water column and the sediment traps
Aggregates inside sediment traps by exposure of acrylamid dishes