REPORT

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Oceanographic cruise TRACES 2015

Cruise report

IRSN/PRP-ENV/SERIS/2015-00031

Radiation Protection Division - Environment (PRP-ENV)
Research & Expertise on Environmental Risks Department (SERIS)

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BP 3, Cadarache - Bât. 159 - 13115 Saint Paul-Lez-Durance Cedex - FRANCE

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Oceanographic cruise TRACES 2015

P. Laguionie, P. Bailly du Bois, O. Cazimajou, B. Fiévet, C. Godinot, S. Lesourd, D. Maro, M. Morillon, V. Perier, E. Poizot

Laboratory of Radioecology, Cherbourg-Octeville (LRC)
Research & Expertise on Environmental Risks Department (SERIS)

n° PRP-ENV/SERIS/2015-00031

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	Author(s)	Verifier	Head of **SERIS**	Director of Environment	Director General **IRSN***
Names	P. LAGUIONIE	P. BAILLY DU BOIS	J. GARNIER-LAPLACE	J. Ch. GARIEL	J. REPUSSARD
Dates	16/11/2015	18/11/15	4.12.15	10/12/15	
Signatures	[signature]	[signature]	[signature]	[signature] Denis BOULAUD Adjoint au Directeur de l'Environnement	

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Jane Thompson (vmt@noc.ac.uk)	NERC, RSU Operations, NERC Research Ship Unit, National Oceanographic Centre (UK)
JNCC Offshore Survey Programme Manager (offshoresurvey@jncc.gov.uk)	JNCC (UK)
marinescotland@gov.scot	Marine Laboratory Aberdeen (UK)
enquiries@oceannet.org	Marine Environmental Data & Information Network (UK)
Amy Kavanagh (Amy.Kavanagh@thecrownestate.co.uk)	The Crown Estate (UK)

ABSTRACT

The main objective of the TRACES 2015 cruise is to help assess the proportion of the known quantities of radionuclides released that will be fixed onto sediments, as well as the kinetics and extent to which these radionuclides can become bioavailable to living organisms (AREVA-INDIGO programme). The studied area covers the Normano-Breton Gulf. The strategy for sampling bottom sediments was based on collection of the surface layer using a Shipeck grab on sites distributed across the entire Normano-Breton Gulf. The seawater was automatically sampled at regular intervals to check the representativity of the MARS hydrodynamic model. The tritium released from the AREVA-NC, which is associated with HTO molecules and thus strictly soluble, was used as a tracer of water masses. Algae and limpets were collected at three offshore sites to supplement the regular coastal sampling. The TRACES 2015 cruise was also used to test new measuring instruments for collecting physical data. These instruments appear promising for improving our knowledge of hydro-sedimentary processes which need to be better integrated into models (AMORAD/MARIN/SEDI programme).

RESUME

L'objectif principal de la campagne TRACES 2015 est de contribuer à évaluer, à partir d'une quantité connue de radionucléides rejetés, quelle proportion va se fixer sur les sédiments, avec quelle cinétique et dans quelle mesure ces radionucléides peuvent redevenir biodisponibles pour les espèces vivantes (programme AREVA-INDIGO). Le lieu d'étude est le Golfe normand-breton. La stratégie d'échantillonnage des sédiments de fond repose sur des prélèvements de la couche superficielle à la benne Shipeck répartis sur l'ensemble du Golfe normand-breton. La collecte régulière d'échantillons d'eau de mer à l'aide d'un automate permet de tester la représentativité du modèle hydrodynamique MARS. Le tritium rejeté par AREVA-NC, strictement soluble, associé à la molécule HTO, est utilisé comme traceur des masses d'eaux. Des prélèvements d'algues et de patelles ont été effectués en 3 points inaccessibles depuis la côte, complémentaires des suivis réguliers (programme AMORAD/MARIN/BIO). La campagne TRACES 2015 a également été l'occasion de tester de nouveaux instruments de mesures physiques, prometteurs dans le cadre de l'amélioration des connaissances des processus hydro-sédimentaires et leur meilleure prise en compte dans les modèles (programme AMORAD/MARIN/SEDI).

KEY WORDS

Oceanographic cruise, Normano-Breton Gulf, Radionuclides, AREVA NC La Hague, Sampling

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1 INTRODUCTION

The TRACES 2015 cruise (22-29 May 2015) is a prolongation of the TRACES 2014 cruise (21-31 May 2014). The area studied covers the Normano-Breton Gulf. The principal objective of the TRACES cruises (2014 and 2015) is to contribute to assessing the proportions of known quantities of released tracers (radionuclides) that will be fixed onto sediments as well as the kinetics and extent to which these radionuclides can become bioavailable to living species. This study is undertaken in the framework of the INDIGO programme (contract with AREVA-NC). The work involves the measurement of tracers derived from releases into the sea from the AREVA-NC nuclear fuel reprocessing plant, which have been known since 1966, including radionuclides allowing the estimation of long-term labelling. The TRACES 2015 cruise was also the occasion to test promising new physical measuring instruments for improving our knowledge of hydro-sedimentary processes, which can then be better integrated into models (programme AMORAD/MARIN /SEDI).

The bottom-sediment sampling strategy was based on using a Shipeck grab for collecting the surface layer and a Flusha corer to attain deeper layers (when the sediments are sufficiently fine to allow penetration) at stations distributed across the whole of the Normano-Breton Gulf. In parallel with this work, for bottom sediments made up of coarse particles (the most frequently observed case) which prevent penetration of the corer, sampling of layers will be carried out manually by divers in the facies most representative of the Normano-Breton Gulf (PREST cruise, second half of 2015). The measurement of radioactivity on the fine fraction of the sampled sediments (grain size less than 63 µm) makes it possible to quantify the processes of mixing and establish vertical inventories of the radionuclides present on the scale of the Normano-Breton Gulf. Indeed, this fine fraction alone accounts for more than 95% of the total radioactivity in the sediments.

The regular collection of seawater samples using an automatic system makes it possible to test the representativity of the hydrodynamic model MARS (developed by Ifremer) on the scale of the Normano-Breton Gulf. Validation of the hydrodynamics is an essential stage in the implementation of a sedimentary transport model. A post-doctoral research project will be carried out for this purpose at the LRC as from January 2016. The tritium released by AREVA-NC, being strictly soluble and associated with the HTO molecule, is used as a tracer of water masses. While the use of tracers is essential for a realistic integration of the processes in space and time, fixed-point measurements of currents allow us to identify local processes that are still poorly taken into account in the models (variable directions of current flow according to depth, turbulence). These measurements were carried out by deploying an acoustic Doppler current profiler (ADCP) at a fixed station and a turbulence profiler.

The coupling between the flow velocity profile ($m.s^{-1}$) and the suspended matter concentration profile ($g.m^3$) allows us to calculate a flux profile ($g.m^2\ s^{-1}$). These data are essential for the quantification of the transfer of materials along with the radionuclides that they contain. During tidal cycles, the suspended matter load was (1) characterized using an acoustic sediment profiler (Aquascat) and an *in situ* particle-measuring instrument (LISST), and (2) quantified by collecting synchronous water samples at five levels in the water column, with each sample being filtered at 0.5 µm to determine the suspended matter concentration. Characterization of the suspended matter by class of sedimentation rate (a first-order parameter used to qualify particles in hydrosedimentary models) was tested by implementing a prototype decantation test-bench developed by the LRC. Additional qualitative information was obtained by time-lapse viewing of the interior of an anti-trawl cage in which the ADCP and Aquascat were fixed, and videos acquired by a submerged device with image return to the ship's bridge. This display system made it possible to assess the transport of particles on the bottom (bed-load traction, saltation) and the suspended matter load. The anti-trawl cage was also equipped with a triaxial shock accelerometer to test the feasibility of detecting the transport of coarse clastic material on the sea-bed (cm- to dm-sized pebbles, for example).

Sampling of algae and limpets were carried out at three points inaccessible from the coast (Les Ecréhou, Les Roches Douvres and Chausey), in addition to the regular monitoring programmes (INDIGO and AMORAD/MARIN/BIO).

2 PERSONNEL ON BOARD

The personnel on board are listed in Table 1.

Table 1: List of scientific personnel on board.

