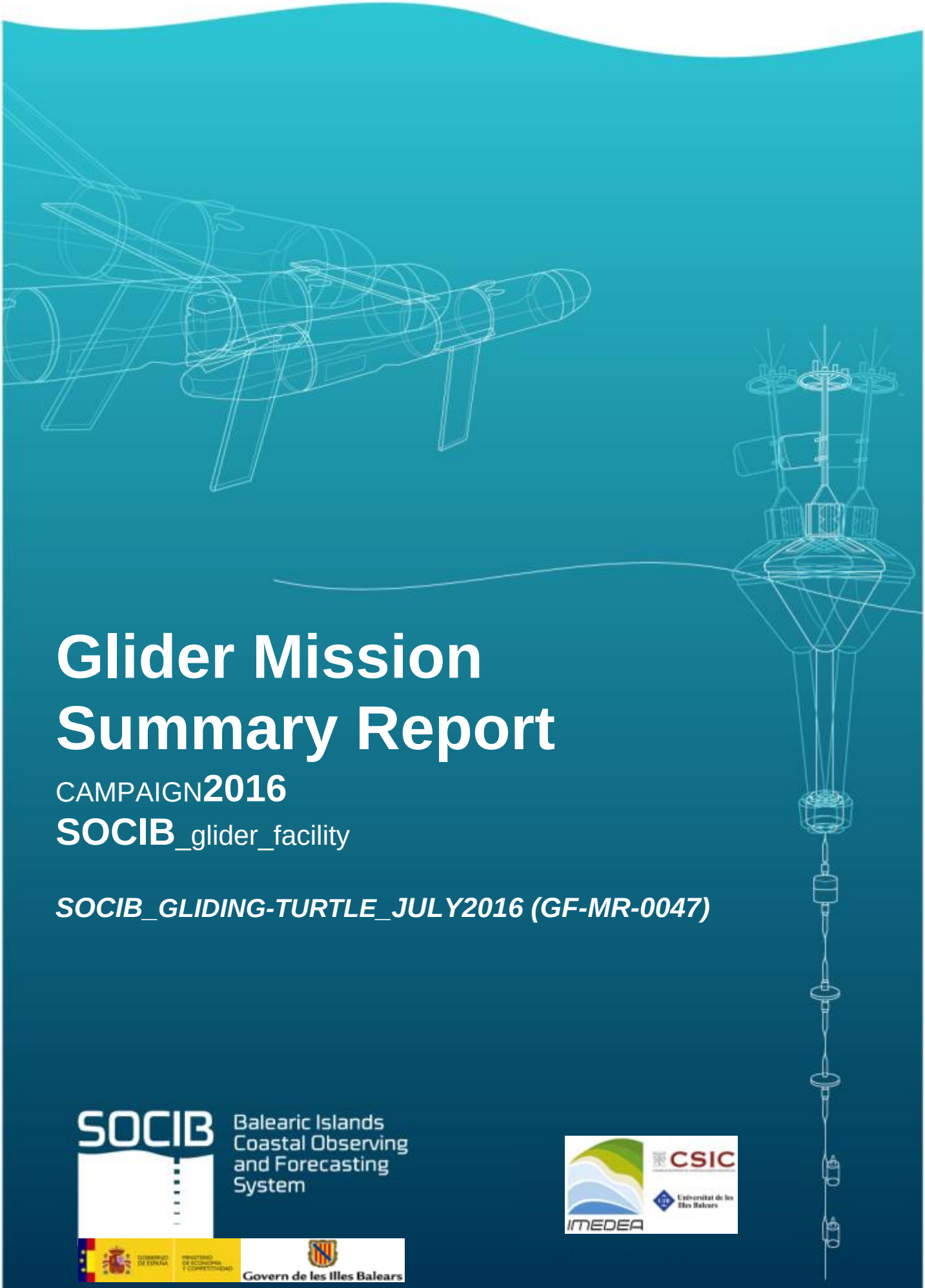

Glider Mission Summary Report

CAMPAIGN**2016**

SOCIB_glider_facility

SOCIB_GLIDING-TURTLE_JULY2016 (GF-MR-0047)

