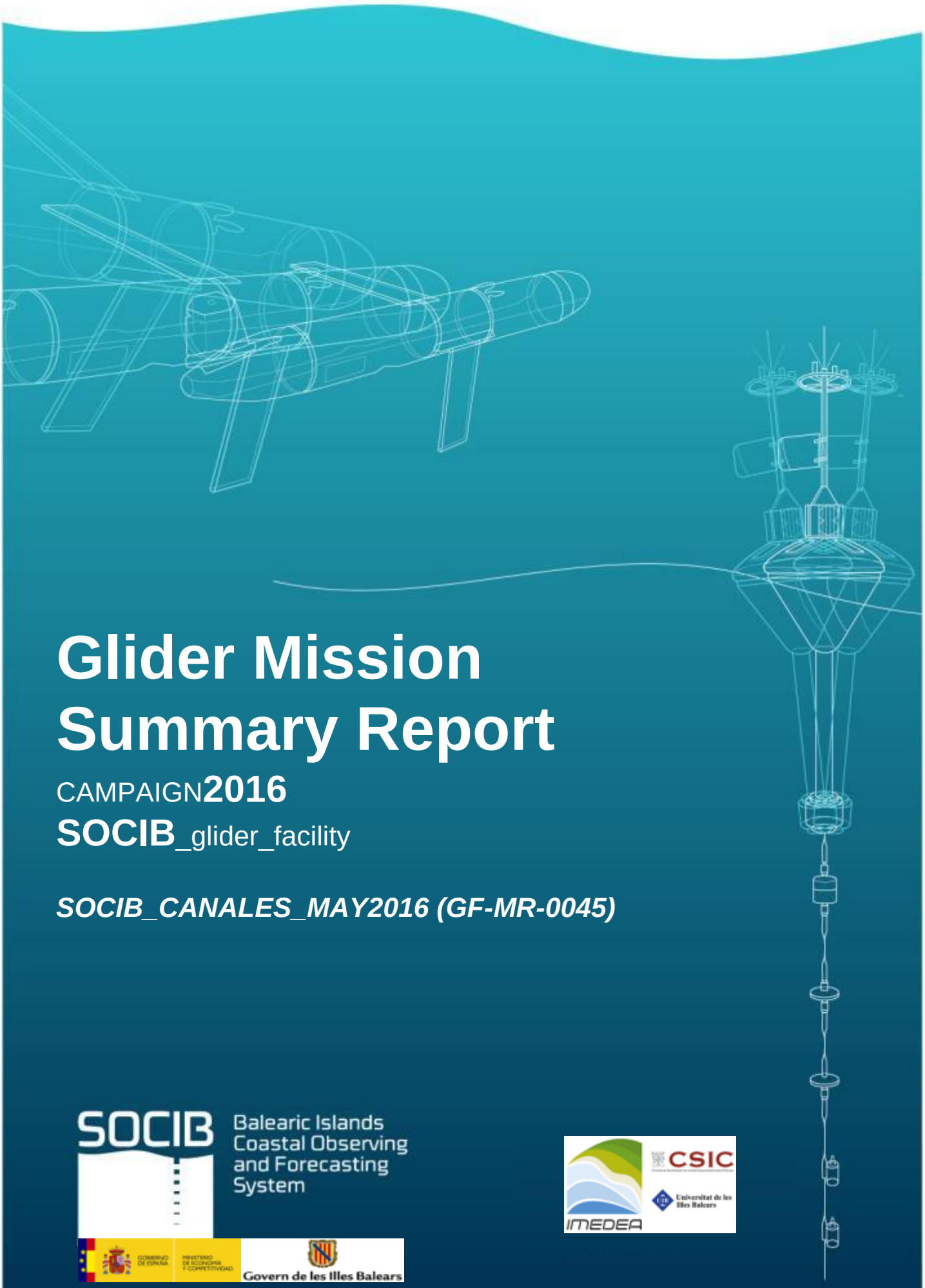

Glider Mission Summary Report

CAMPAIGN**2016**

SOCIB_glider_facility

SOCIB_CANALES_MAY2016 (GF-MR-0045)

SOCIB Balearic Islands Coastal Observing and Forecasting System

Govern de les Illes Balears

IMEDEA CSIC Universitat de les Illes Balears

Mission Name	*SOCIB_CANALES_MAY2016 (GF-MR-0045)*		
Platform Model	*Slocum 1000 G2*		
Platform ID / Name / WMO Code	*U243 / SDEEP00 / 68457*		
Related Platforms / Missions	*IDEEP00 (Algerian-Basin Mission, GF-MR-0046)* *SOCIB-R/V (Canales-May-RV-2016)* *SOCIB-R/V (ADCP sampling-day under SENTINEL-3)* *SENTINEL-3 satellite* *SCB-APEX006 & SCB_SVP027*		
Start Date	*2016-04-27*		
End Date	*2016-06-24*		
Total Days	*58*	**Total distance (Km / Nm)**	*1110 / 600*
Survey Area (NODC or SDN region)	*Balearic Channels: Mallorca-Eïvissa (MC) and Eïvissa-Valencia (IC) [Western Mediterranean Sea]*		
Objective(s)	• *Establishing the variability of the N/S exchange of water masses that occur through the Ibiza Channel(IC). Sampling standard transects across the Ibiza Channel several times using physical and biogeochemical sensors. No greater than 1 month gap in between consecutive iterations. The Mallorca Channel is also sampled when operationally practical.*		