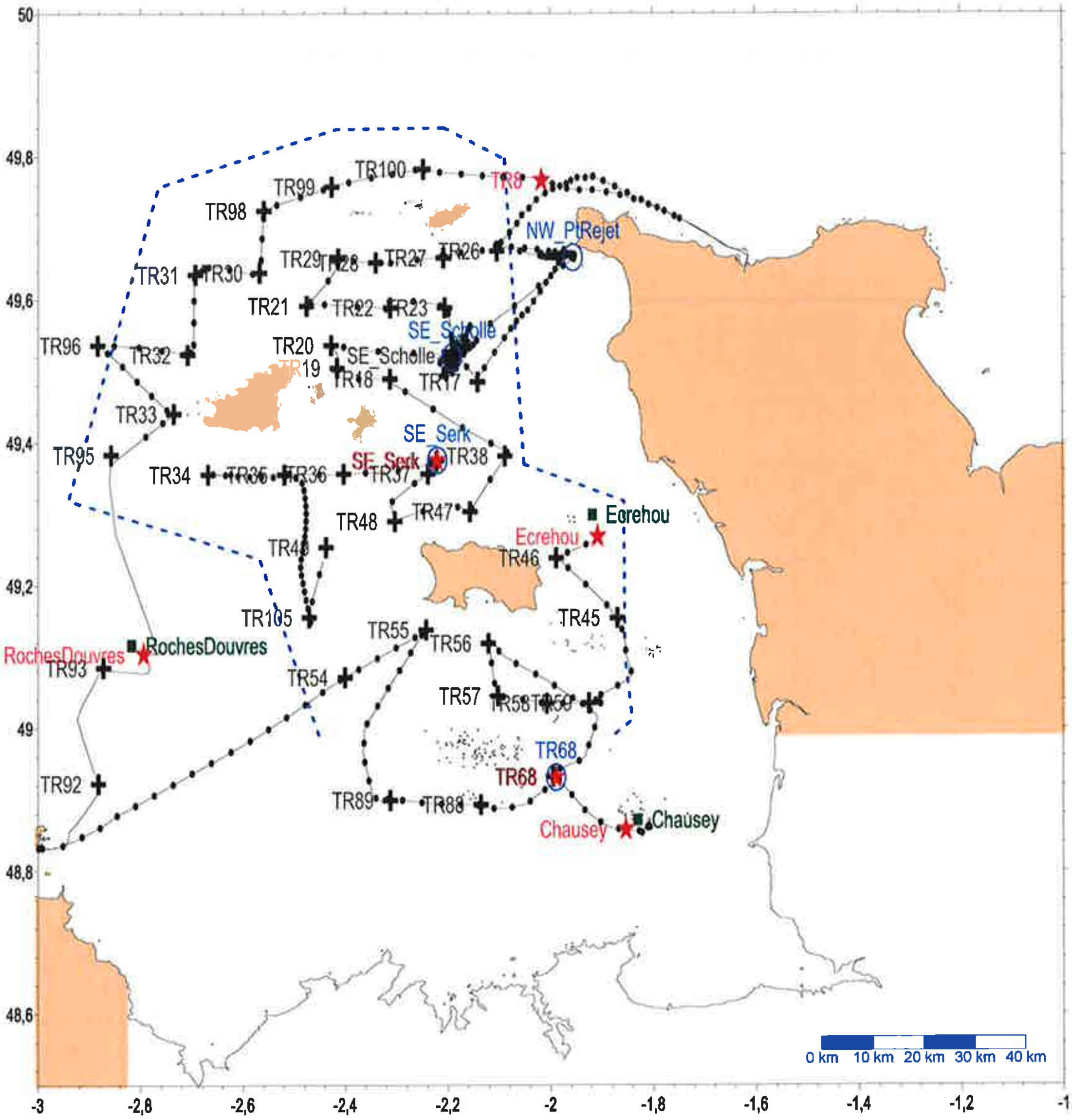
Category	Surname	First name	Speciality	Responsibility and role on board	Employing organization	Period on board	
						Embarkation Date[1] (place[2])	Disembarkation Date1 (place[2])
Scientist	LAGUIONIE	Philippe	Physics	Mission Chief	IRSN	22 (CO)	29 (CO)
	BAILLY du BOIS	Pascal	Physics	Sampling, treatments	IRSN	22 (CO)	25 (SP)
	CAZIMAJOU	Olivier	Biology	Sampling, treatments	IRSN	22 (CO)	29 (CO)
	FIEVET	Bruno	Biology	Sampling, treatments	IRSN	25 (SP)	29 (CO)
	GODINOT	Claire	Biology	Sampling, treatments	IRSN	22 (CO)	29 (CO)
	LESOURD	Sandric	Geology	Sediment descriptions	University of Caen	22 (CO)	29 (CO)
	MARO	Denis	Physics	Sampling, treatments	IRSN	22 (CO)	25 (CO)
	MORILLON	Mehdi	Data processing	Sampling, treatments	IRSN	22 (CO)	29 (CO)
	PERIER	Vincent	Physics	Sampling, treatments	ALTRAN	22 (CO)	29 (CO)
	POIZOT	Emmanuel	Geosciences	Measurement of turbulence profiles	CNAM	25 (SP)	29 (CO)
Mariner	LE MOAL	Yves		Captain	CNRS		
	CARRAL	Frédéric		Chief Mate	CNRS		
	LE RIDANT	Stéphane		Second Mate	CNRS		
	LEBRETON	Frédéric		Lieutenant	CNRS		
	BABLIN	Hervé		Boatswain	CNRS		
	DUPOUY	Bertrand		Cook	CNRS		
	ROBERT	Damien		Greaser	CNRS		

[1]day/05/2015

[2]CO: Cherbourg-Octeville; SP: Saint Peter, Guernesey

3 WORK AREA

The work area of TRACES 2015 is located in the Normano-Breton Gulf, between longitudes -1.6° and -3° and latitudes 48.8° and 49.8° (WGS84) as shown on Figure 1. It is mainly located in United Kingdom territorial waters.



■	Coastal sampling of biological materials
•	Sampling of surface waters from vessel under way
O	Immersion for several hours of anti-trawl frame equipped with an acoustic current profiler, a suspended sediment profiler, a triaxial accelerometer and a display system
★	Measurement of turbulence profiles from vessel while drifting
+	Sampling of bottom sediment from vessel on station
---	Limit of United Kingdom territorial waters
–	Track of R/V Côtes de la Manche
SE_Scholle	Measurement of granulometric profiles *in situ* and sampling of water and suspended matter at depth with hourly time steps on a 24-hour cycle, from vessel on station

Figure 1: Localization of operations carried out during TRACES 2015 cruise in the Normano-Breton Gulf.

4 DESCRIPTION OF OPERATIONS CARRIED OUT

4.1 QUANTITATIVE OBJECTIVES

The quantitative objectives are listed in Table 2. Percentages of success lower than 100% are explained in section 4.10 dealing with the problems encountered.

Table 2: List of operations carried out.

Operations	Number or quantity envisaged	Number or quantity carried out	Percentage of success
Sampling of bottom sediments by Shipeck grab	59	45	76%
Sampling of bottom sediments by Flusha corer	If allowed by nature of bottom sediment (< 5)	0 (absence of fine sediments)	Not applicable
Sampling of biological materials (limpets, wrack)	3 sites accessible by Zodiac (Roches Douvres, Chausey and Ecréhou)	3 sites (Roches Douvres, Chausey and Ecréhou)	100%
Immersion of an autonomous instrumented anti-trawl cage (ADCP, Aquascat, Accelerometer and RaspiCam)	4 sites (between 7 and 26 hours of data acquisition according to site)	4 sites (between 9 and 26 hours of data acquisition according to site)	> 100%
Under-way sampling of surface waters with an automatic system	Approximately 1000 (1 every 10 minutes)	556	56%
Sampling of water at depth (and suspended matter) on station with 1 line of 5 Niskin bottles	5 simultaneous samplings every hour during 24 H (125 samples)	125	100%
On-board filtration of samples collected in Niskin bottles	125	125	100%
On-board measurement of granulometry of samples collected using Niskin bottles	125	5	4%

List of operations carried out (continuation)

Operations	Number or quantity envisaged	Number or quantity	Percentage of success
Measurement of granulometric profiles of suspended matter by immersion of a LISST connected to a mooring line	1 profile every hour during 24 H (25 profiles)	25	100%
Tests of immersion and piloting of a mini ROV to carry out underwater viewing	4 tests (during immersion of autonomous instrumented anti-trawl cage)	0	Not applicable
Implementation of a sea-bed viewing system	5 displays using system fixed on launching line of the autonomous instrumented anti-trawl cage + 59 displays with system fixed on launching line of the Shipeck grab	3 displays using system fixed on launching line of the autonomous instrumented anti-trawl cage + 3 displays with system fixed on launching line of the Shipeck grab	5 to 60%
Decantation test-bench for measurement of sedimentation rate of suspended particles		Bench equipped for continuous sampling of surface water	Not applicable
Measurement of turbulence profiles	10 profiles	20 profiles	200%

4.2 SAMPLING OF BOTTOM SEDIMENTS BY SHIPECK GRAB

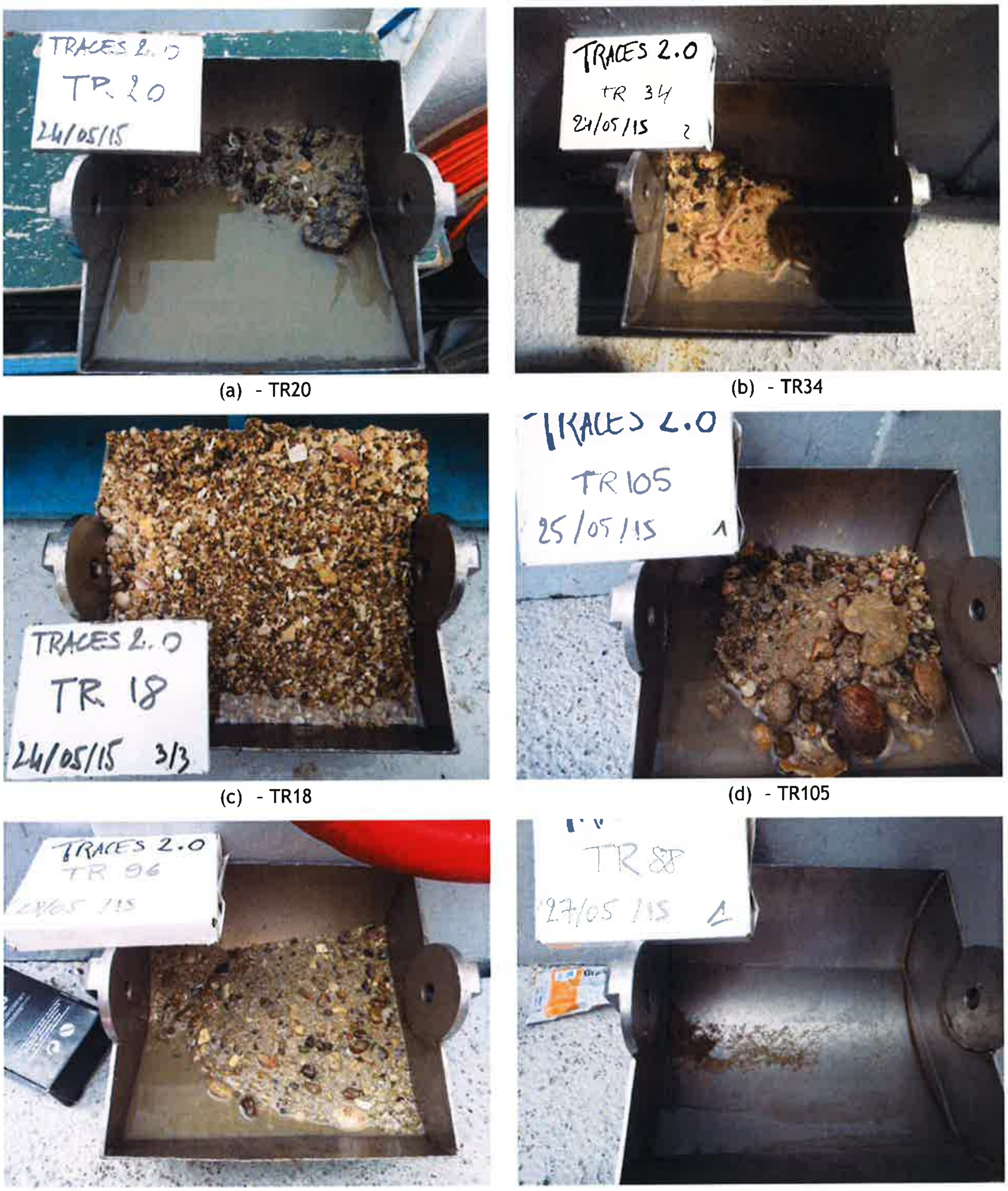
A total of 45 samplings of the topmost few centimetres of bottom sediment were carried out using a Shipeck grab (Figure 2). These samples reveal a strong heterogeneity of the bottom sediments in the Normano-Breton Gulf. The facies encountered are generally of sandy type (muddy to coarse), with more or less abundant shell debris, stones, pebbles and living organisms. Occasionally, the absence of sediments in the Shipeck grab is attributed to the presence of a rocky bottom. A small amount sediment in the grab bucket can be characteristic of sampling carried out in a localized sedimentary pocket among the rocks (Figure 2 (f)).