SOCIB Balearic Islands Coastal Observing and Forecasting System

Govern de les Illes Balears

IMEDEA CSIC Universitat de les Illes Balears

Mission Name	*SOCIB_GLIDING-TURTLE_JULY2016 (GF-MR-0047)*		
Platform Model	*Slocum 200m G1*		
Platform ID / Name / WMO Code	*U050 / ICOAST00 / 68968*		
Related Platforms / Missions	*IDEEP00 (CanalesJULY2016, GF-MR-0048)* *SOCIB-R/V (Canales-July-RV-2016)* *ARGOS Tags #151933-#1511936*		
Start Date	*2016-07-13*		
End Date	*2016-07-26*		
Total Days	*13*	**Total distance (Km / Nm)**	*191 / 103*
Survey Area (NODC or SDN region)	*West coast of Mallorca (between Palma's Bay and Cabrera island [Western Mediterranean Sea]*		
Objective(s)	• *Gliding Turtles is a research experiment aimed to analyse the fine-scale patterns of sea turtles (Caretta caretta) in relation to oceanographic features and human activities through a multi-platform approach to support the conservation of marine pelagic ecosystems [David March, dmarch@socib.es, July2016]*		

Scientific Sensors (name & model / serial_number / calibration date)	• *CTD -SBE- / sn 0041 / 08-Feb-2011* • *FLNTU -WetLabs- / sn696 / 02-Feb-2011* • *OPTODE -Aandera- / sn 429 / 20-Jan-2011* *(calibration sheets available upon request to glidertech@socib.es)*
Number of Profiles	*1284 (CTD), 0 (FLNTU), 1284 (OXY)*

Figure 1. Depth VS Time

Significant Events	• *1st ICOAST00 mission in 2016 (and first one since ALBOREX-2104)* • *Dual launching operation (ICOAST00 and tagged-turtle "Eddy")* • *Launching one day after IDEEP00 launch on-board Canales-SUMMER SOCIB-RV cruise* • *1st "adaptive sampling" mission (driven by a living and wild animal)* • *Very intense route commanding (daily reload of GOTO file)* • *Science-super "Ringbuff Overflow" problem (13hrs of no sampling at all, 19/July)* • *FLNTU covered with protective during the whole mission (useless Chlor and Turb data)* • *2 periods of "waiting" for the turtle to return to favorable waters and 2 successful periods of "chasing the turtle"* • *More biofouling than expected at the recovery*
Mission Summary	*Introduction* *This mission, the 1st one by ICOAST00 in 2016, stands for the very first GLIDING-TURTLE mission in 2016 (contact dmarch@socib.es for further details on the background and project filiations of this mission). Internal code is GF-MR-0047. After initial operational and logistical challenges (especially with regard to the synchronization with the turtle release) a solid and intense mission monitoring and piloting was executed. All this resulted in a total of 13 days of deployment with a preliminary turtle-tracking success of a 50%. It was also synoptic, at different times, with multiple SOCIB observing platforms (especially with GF-MR-0048). The execution of the mission was a tactical and operational success but the fact that the FLNTU was covered by a sun-screen tape during the entire deployment. Considering it was a 'demo' mission, the outputs, from a technical point-of-view are considered highly valuable.*

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Pre-mission Report

Created prior to the start of the preparations, compiling the key preliminary aspects of this GF-MR-0047, derived from planning sessions.

Preparation

Phases were executed between 23/June/2016 to 12/July/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 greater than 20º). This glider remained in stand-by (between this phase and the next) longer than usual due to the indetermination introduced by the capture of the turtle and the management of the tagging and posterior release. ICOAST00 was stored at Calanova's hangar during all this waiting period.

Launching

This field operation (13/July) was considerably more complex than the standard due to 2 factors: (First) some G-F and ETD members were those days on board SOCIB-R/V as part of the Canales-SUMMER-2016 cruise and (Second) the turtle had to be released from SOCIB-I vessel with SOCIB GF and ETD members on-board, as well as 1 Alnitak technician. Additionally, ICOAST00 pilot was remotely acting from IMEDEA. These three teams were in permanent contact by GSM-phones and messaging applications (when possible). 1 ETD, 1 GF, the PI and 1 Alnitak composed the on-field team on board SOCIB RIB Hurricane 9m. Glider was released in N39° 16.842' E02° 38.322' at 09:52am-utc. The deployment was an operative and tactical success (considering the circumstances) at first although recovery revealed that SOCIB-I glider-tech failed to remove the protective tape installed on the FLNTU sensor. Glider executed successful test dives prior to the initial survey dive (regardless the extraordinary elements, the launching protocol was strictly fulfilled). Note: very nice pictures were taken of the simultaneous glider-turtle release.