Scientific Sensors (name & model / serial_number / calibration date)	• *GPCTD -SBE- / sn 0064 / 21-Nov-2014* • *FLNTU -WetLabs- / sn3711 / 22-Oct-2014* • *OPTODE -Aandera- / sn 1409 / 18-Jun-2014* *(calibration sheets available upon request to glidertech@socib.es)*
Number of Profiles	*3173 (CTD), 1458 (FLNTU), 1458 (OXY)* *(See Figure 1 on profiles max. depth)*
Significant Events	• *3rd **CANALES** mission in 2016 (G2 deep glider)* • *1st mission undertaken by **SDEEP00** in 2016 (powered by SAFT Lithium battpack.)* • *1st trial of SOCIB Custom Pickpoint* • *All-time longest Canales (1 MC transect + 11 IC transects)* • *Glider launched 12Km away from MC-leg initial-waypoint* • *Important frontal currents when navigating in parallel to Northern coast of Eïvissa* • *No deviating currents at Eastern wpt of IC but some deviation observed in the Western half of this IC-leg* • *Synoptic **SOCIB-R/V** missions (Canales Spring 2016 && ADCP-Sentinel3)* • *Synoptic **IDEEP00** glider mission (Algerian-Basin-Sentinel3)* • *Out-Of-Band abort motivated by a Software "blackout" during 20' approx.* • *Multiple non-critic missed calls* • *Dockserver240 (primary) down for a whole weekend (without consequences) due to a switch breakdown at IMEDEA's CPD* • *MS-INPUT and VACUUM Aborts due to unexpected battery end-of-life* • *Mission aborted prematurely and **SDEEP00** recovered in the middle of the 12th IC transect (low battery remaining-capacity the most likely explanation)* • *Tail/Digifin severely damaged (detected at Mission Conclusion)*
Mission Summary	*Introduction* *This mission, the 1st one by SDEEP00 in 2016, stands for the third CANALES mission in 2016. Internal code is GF-MR-0045. A record of IC transects was accomplished after covering IC track 11 times (completely) and a 12th iteration (cut in the middle due to emergency recovery); additionally, one MC was covered at the beginning of the mission. It was also synoptic, at different times, with multiple SOCIB observing platforms. Unexpectedly, Lithium batteries performance dropped prematurely forcing a mission abort. At conclusion, it is remarkable that the glider's tail/digifin appeared severely damaged.* *Pre-mission Report* *Created prior to the start of the preparations, compiling the key preliminary aspects of this GF-MR-0045, derived from planning sessions.* *Preparation* *Phases were executed between 14/Mar/2016 to 26/Mar/2016. All checks and configurations were undertaken according to the pre-mission-report and applicable protocols. There were neither relevant issues nor problems worth to be mentioned here. Compass error was measured in a EMI-free forest location (max. error around ±8º). This glider remained in stand-by (between this phase and the next) longer than usual due to the occurrence of the Glider Training hosted at IMEDEA.*

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Launching

This field operation (27/Apr) was executed by 1 ETD and 1 GF facility members on board SOCIB RIB Hurricane 9m. Glider was released in N39°25.631' E02°14.661' at 10:00-utc. The deployment was an operative and tactical success (environmental conditions were very good). Pilot was onshore. Glider executed successful test dives prior to the initial survey dive.

Survey

In general terms, it was successful but at a higher mechanical and piloting cost than desired. Main preliminary objectives were all accomplished with some major setbacks. Unfortunately, the occurrence of critical situations resulted in emergency actions both from remote and local positions.

- ***Navigation**: it was satisfactory. Fluid and continuous advancements with an average deviation from programmed route of 1,2Km. Multiple waypoint-lists were commanded with modifications to implement a current-evasion maneuver and extending the target-number of IC transects. First mission transect was a test-segment from launching site to 1st waypoint in MC. The majority of waypoints were accomplished successfully (max. dead-reckoning error of 1Km). There was a significant stop due to frontal currents (while surrounding Eivissa island) that required evasive maneuver and multiple interruptions due to mission-aborts (caused by battery failure). No signs of ↑ or ↓ intense currents at the sides of IC. The return trip was smooth and without problems. Navigation was not altered for recovery considering the glider continued along the IC while waiting for the field-team. Final traced route composed out of: (a) 1 MC transects, (b) 11 IC transects and (c) 1 incomplete IC transect. A total of 600Nm were covered. An average X-Y speed of 0,33m/s was accomplished. Surface periods lasted (in avg.) 898secs with a drifted distance of 225 meters. Current-correction algorithm was on during the entire mission.*

- ***Underwater Maneuvering**: was initially configured accordingly to scientific objectives, environmental conditions (mainly bathymetry for this mission) and 'flying' efficiency. (See Chart 1 for details). During the mission the strategy was slightly changed multiple times to adapt to variations in these aspects (mainly flotation parameters to fly more efficiently). Basically, a standard configuration (surface by UTC time, 4 times a day, infinite yo-ing, altimeter on, manual pitch control) was implemented. Average vertical speeds of 0,15m/s (climbing) and 0,19m/s (diving) were accomplished resulting in a mean horizontal speed of 0,293m/s. Both target depths (upper and bottom) remained constant during the main part of the mission (15 and 950 meters respectively). In general, top and bottom inflections occurred at the expected depths (due to bottom detection or max. depth reached).*
  However, during the last part of the mission some undesirable events occurred: (1) underwater software reset by Watchdog device; (2) Bottom hit due to pump failing from starting-up and (3) a series of aborts the day before the emergency recovery. The cause of all of these successes has been stated as a poor energy supply by a decaying voltage of on-board Lithium batteries.