Table 3: Dates and locations of sampling of bottom sediments by Shipeck grab.

Site	Longitude WGS84 (Dec.°)	Latitude WGS84 (Dec.°)	Water depth (m)	Date (day/month/year)	Time (hr:min UT)
TR7	-1.916	49.773	106	22/05/2015	08:51
TR26	-2.104	49.668	37	22/05/2015	19:05
TR27	-2.208	49.658	32	22/05/2015	19:40
TR23	-2.206	49.589	32	22/05/2015	23:45
TR17	-2.142	49.485	37	23/05/2015	01:00
SE-Scholle	-2.191	49.522	42	23/05/2015	00:24
TR22	-2.311	49.589	45	22/05/2015	23:00
TR28	-2.340	49.652	47	22/05/2015	20:35
TR29	-2.413	49.657	22	22/05/2015	21:05
TR21	-2.475	49.591	50	22/05/2015	21:44
TR20	-2.427	49.536	49	24/05/2015	15:07
TR19	-2.415	49.504	28	24/05/2015	15:27
TR18	-2.312	49.489	44	24/05/2015	16:00
TR38	-2.089	49.381	33	24/05/2015	17:15
TR47	-2.157	49.303	30	24/05/2015	17:50
TR37	-2.239	49.356	41	24/05/2015	19:13
SE-Serk	-2.222	49.375	53	24/05/2015	19:39
TR48	-2.303	49.290	39	24/05/2015	18:30
TR55	-2.243	49.138	33	27/05/2015	14:00
TR105	-2.470	49.155	51	25/05/2015	05:35
TR49	-2.437	49.254	56	25/05/2015	06:22
TR36	-2.403	49.356	58	24/05/2015	20:59
TR35	-2.518	49.355	62	24/05/2015	21:35
TR46	-1.988	49.238	29	26/05/2015	07:31
TR45	-1.869	49.154	14	26/05/2015	08:15
TR59	-1.925	49.035	23	26/05/2015	08:55
TR58	-2.007	49.035	26	26/05/2015	10:26
TR57	-2.103	49.045	28	26/05/2015	11:05
TR56	-2.121	49.119	23	26/05/2015	11:40

Dates and locations of sampling of bottom sediments by Shipeck grab (continuation)

Site	Longitude WGS84 (Dec.°)	Latitude WGS84 (Dec.°)	Water depth (m)	Date (day/month/year)	Time (hr:min UT)
TR54	-2.400	49.071	40	27/05/2015	15:06
TR89	-2.312	48.899	44	27/05/2015	12:15
TR88	-2.136	48.893	23	27/05/2015	11:11
TR68	-1.995	48.932	23	26/05/2015	13:36
TR92	-2.882	48.922	51	28/05/2015	06:41
TR93	-2.872	49.085	51	28/05/2015	08:00
TR34	-2.668	49.355	69	25/05/2015	22:30
TR95	-2.857	49.383	70	28/05/2015	12:55
TR33	-2.735	49.440	65	28/05/2015	13:22
TR32	-2.708	49.523	72	28/05/2015	15:06
TR96	-2.883	49.536	74	28/05/2015	14:24
TR31	-2.693	49.635	72	28/05/2015	15:58
TR30	-2.567	49.638	71	28/05/2015	17:05
TR98	-2.559	49.724	85	28/05/2015	17:40
TR99	-2.426	49.758	60	28/05/2015	18:25
TR100	-2.248	49.782	65	28/05/2015	19:08



(a) - TR20 (b) - TR34

(c) - TR18 (d) - TR105

(e) - TR96 (f) - TR88

Figure 2: Examples of bottom sediments sampled by Shipeck grab during TRACES 2015 cruise in the Normano-Breton Gulf; sampling locations are shown on Figure 1.

4.3 SAMPLING OF BIOLOGICAL MATERIALS

Limpets and wracks were collected at low tide on the sites of Les Ecrehou (26/05/2015; Figure 3), Chausey (27/05/2015) and Les Roches Douvres (28/05/2015).

Figure 3: Site used for sampling of wracks on Les Ecrehou (26/05/2015).

4.4 IMMERSION OF AN AUTONOMOUS INSTRUMENTED ANTI-TRAWL CAGE (ADCP, AQUASCAT, ACCELEROMETER AND RASPICAM)

An anti-trawl cage, Figure 4 (a), was immersed for several hours at 4 different stations, Table 4. The cage was equipped with the following instruments:

[1] An ADCP (RDI, Sentinel V, 500 kHz) for the three-dimensional measurement of flow velocity in the water column by acoustic signal, Figure 4 (b) and Appendix 6.2 (Figure 19 to Figure 22). The vertical resolution ranged between 0.5 and 0.6 m and the data acquisition frequency was 1 Hz.

[2] An Aquascat suspended sediment profiler (Aquatec Group, 1000R, 4 frequencies of 500 kHz, 1 MHz, 2 MHz and 4 MHz) for measurement of the suspended matter load by acoustic signal over a distance of 10 m from the transducer (Figure 4 (c) and (d)). The transducers were directed vertically except for the 500 kHz transducer, which was directed at 20° (NW_PtRejet) or at 45° (SE_Scholle, SE_Serk and TR68) with respect to the horizontal to avoid interferences with the ADCP signal. In addition, since low frequencies are suitable for the detection of high concentrations, it is interesting to target the flow zone close to the bottom, which potentially shows the highest concentrations in suspended matter. The spatial resolution was 40 mm, with a measurement frequency of 10 Hz and a data acquisition frequency of 0.3125 Hz. The averaged profiles were recorded every 10 minutes based on 5,900 measurements (with 10 s dead-time between each profile).

[3] An accelerometer (MSR, 145B8A, 1 kHz) for the detection of shocks received by the anti-trawl cage during its deployment (detection of shocks caused by the impact of pebbles, for example).

[4] A RaspiCam (miniature camera) for viewing the suspended matter trapped in the anti-trawl cage, Figure 5.

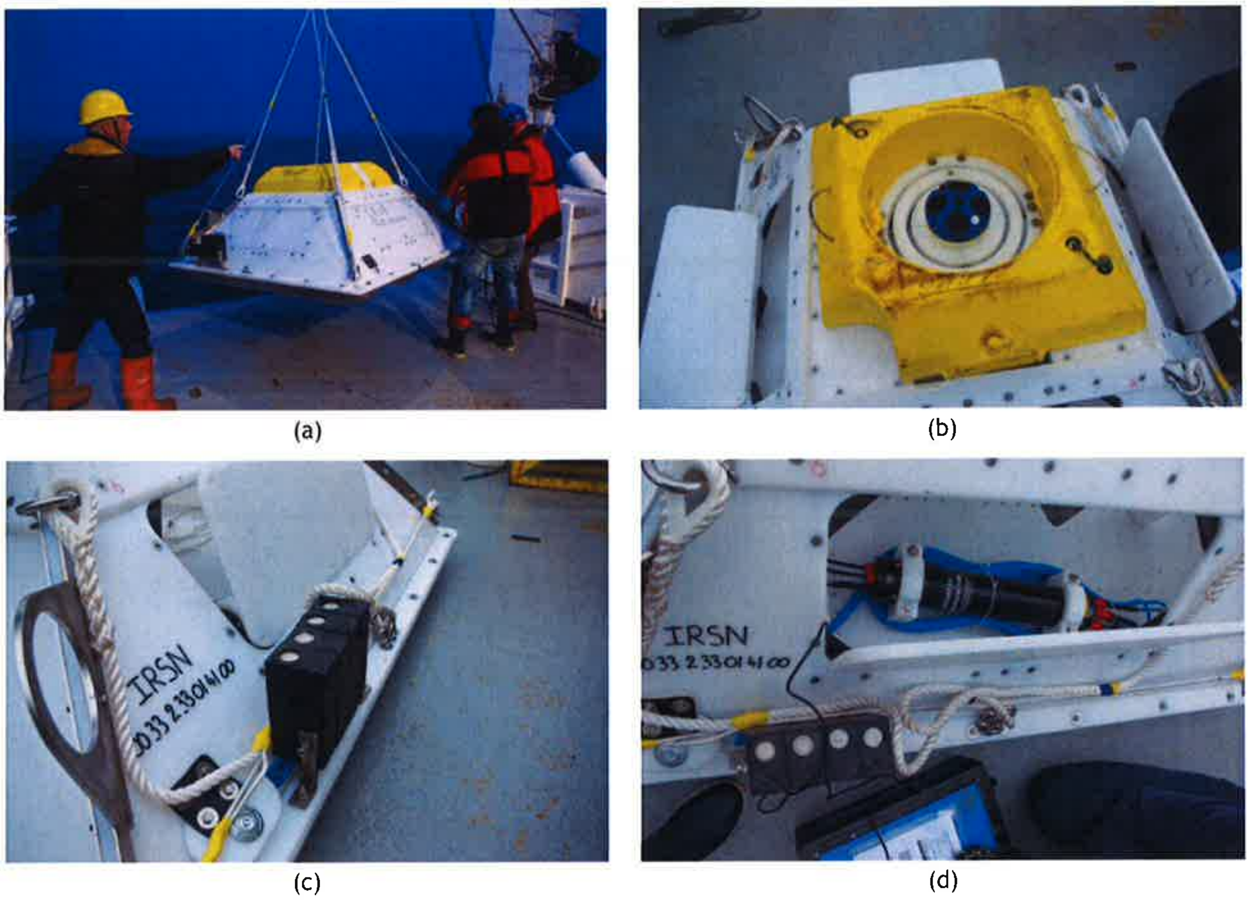


Figure 4: Launching of the instrumented anti-trawl cage (a), with views of the ADCP (b) and Aquascat (transducers (c) and data acquisition unit (d)).

Table 4: Periods and locations of deployment of the instrumented anti-trawl cage.

Site	Longitude WGS84 (Dec.°)	Latitude WGS84 (Dec.°)	Water depth (m)	Date and time of launching (day/month/year hr:min UT)	Date and time of recovery (day/month/year) hr:min UT)
NW_PtRejet	-1.955	49.659	23	22/05/2015 17:00	23/05/2015 06:45
SE_Scholle	-2.192	49.520	41	23/05/2015 12:33	24/05/2015 14:25
SE_Serk	-2.221	49.375	48	24/05/2015 19:45	25/05/2015 15:32
TR68	-1.989	48.931	16	26/05/2015 13:04	27/05/2015 10:12

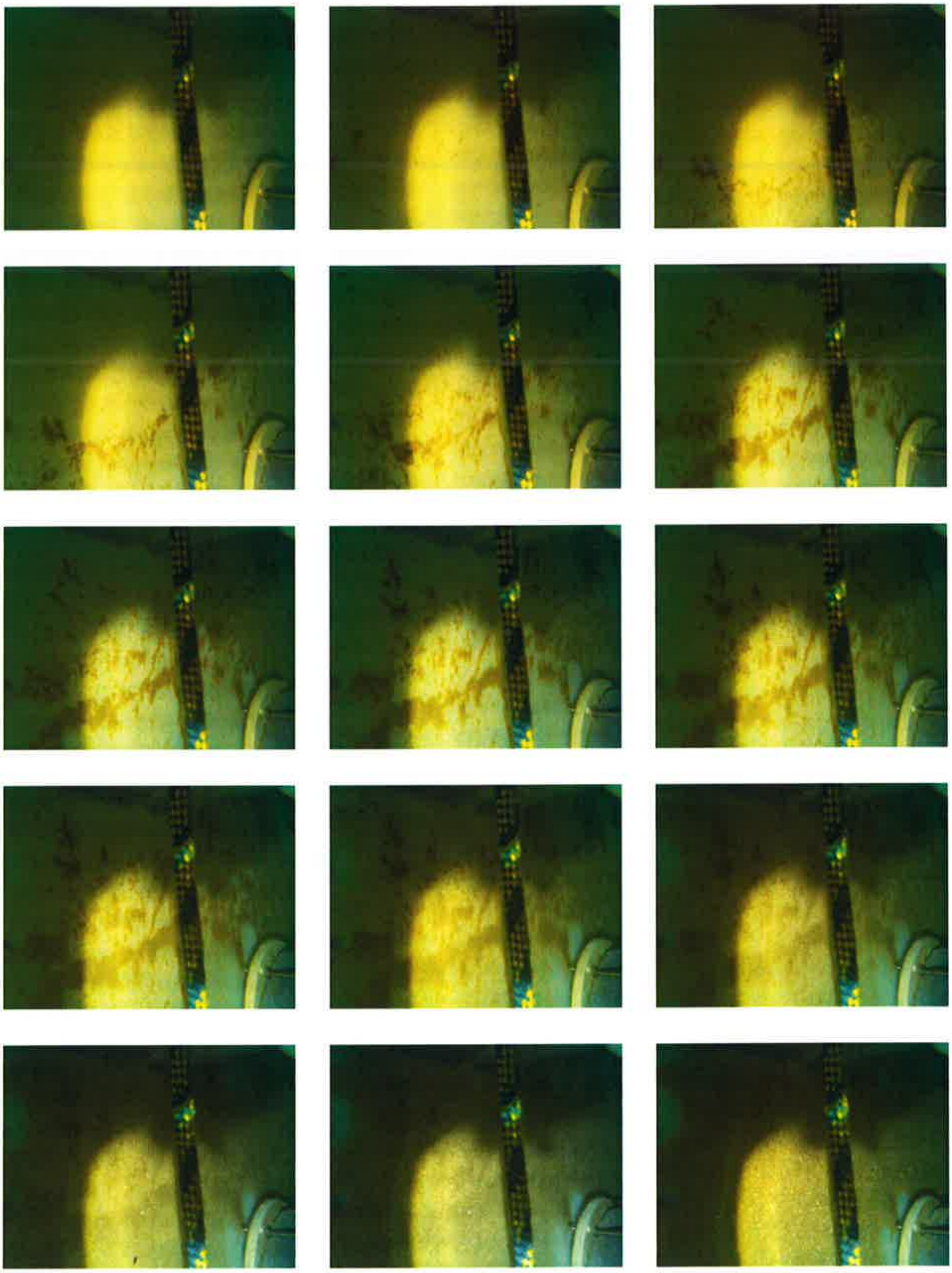


Figure 5: Extract of a Raspicam time-lapse video taken inside the anti-trawl cage immersed during a tidal cycle (SE_Scholle site, Table 4), highlighting the dynamics of sandy particles by trapping in the cage; 1 photograph approximately every 15 minutes; the bottom of the cage is coated with sandy particles through the course of time.

4.5 UNDER-WAY SAMPLING OF SURFACE WATERS BY AN AUTOMATIC SYSTEM

A total of 556 surface water samples were collected while the vessel was under way (Figure 1), using an automatic sampling system (Figure 6). The ^{3}H concentrations of these samples will be used for validation of the MARS hydrodynamic model on the scale of the Normano-Breton Gulf (the quantities released by the AREVA-NC La Hague plant are known from the literature).

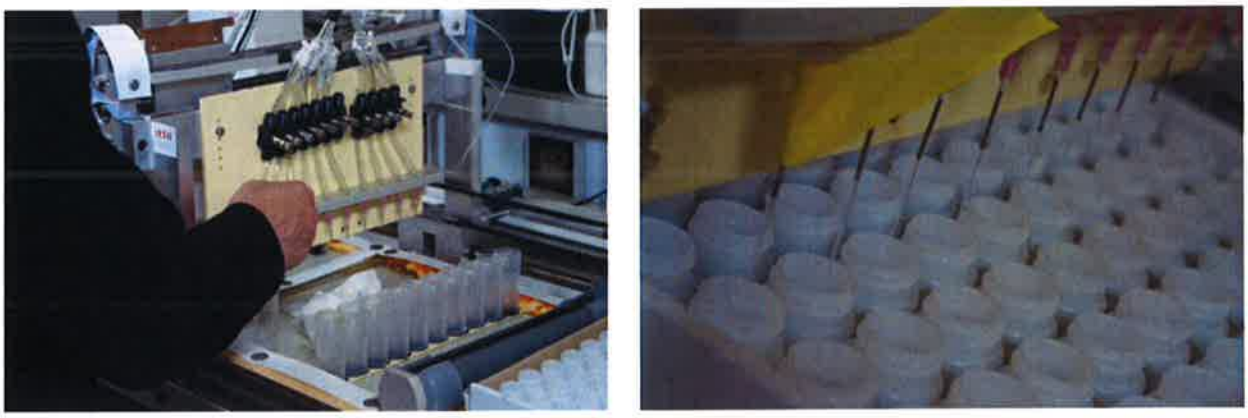


Figure 6: Illustrations of the automatic sampling system.

4.6 COLLECTION OF WATER SAMPLES AND SUSPENDED MATTER IN THE WATER COLUMN AND MEASUREMENT OF IN-SITU GRANULOMETRIC PROFILES

The monitoring of suspended matter concentration as a function of depth in the water column and time was carried out by collecting five synchronous water samples, with 5-l Niskin bottles, which were then filtered at 0.5 µm. The sampling line used is schematized on Figure 7. The sampling was carried out at no more than 8 km from the SE_Scholle site (place of deployment of the anti-trawl cage, Figure 1), every hour between 23/05/2015 14:00 UT and 24/05/2015 13:00 UT. Granulometric profiles of the suspended matter were also acquired *in situ* with an hourly time step using a LISST (Scientific Sequoia, 100X). A direct *in situ* measurement of granulometry avoids biases related to the rehandling of the samples during sampling. One of the objectives of this monitoring is to calibrate the acoustic signal of Aquascat with the distribution according to grain-size class and the concentration of suspended particles. The sampling line was also equipped with two pressure transducers (1 on the LISST and 1 on the Niskin bottle nearest to the surface) so as to be able to recalculate the water depth of each sample by assuming straightness of the line. The LISST yielded continuous measurements of the distribution of particle size throughout the water column according to 32 classes between 2.5 and 500 µm. The acquisition frequency was 1 Hz.

The experimental protocol is as follows:

1- Starting of the LISST (firstly calibrated with filtered sea water).
2- Launching of the sampling line (Figure 7, Figure 8 (a)) until the LISST (in its protection cage) comes into contact with the bottom sediment.
3- Triggering closure in cascade of the 5 Niskin bottles by sending a messenger.

4- Measuring the volumes trapped in the Niskin bottles by transfer of samples into 5 L and 1 L beakers (containers rinsed with sea water between each sampling), Figure 8 (b) and (c).

5- Filtration by depression of the collected volumes on 0.5 µm glass fibre filters (only I filter is used for each sampling; the filters are firstly oven-dried at 50°C for 1 hour and then their tare weight is determined) (Figure 8 (d) and (e)).

6- Rinsing of the walls of the reservoir and filter of the filtration unit using 50 ml of deionized water (to de-salt the particulate phase retained by the filter) and storage of the filters in hermetic plastic boxes (Figure 8 (f) and (g)).

7- Launching of the LISST (in its protection cage) until it comes into contact with the bottom sediment.

8- Measurement of the *in situ* granulometry of the suspended matter at 30 s intervals: (1) every metre over the first 10 m, then (2) every 5 m up to the free water surface.

9- On return from the cruise: drying of filters and weighing (under the same experimental conditions as during tare weighing) for determination of the suspended matter concentration and description of the particulate phase under the microscope.