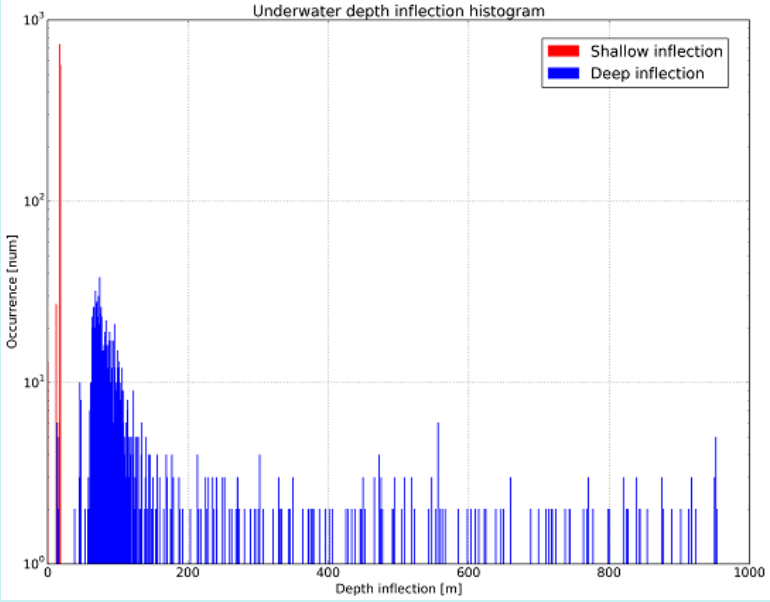

Figure 1 - Diving Max-Depth Histogram

- ***Data Logging**: sampling seemed to have been successful and according to details shown in Chart 2 (48 non-critical oddities raised by science-super). The strategy was changed multiple times in order to save energy by turning on/off the optical sensors whilst CTD remained ON during the whole mission. This resulted in 3173 CTD profiles and 1458 for OXY and FLNTU each (690332m of water-column sampled with CTD, 190912 with FLNTU and 288391m with OXY). Intersample mean-times for CTD, OXY and FLNTU are 3,956sec, 5,152 sec and 10,0sec*

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respectively. The number of samples taken have been: 2556254 (CTD), 1253663 (OXY) and 885060 (FLNTU).

- ***Engineering***
  - *Power Source: Brand new Primary Lithium Battery pack with, as considered prior to the mission, 420Ah of nominal capacity. After this experience, the nominal capacity of the packs from this manufacturer are considered usable only until depleting 310Ah The supply was stable and capable of fulfilling the requirements of all the on-board systems until the 10th IC transect. After that, SDEEP00 should have been commanded to return to home-port. But it wasn't (relying on a false greater capacity) so the 'depletion-knee' appeared in the middle of the 12th IC transect whilst it was already obvious during the 11th one. Finally, glider operation became unfeasible passed when consumption reached 311Ah.*
  - *Electro-Mechanical: actuators and sensors exhibited an excellent performance during before battery weakness began. Until then, a few pitch_motor and de_pump oddities were registered (and the usual high-number of Digifin oddities). Then, probably due to the 'depletion-knee' of the batteries, de_pump raised a total of 163 oddities, warnings and, ultimately, 4 errors. The bottom-hits during this mission were probably caused by these pump failures.*
  - *Communication Systems: were reliable and fluent. There were 31 drop-calls and 6 missing-calls. ARGOS sent 2523 messages. GPS fix time (mean) was 124 seconds and there were no pre-fix failures. No radio-link (900Mhz) issues during local communications.*
  - *Electronic Modules: (processors, memory cards, control boards,...) revealed no evidences of problems but a particular dive (16/June@02:52am,utc) during which the software seemed to 'freeze'. This caused the first abort of the mission (officially of type Out-of-Band) and, more importantly, a reset by Watchdog that occurred underwater. The origin of this freezing is unknown (manufacturer has been consulted about this).*
  - *Contextual/Awareness Sensors: pressure transducer, internal vacuum and internal temperature seemed to have worked correctly. Compass also reported coherent values. Altimeter (although under suspicion due to the false detections and having had to decrease its Max-Range) detected the bottom correctly.*
  - *Hull/Hydrodynamics: no signs of problems.*
  - *Device Error-Statistics: 8 Errors (1 from Compas; 7 from De_Pump after batteries started to fail), 23 Warnings (16 GPS, 4 Compass, 3 Iridium) and 1761 Oddities (4 Pitch_motor, 48 Science_Super, 1195 Digifin, 351 Iridium, 163 De_Pump). Only those raised by De_Pump are of special concern (the rest are more normal). Telemetric data reveal that all of these De_Pump dit not occur prior to the 'depletion-knee' of the batteries*
  - *Mission Runs: multiple missions runs (more than usual) due to the aborts experienced after the failure of the batteries and, firstly, by the underwater reset ("frozen" software). Mission numbers were: #363 (27/Apr, "status.mi"), #364 (27/Apr, "overtime.mi"), #365 ("ovrdepth.mi"), #366 (27/Apr, "camay100.mi"), #367 (16/Jun, "initial.mi"), #368 ("lastgasp.mi"), #369 ("camay101.mi"), #370 ("camay102.mi"), #371 ("camay103.mi"), #372 ("lastgasp.mi"), #373 ("camay103.mi"), #374 ("camay103.mi"), #375 ("lastgasp.mi"), #376 ("camay103.mi")*