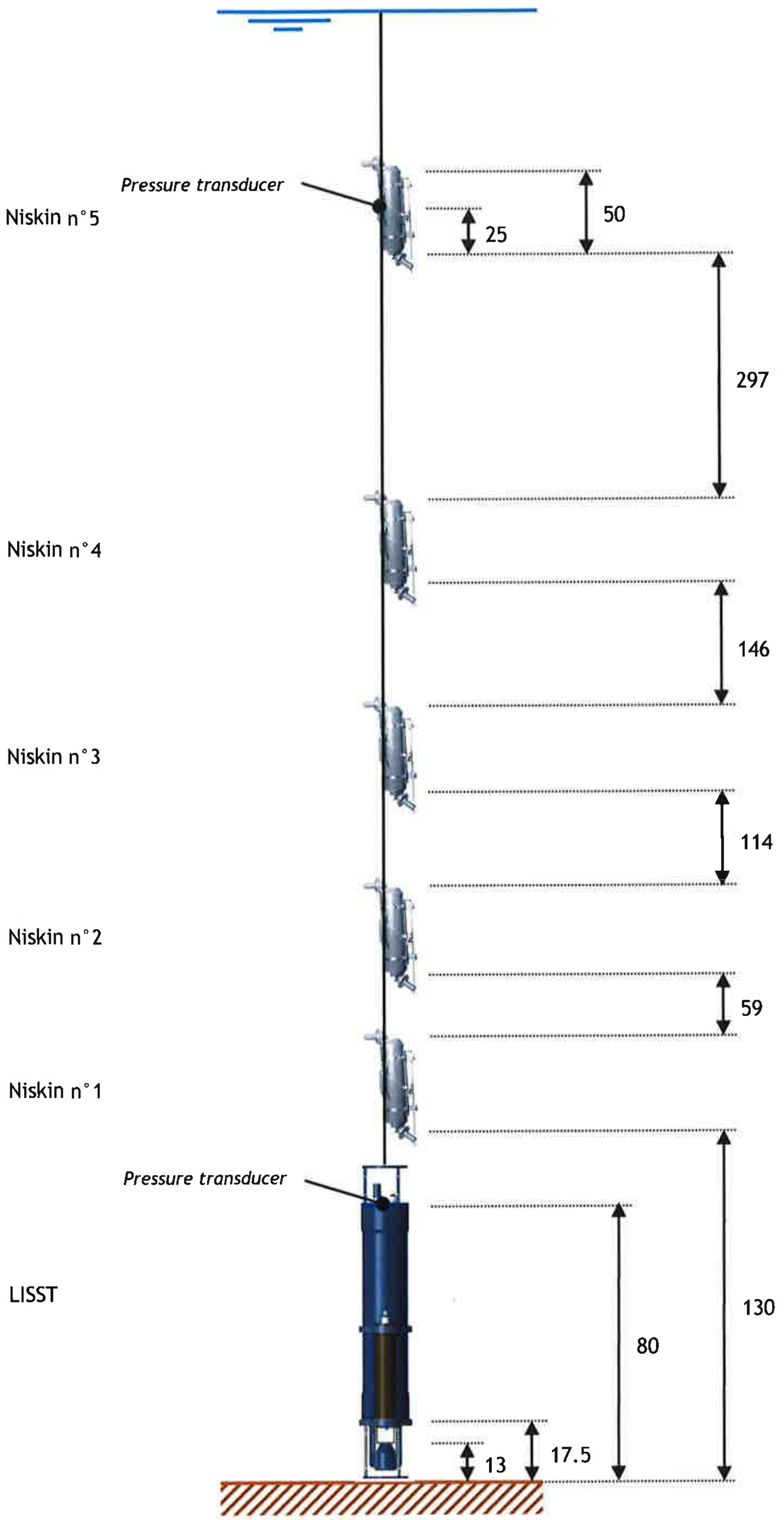


Figure 7: Diagram of the sampling line used for TRACES 2015, consisting of a LISST, 5 Niskin bottles and 2 pressure transducers (with dimensions given in cm).

Figure 8: Illustration of the treatment of a water sample from its collection in a Niskin bottle until filtration by depression on a 0.5-µm glass fibre filter; the steps (a) to (g) are described in the experimental protocol set out in section 0.

4.7 IMPLEMENTATION OF SEA-BED DISPLAY SYSTEM

The display system used consists of a CANON XA 25 camera placed in a watertight box protected by a cage, with two remote LED spotlights (7 000 lumens). The unit is fixed:

[1] On a support cable which helps the deployment of the anti-trawl cage on the sites NW_PtRejet (22/05/2015) and TR68 (26/05/2015), Table 4. This is important to ensure horizontal positioning of the anti-trawl cage, since otherwise the acoustic mechanism for release of its float cannot function.

[2] On a tripod for viewing the sea-bed near Les Ecrehou (26/05/2015) and Chausey (27/05/2015).

A coaxial video cable allows return of the image to an on-board display unit in real time (Figure 10 However, the use of this display unit is not essential for the operation of the system. The presence of a highly concentrated particulate load (probably composed of organic matter; near Les Ecrehou (Figure 10 (b)) is one of the outstanding observations in these first tests. The particulate load observed at this site was in suspension despite the very weak flow velocities at low water (a few cm per second).

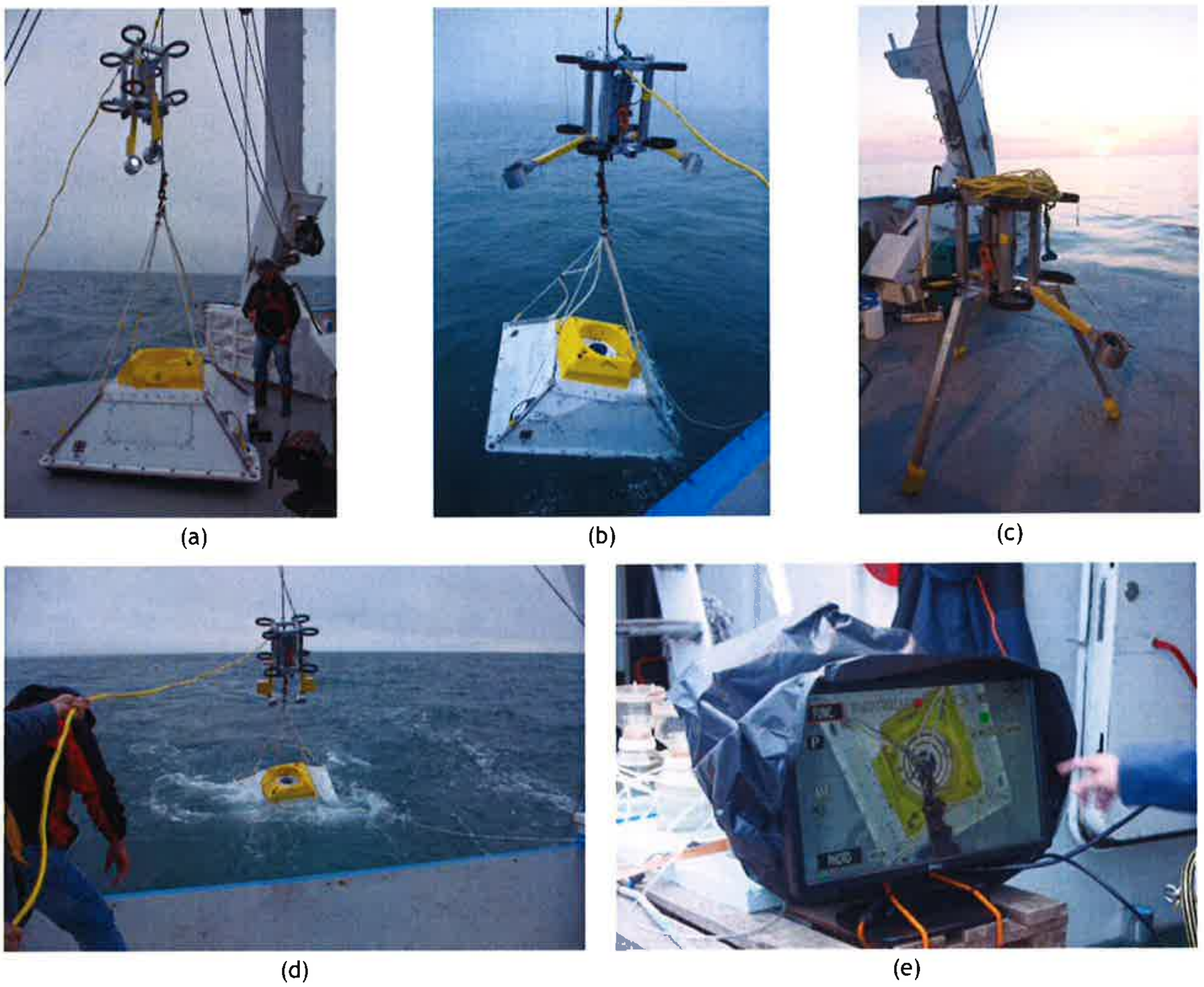
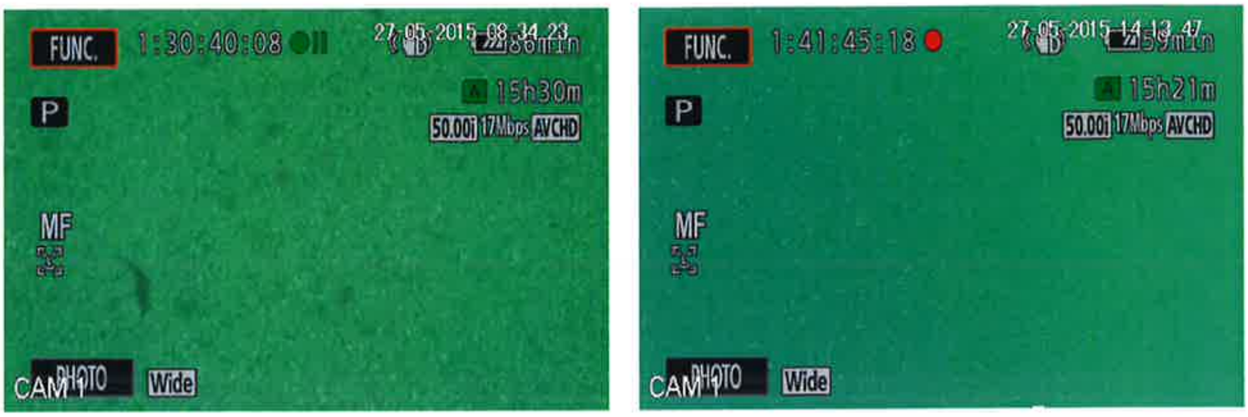


Figure 9: Implementation of video system on a support cable to help the positioning of *in situ* tools (a), (b) and (d), or on a tripod for viewing the sea-bed (c); return of the image on line to a display unit on the bridge (e).



(a) (b)

Figure 10: Examples of views obtained under natural daylight conditions during deployment of the *in situ* video: bottom sediment (a) and suspended matter (b).

4.8 TESTING OF A DECANTATION BENCH FOR MEASURING SEDIMENTATION RATE OF SUSPENDED PARTICLES

A prototype decantation bench was tested during TRACES 2015 (Figure 11). In the long term, the aim is to characterize the suspended matter in terms of class of sedimentation rate (a first-order parameter in hydrosedimentary modelling). Each decantation cell of the bench will be calibrated in the laboratory using spherical silica particles to which Stokes' Law can be applied. Given the low suspended matter concentrations in the English Channel (generally between 10 and 30 mg l-1,), the bench received an uninterrupted supply of surface seawater (controlled flow of 0.5 L min-1) during the cruise. The particles collected in each decantation cell will be characterized in the laboratory (granulometry, microscopy) and, after drying and weighing, their *in situ* concentration will be determined (assuming no disaggregation of the particulate matter and flocculates during sampling).

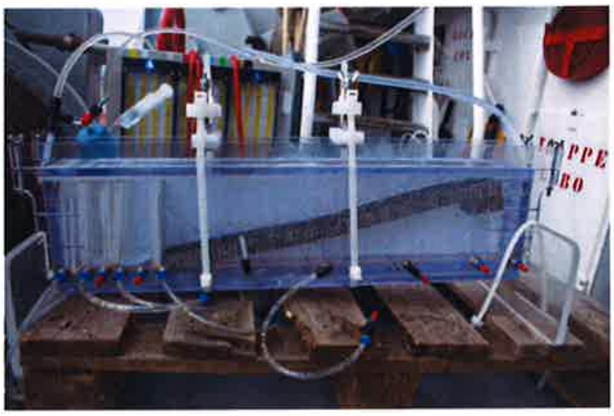


Figure 11: Decantation test-bench for collection of suspended matter by class of sedimentation rate.

4.9 MEASUREMENT OF TURBULENCE PROFILES

Micro-scale turbulence profiles were measured at 5 stations (Figure 1 ; 5 profiles per station) using a VMP-250 Turbulence profiler (Rockland Scientific International) (Figure 12). Measurements were carried out according to a Lagrangian approach with the vessel drifting for 3 minutes on average, by allowing the probe to descend under its own weight from the free water surface to the water-sediment interface.

Figure 12: VMP-250 Turbulence Profiler (Rockland Scientific International).

4.10 PROBLEMS ENCOUNTERED

The problems encountered relate to:

[1] Sampling of the bottom sediments by Shipeck grab: in water depths of 100 m with high current velocities (example: 3 m.s-1 at TR07), sampling could not be carried out (since the grab sampler did not reach the bottom) in spite of the greatly increased length of unreeled cable.

[2] Seabed sampling by Flusha corer was prevented because of the coarse nature of the sediments encountered (the Flusha corer is suitable for penetrating a muddy bottom)

[3] The launching of the anti-trawl cage at NW_PtRejet was shifted by 6 hours following a first unsuccessful attempt due to the strong currents (> 0.5 m.s-1). At slack tide, the work period is about 20 minutes, so, within a margin of 10 minutes, deployment of the equipment is no longer possible;

[4] The launching of the sampling line, initially planned to take place at NW_PtRejet, was moved to SE_Scholle. Even when ballasted by several tens of kilograms, the sampling line did not reach the seabed at NW_PtRejet under the current velocities encountered there.

[5] The tests of immersion and piloting of the mini-ROV designed by the University of Caen to carry out underwater viewing did not take place, since the ROV was under repair at the time of the cruise.

[6] On-board measurement of the granulometry (using the LISST) of suspended sediment samples collected by Niskin bottles during the 24-hour cycle was cancelled. Indeed, the chaining of the sample treatment operations in a lean supply flow made it impossible to carry out the planned measurements. However, some *in situ* analyses (less destructive) were retained.

5 CONCLUSION

The TRACES 2015 cruise achieved the objectives that were set for the representative sampling of seawater, sediments and biological materials in the Normano-Breton Gulf. This cruise also provided the occasion to test promising new physical measuring instruments in the framework of improving our knowledge of hydro-sedimentary processes so these can be better taken into account in the models. The results of the TRACES 2014 and 2015 cruises will allow us to specify the conditions of mobilization of deposited sediments, as well as the dynamics of their evolution and the labelling induced in living species. This information will be exploited to evaluate the medium and long-term fate of radionuclides released into the environment. The ultimate goal is to obtain models simulating the dispersion, transport and transfer of radionuclides in the marine ecosystem on a multiannual scale.

6 APPENDICES

6.1 WATER LEVELS AND CURRENTS

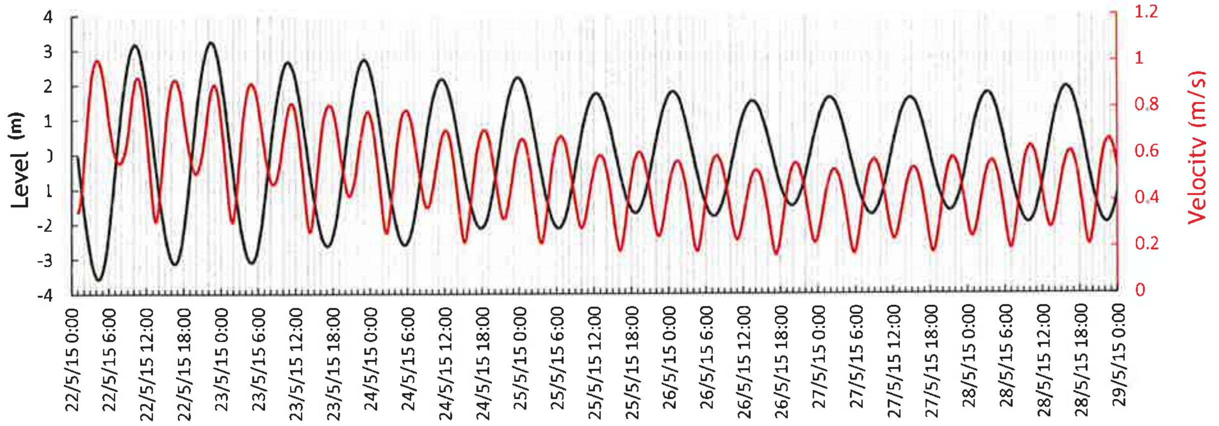


Figure 13: Simulation of water level and current velocity at SE_SERK as a function of time, taking account of wind forecasts (computer code MARS).

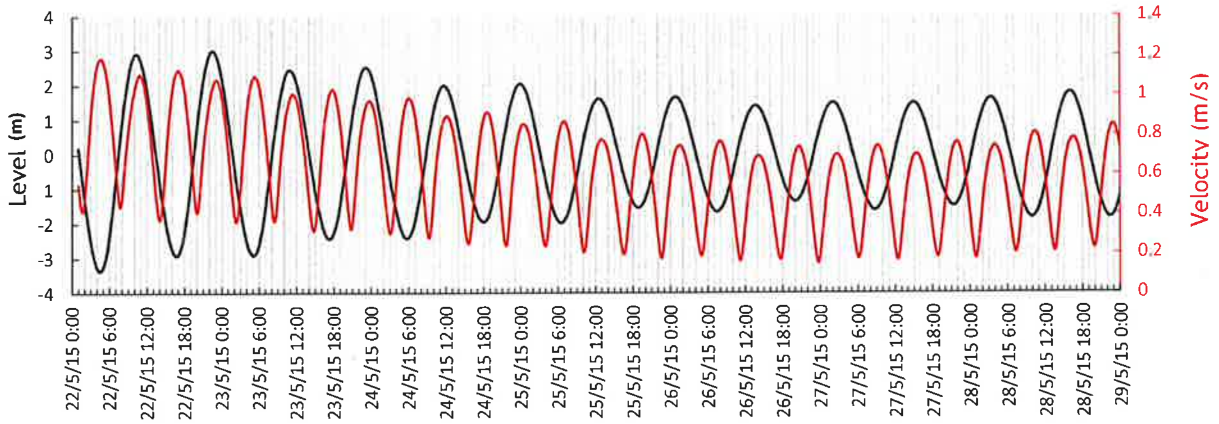


Figure 14: Simulation of water level and current velocity at SE_SCHOLLE as a function of time, taking account of wind forecasts (computer code MARS).

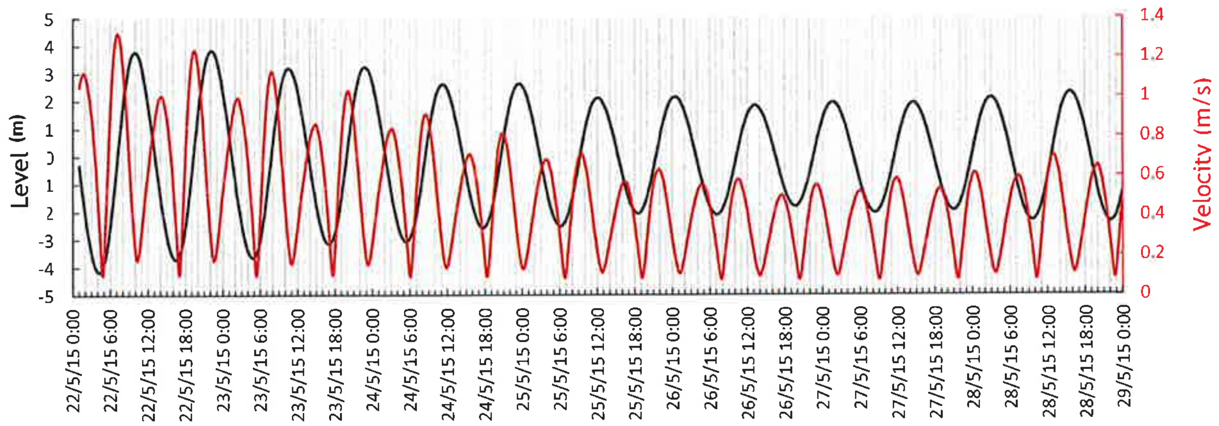


Figure 15: Simulation of water level and current velocity at TR68 as a function of time, taking account of wind forecasts (computer code MARS).

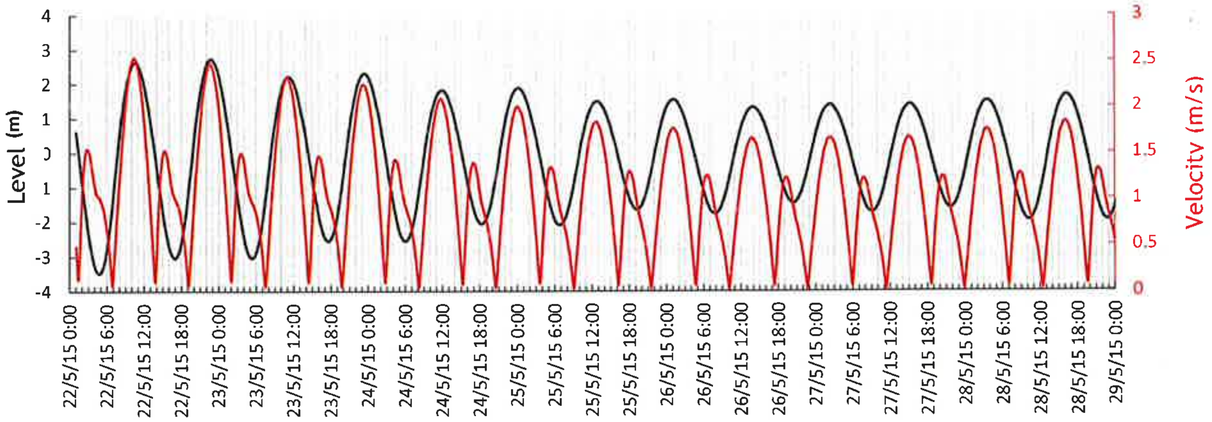


Figure 16: Simulation of water level and current velocity at NW_PTREJET as a function of time, taking account of wind forecasts (computer code MARS).