Recovery

This was an emergency extraction motivated by a failure of the Lithium batteries. After 48 hours of an abnormal Glider aborts, it was quickly arranged and executed on June-24th in N39° 00.545' E00° 37.196' (See "MISSION ABORT/END" position in Figure-2). A team formed by 1-ETD and 1-GF departed early in the morning and cruised (on board SOCIB-I RIB) for 4,5 hours until interception (Glider was already at surface waiting) and was extracted with no problem availing a favorable sea-state. SDEEP00 performed a series of shallow dives, during that cruise, to minimize the risk of hovering at surface.

Conclusion

This phase started on the 28th of June and took longer than usual due to a series of observations related to biofouling and mechanical deformation. This phase concluded on July-6th with the following headlines: (1) vehicle's hull was disassembled, flight-mechanisms and electronics revised and batteries removed; (2) external surfaces and sensors cleaned and refurbished (light signs of corrosion and important evidences of biofouling growth); (3) gathered-data backed up by direct extraction of memory flash cards and uploading to SOCIB's data-center for post-processing; and, finally, (4) preparing the glider for storage (under the status of Need-for-Repair due to the Digifin's issue).

Remarkable: (1) The Lithium batteries 'died' when 310Ah had been consumed and the appearance of the 'depletion knee' is the official cause of the voltage failure which provoked the recovery. See Figure 2. (2) The Digifin and Tail-boom appeared severely bent to Starboard. Due to this deformation the Cowling also suffered damages. Glider manufacturer has been contacted to this regard and telemetry carefully analyzed. However, there is not an official explanation about what forces (and their origin) could have done such damage. The most likely ultimate consequence is the glider being sent to factory for repair and opportunistic refurbishment.

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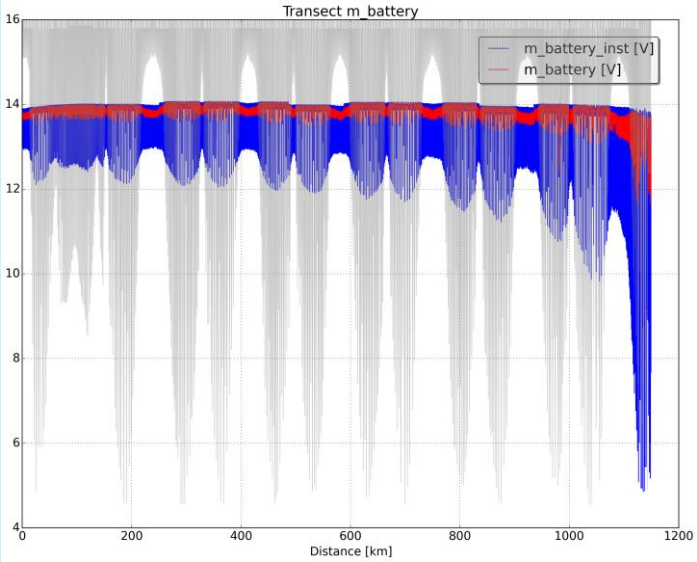

Figure 2 - Battery evolution and decay

Administration/Notification

Although multiple administrative and notification procedures took place during the different stages described above, these have not been reported because are considered out of the scope of this report. Same applies for multimedia and public-diffusion; and also for accounting.

HHRR

Coordination amongst multiple participants (glider-techs, field-techs, scientists & open-access-users) was fluent and efficient in spite of the field failure during recovery. There were no severe personal damages (one of the field techs received a small cut on his leg due to the wing-rail pin) and the availability of each member, for all the tasks assigned at each moment, was correct (including on-alert shifts for field intervention and 24/7 glider monitoring during survey). Specially this time, the emergency reaction to the aborts and to the call for immediate recovery was quickly arranged and everybody got actively involved and with a total predisposition to be a part of the field team.