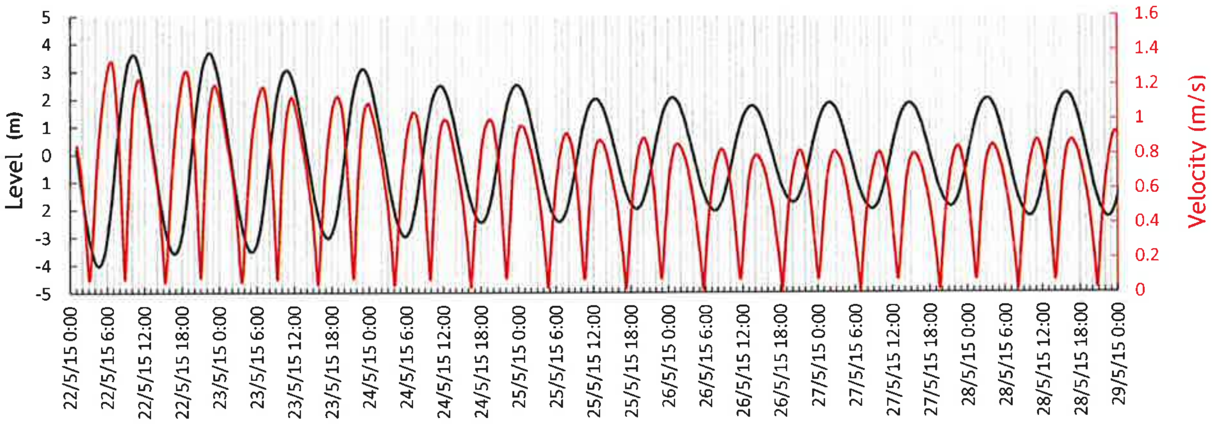


Figure 17: Simulation of water level and current velocity at ECREHOU as a function of time, taking account of wind forecasts (computer code MARS).

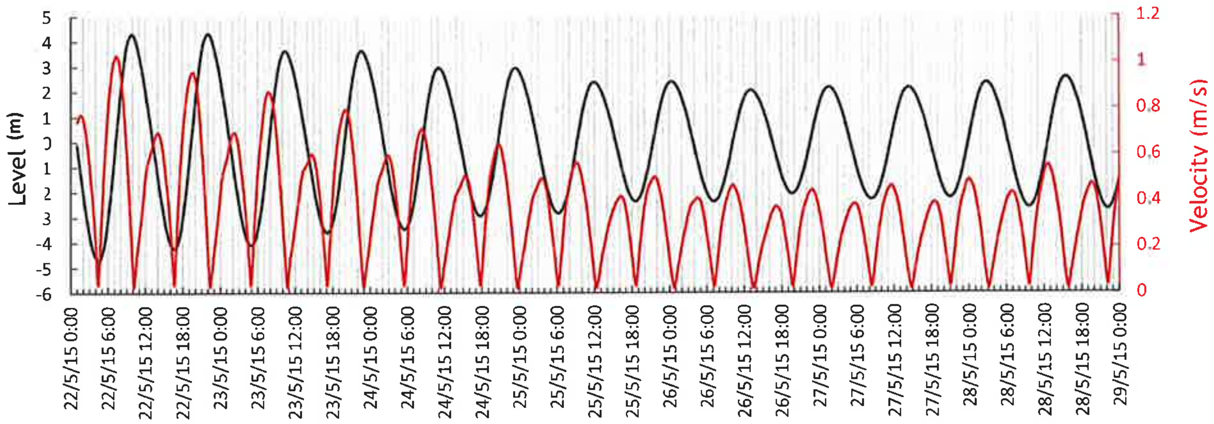


Figure 18: Simulation of water level and current velocity at CHAUSEY as a function of time, taking account of wind forecasts (computer code MARS).

6.2 ADCP DATA

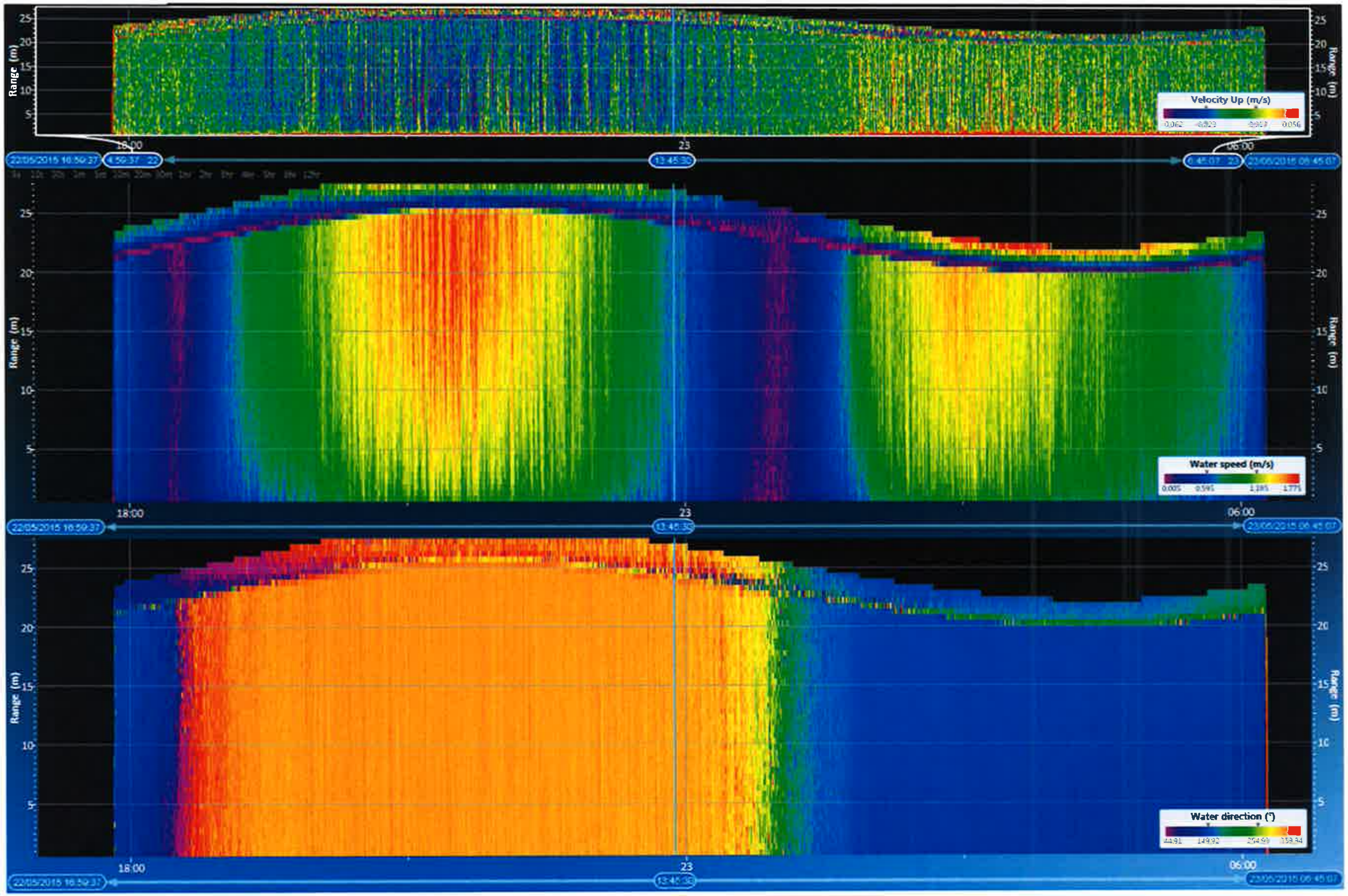


Figure 19: Data collected by ADCP at station NW_PTREJET between 22/05/2015 16:59:37 UT and 23/05/2015 06:44:37 UT (vertical resolution = 0.5 m; acquisition frequency = 1 Hz).