Detailed Charts:

Date (utc)	D_{UTI}	D_{UBI}	T_{UND}	d_{BOT}	N_{DIV}	N_{COM}	t_{UTC}	H_{WPT}
27/Apr@(M.S.) [1]	20	950	21600	40	∞	12	4,11,16,20	1000
10/May@16:16 [2]	15	45	1200	40	2	12	4,11,16,20	1000
10/May@17:01	20	950	21600	40	∞	12	4,11,16,20	1000
24/Jun@10:57 [3]	20	300	3750	40	1	12	4,11,16,20	1000
24/Jun@13:37	15	45	1200	40	2	12	4,11,16,20	1000

[1]: Prior to this nominal underwater strategy, preliminary test dives were performed (to validate trimming and bottom detection)
[2]: Shallow diving to check (via NRT transmission) optical sensor sampling
[3]: Shallow diving to keep the glider navigating underwater while waiting for recovery team to intercept it

(M.S.): Mission Start	N_{DIV}: Surface upon completion of this # of dives
D_{UTI}: Underwater Top Inflection Depth (m)	N_{COM}: Surface if this amount of hours without stable communications (hrs)
D_{UBI}: Underwater Bottom Inflection Depth (m)	t_{UTC}: Surface at this particular UTC times
T_{UND}: Average Period of Underwater Navigation (secs)	H_{WPT}: Surface if a waypoint is hit within that distance (m)
d_{BOT}: Minimum Distance to Sea-floor to be kept (m)	

Chart 1 Summary of Underwater Strategies (Navigation)

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Date (utc)	S_{EN}	f_{SMP}	D_{RNG}	M_{DIV}	M_{CLI}
27/Apr/2016 (at Mission Start)	CTD	0,5000	[-5, 2000]	yes	yes
	OXY	0,2500	[-5, 2000]	yes	yes
	FLNTU	0,1250	[-5, 150]	yes	yes
	FLNTU	0,0625	[150, 300]	yes	yes
11/May/2016	CTD	0,5000	[-5, 2000]	yes	yes
	OXY	Off	-	-	-
	FLNTU	Off	-	-	-
	FLNTU	Off	-	-	-
22/May/2016	CTD	0,5000	[-5, 2000]	yes	yes
	OXY	0,2500	[-5, 2000]	yes	yes
	FLNTU	0,1250	[-5, 150]	yes	yes
	FLNTU	0,0625	[150, 300]	yes	yes
27/May/2016	CTD	0,5000	[-5, 2000]	yes	yes
	OXY	Off	-	-	-
	FLNTU	Off	-	-	-
	FLNTU	Off	-	-	-
08/Jun/2016	CTD	0,5000	[-5, 2000]	yes	yes
	OXY	0,2500	[-5, 2000]	yes	yes
	FLNTU	0,1250	[-5, 150]	yes	yes
	FLNTU	0,0625	[150, 300]	yes	yes
13/Jun/2016 (until Mission End)	CTD	0,5000	[-5, 2000]	yes	yes
	OXY	Off	-	-	-
	FLNTU	Off	-	-	-
	FLNTU	Off	-	-	-

S_{EN}: Sensor type
f_{SMP}: Frequency of sampling (Hz)
D_{RNG}: Depth range this configuration applies (m)
M_{DIV}: Sampling during Diving maneuver
M_{CLI}: Sampling during Climbing maneuver

Chart 2 Summary of Commanded Sampling Strategies

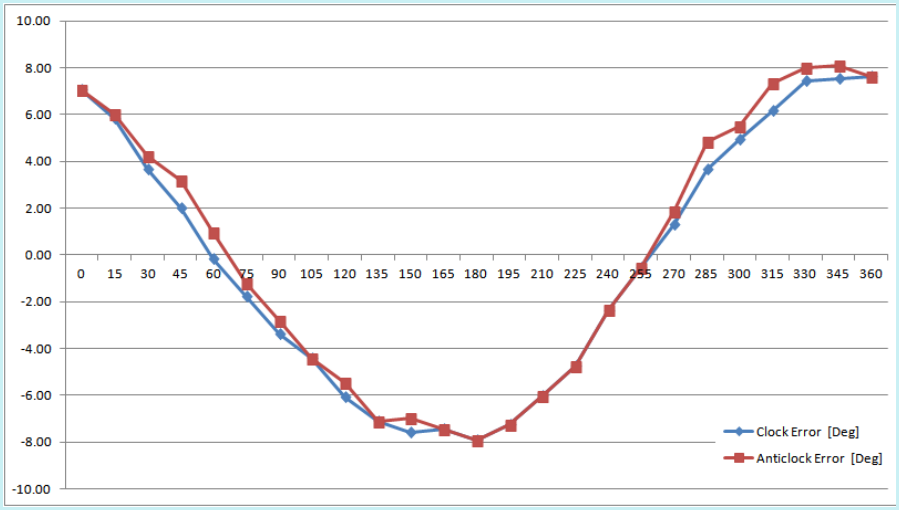

Figure 3 - Error measured during Compass Error Check procedure in an electromagnetic-field-free environment located in a forest close to IMEDEA (in Esporles)

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Principal Investigator (e-mail or contact phone/address)	• *Prof. Joaquim Tintoré jtintore@socib.es (+34 971439821)*
Institute	*SOCIB in collaboration with IMEDEA*
Project Affiliation (web-site)	*http://www.socib.eu*
Partnership / Participation	• *SOCIB* • *IMEDEA*
Glider Software Version	*Nav : v7.13 Acomms, Payload: 3.17*
Data Retrieval (real-time [RT] / delaved-mode [DM])	• *RT: sub-set via satellite link at each surface maneuver* • *DM: full/direct memory card backup after glider disassembly during Conclusion mission-phase*
Compass Calibration (specify procedure)	*Compass error was measured. Observed error followed a well-known sinusoid-shape although the glider followed traced-route very well(See Figure 3.1)*
Battery Type	*SAFT Custom Lithium Pack (430Ah-nominal capacity) (With in-house-designed ballasting chassis)*
Battery Consumption (Ah)	*311.851Ah (reading from 1.748 to 313.599Ah)*
Data Available From	*http://thredds.socib.es/thredds/fileServer/auv/glider/sdeep00-scb_sldeep000/L2/2016/dep0018_sdeep00_scb-sldeep000_L2_2016-04-27_data_dt.nc*
Further Details	*glidertech@socib.es*

Figure 1

(Map providing general overview of Survey Area)

On-line Track

http://apps.socib.es/dapp/?deployments=598-59-0-FFFF00&layers=ocean_basemap&units=scientific

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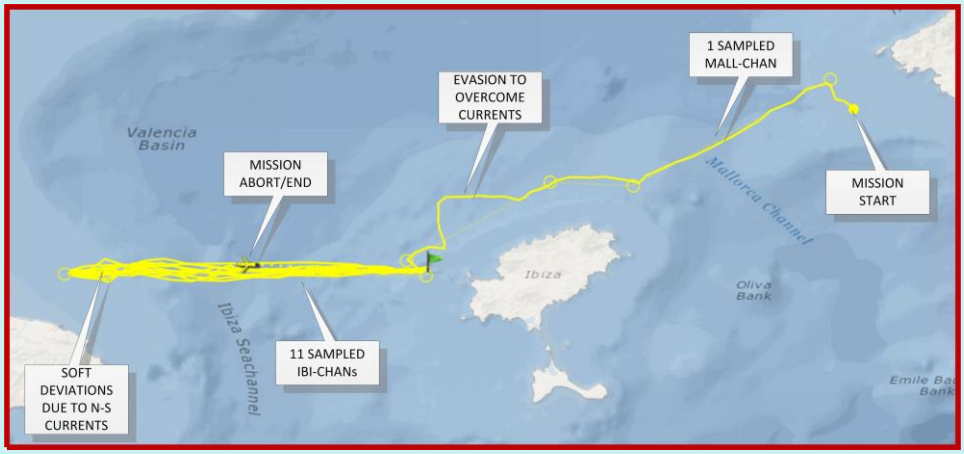
Figure 2

(Map providing detailed overview of Survey Area and traced Flight Path with surface points if possible)

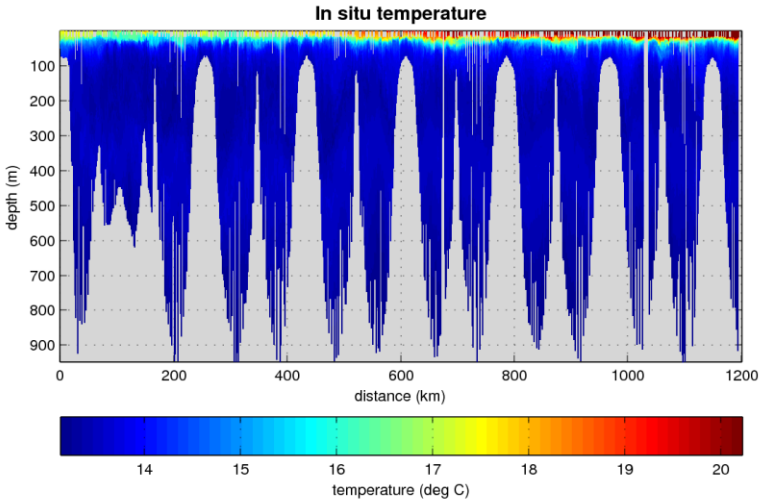


Scientific Preliminary Review

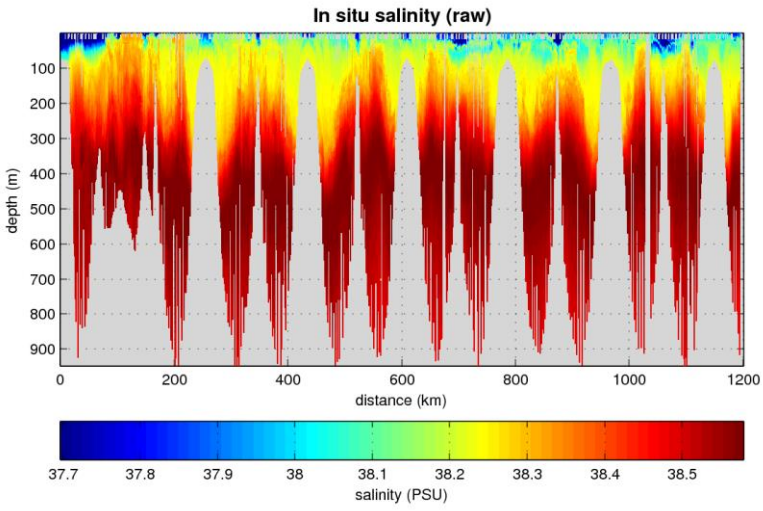
(Compilation of preliminary post-processing plots provided by SOCIB's data-center glider-toolbox and processing services. Contact data.center@socib.es for further info. Plots available through DAPP - See Figure 1 -.