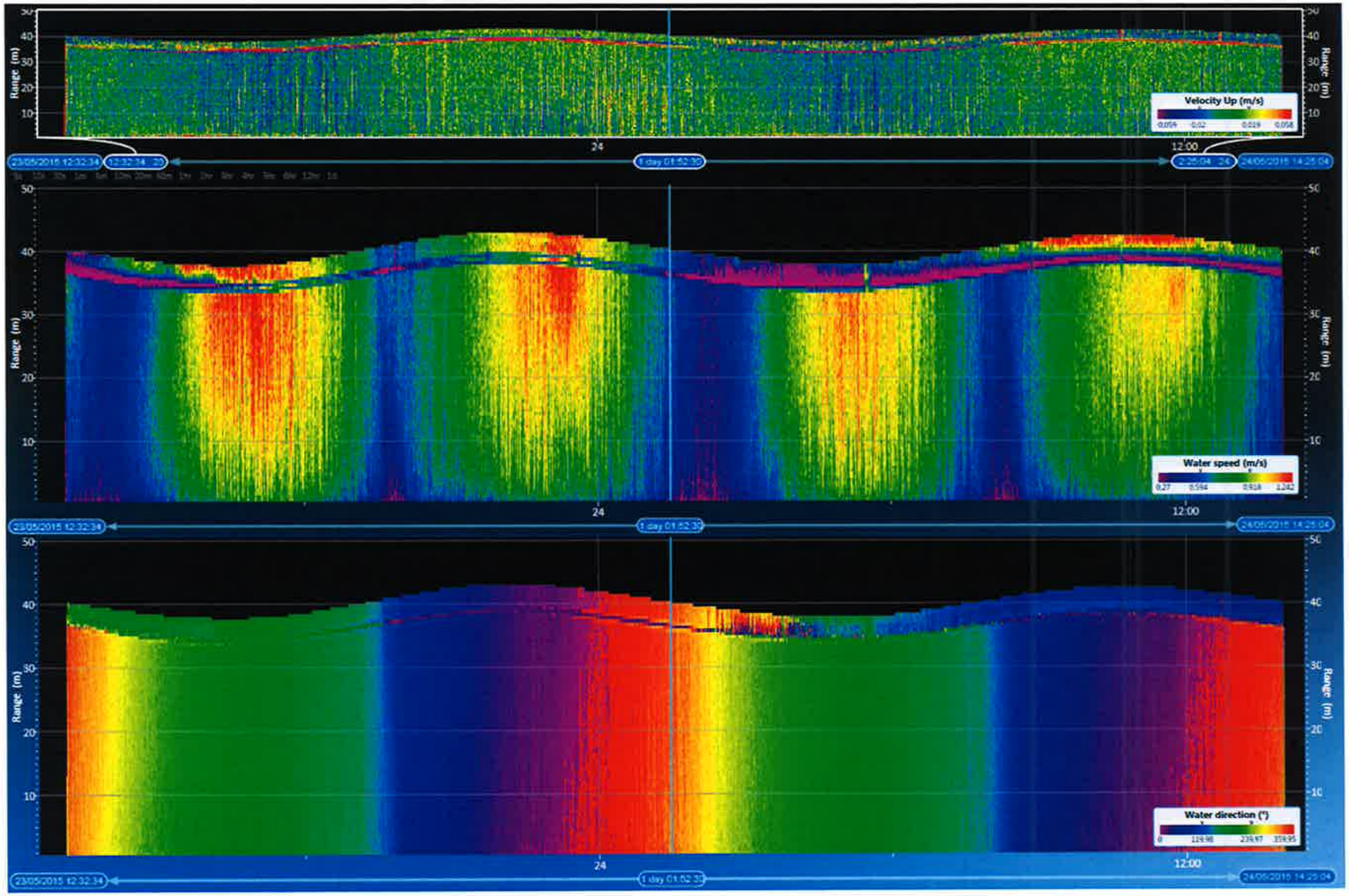


Figure 20: Data collected by ADCP at station SE_SCHOLLE between 23/05/2015 12:32:34 UT and 24/05/2015 14:24:34 UT (vertical resolution = 0.5 m; acquisition frequency = 1 Hz).

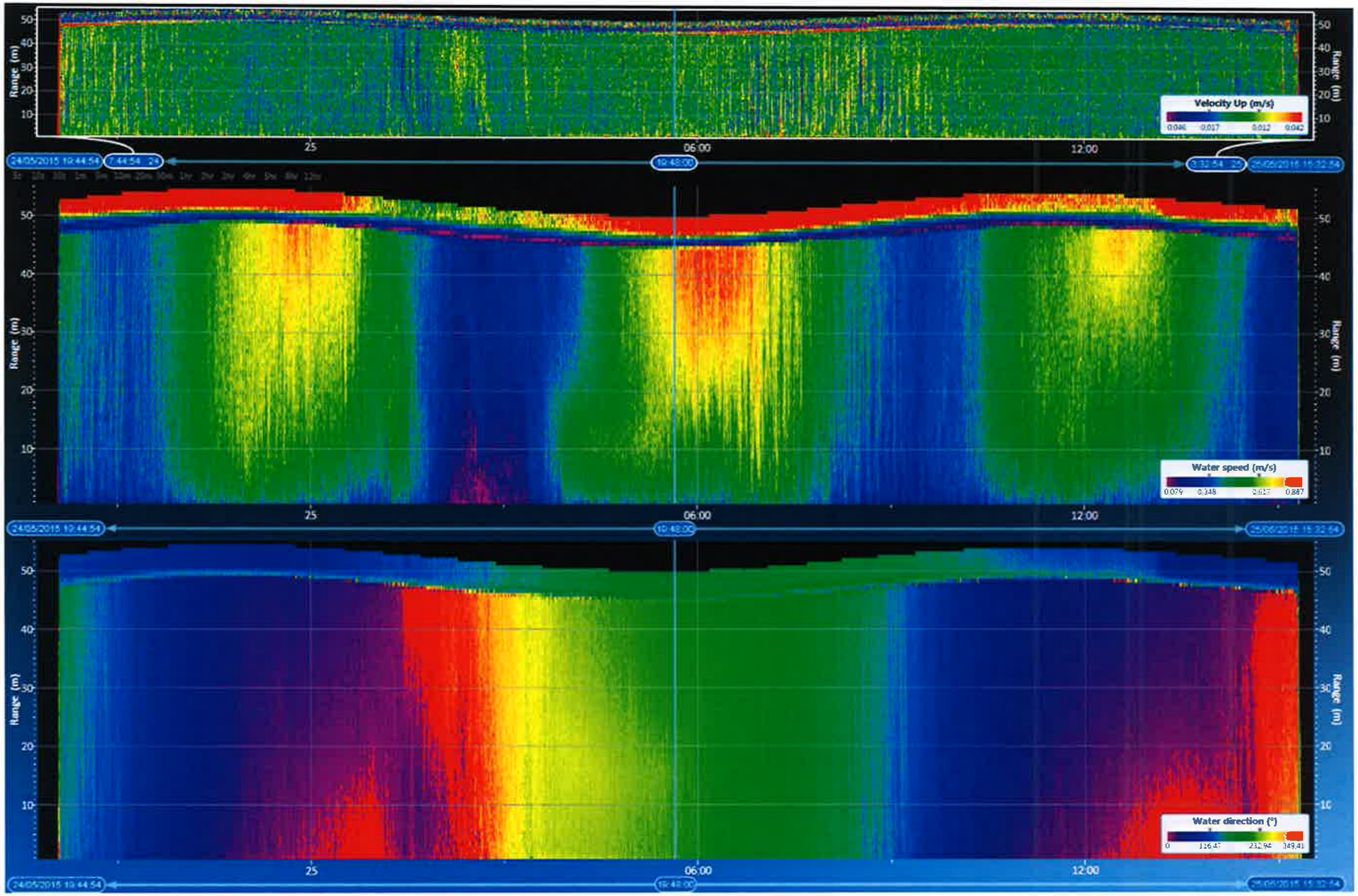


Figure 21: Data collected by ADCP at station SE_SERK between 24/05/2015 19:44:54 UT and 25/05/2015 15:32:24 UT (vertical resolution = 0.6 m; acquisition frequency = 1 Hz).

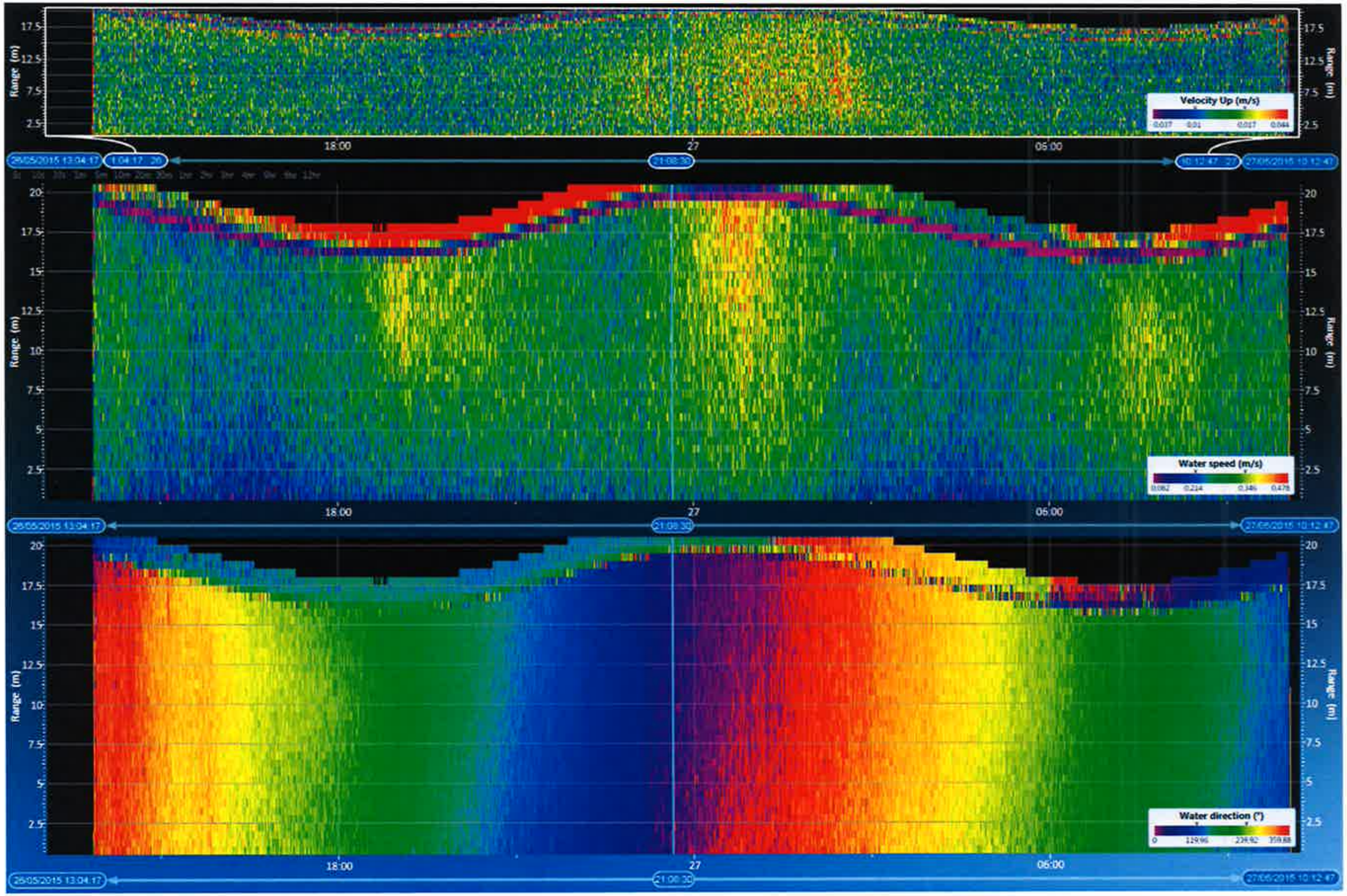


Figure 22: Data collected by ADCP at station TR68 between 26/05/2015 13:04:17 UT and 27/05/2015 10:12:17 UT (vertical resolution = 0.5 m; acquisition frequency = 1 Hz).