Comments provided by SOCIB's scientific staff)

CTD



Plot 1 - In situ temperature (full depth range)



Plot 2– In situ salinity (full depth range)

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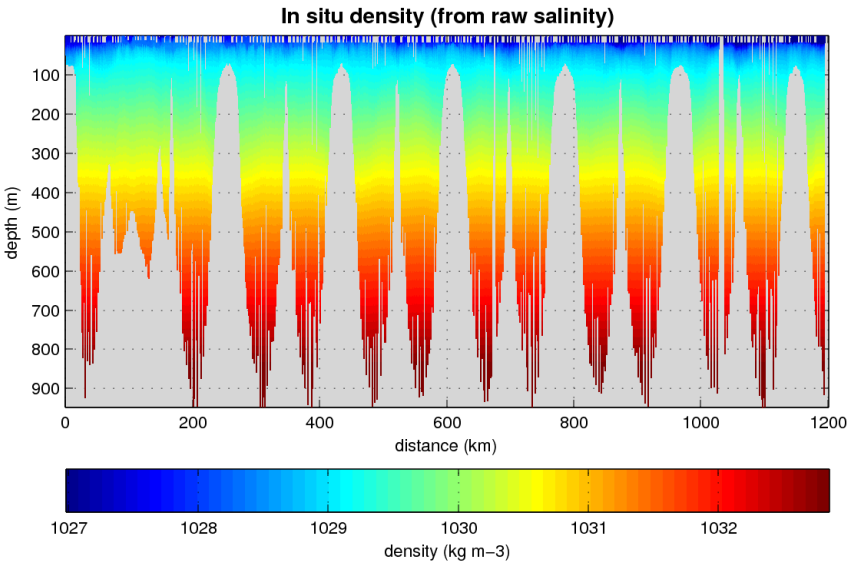
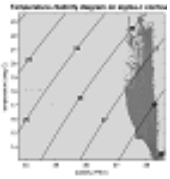
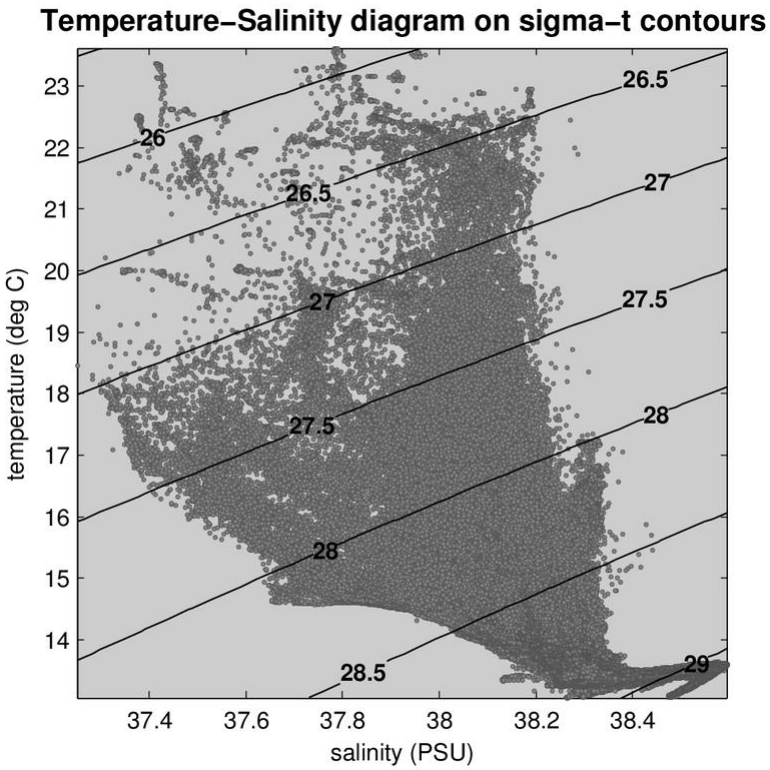


Plot 3 – density derived from corrected salinity and temperature (full depth range)

(Plot4 shown here is the result of a Quality-Control method applied by SOCIB's Data-Center to filter suspiciously low salinities that were totally out-of-range in the Balearic Channels region - see a miniaturization of the original-plot below-.

Contact akrietemeyer@socib.es for further info.)





Plot 4 – T-S diagram (thermal-lag corrected)

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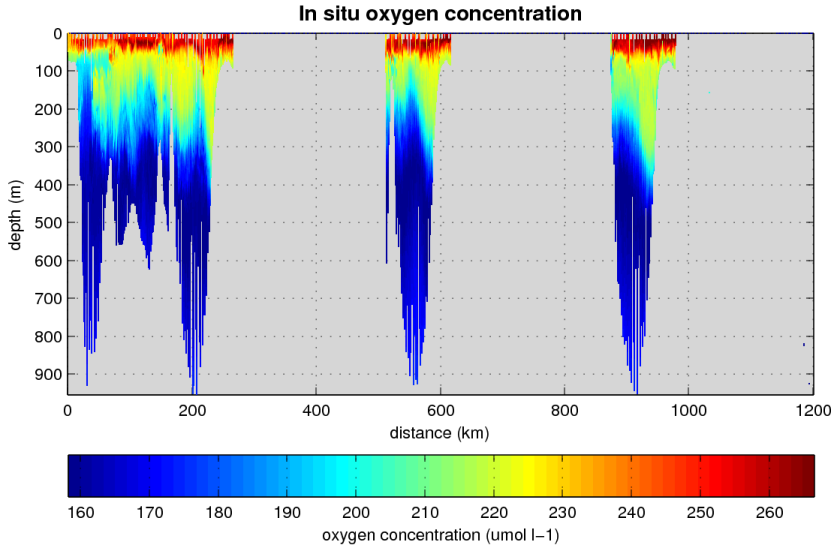
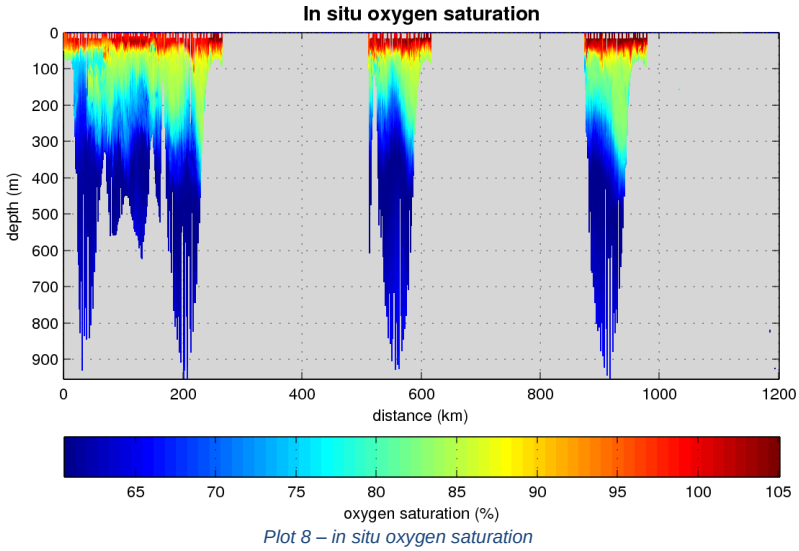
OXYGEN



Plot 7 – in situ oxygen concentration



Plot 8 – in situ oxygen saturation

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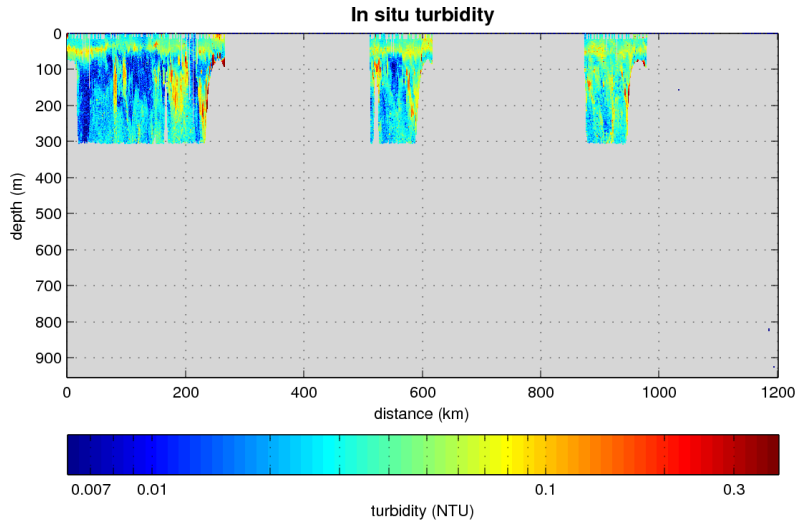
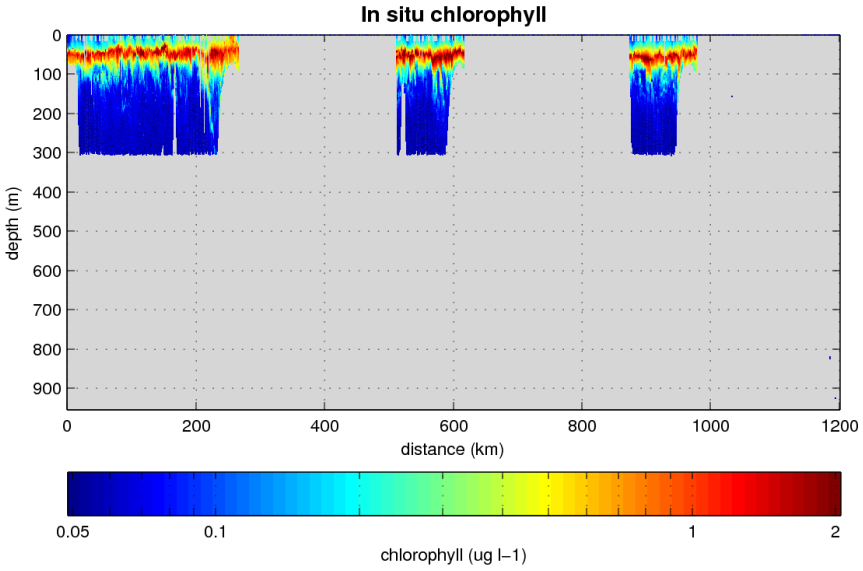
TURBIDITY & CHLOROPHYLL



Plot 9 – in situ turbidity



Plot 10 – in situ fluorescence

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