Survey

Again, this part of the mission was different to the standard surveys SOCIB-GF is usually devoted to. It was in fact the first adaptive sampling/navigation attempted in many years. The fact that the driving-factor (determining the attack-heading) was a living animal freely moving in its natural environment introduced an indetermination that forced both the PI, and piloting-team, to evaluate the situation (and the necessity to re-adjust the commanded route) every 3 to 5 hours (no changes made at night to assure the rest of the team). Another significant novelty was the configuration applied to implement that commanded track. The standard linear waypoint list (with no repetition) was replaced by a circular scheme with infinite looping (so the glider never ran out of waypoints to pursue) and, very importantly, without surfacing due to hit-a-waypoint. Thanks to this, in the case that the turtle maintained its position the glider would stand-by navigating around a central point describing a triangle; whereas, if the animal was far away enough, this central point was moved to an estimated location (over turtle's ahead-path) so the glider would resume the turtle tracking. The results of this new strategy were very positive. Important: a security perimeter was established depending on three variables that were water-depth (bathymetry), distance-to-shore (cartography) and ship-traffic (AIS). The assumed risk-level, with respect to these factors, could be catalogued as Medium following a rather conservative approach considering the summer season and proximity to coast-line (the turtle moved very close to show in two different stages of the mission and the glider had to remain waiting for the specimen to return to deeper and safer waters.

In general terms, it was successful but at a higher logistical and piloting cost than usual. Main preliminary objectives were all accomplished with the major setback of the covered FLNTU sensor. Unfortunately, by the time the mission had to be concluded the turtle resumed advancing linearly and towards Formentera island. The limiting factor, besides excessive distance to SOCIB-I home-port, was deployment-time which was restricted by personnel rest (summer holidays) and mission cost whereas there were enough batteries to continue at least 10 additional days.

- ***Navigation**: it was very satisfactory. The glider responded well to the commanded target waypoints. Due to the adaptive character of the mission, an average of 2 different waypoint lists were configured per day. This resulted in an irregular and non continuous advancement, especially when the glider had to wait for the turtle to return to more favorable waters. This happened more significantly during the first 3 days of mission and 20-23/Jul. For the rest of the mission, ICOAST00 followed the turtle very well considering its own technical limitations. This success was more evident during the "chasing" occurred between the 13th and the 20th of July. Maximum deviations of 0,5 Nm were observed during this successful period. Additionally, there were no evidences of adverse currents. With respect to surface periods, NRT transmission was avoided to reduce the exposition time to ship collision. Configuration interventions were executed as fastest as possible to also contribute to minimize that risk. A security policy was applied avoiding bathymetries shallower than 60 meters and areas closer to the coast-line than 7Km. The fact of not surfacing after every waypoint hit incremented the error in heading modification. Nevertheless, position was hold successfully during waiting loops.*

- ***Underwater Maneuvering**: a single configuration was applied during the whole deployment (See Chart 1 for details) and was modified only once to lower the gliding angle to +-22deg so to fly more efficiently in very shallow waters. ICOAST00 to fly between -5 and -190 meters of depth using an 85% of the buoyancy drive. Bottom distance was set to 20 meters. Mission telemetry (obtained during Conclusion phase) revealed that the resulting 'flight' was pretty much adapted to these commands. No sea-floor collisions were observed. Due to trimming imprecision, the vertical velocities were very asymmetrical (ICOAST00 dove much slower than*

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ascended) with 0,06 m/s on diving and -0,22 m/s on climbing. Surface events were triggered as expected due to the No-comms-for-a-while timmer as expected.

- ***Data Logging**: The strategy (see Chart 2 for details) was set at the beginning of the mission and not altered during the entire execution of it. This strategy basically configured the scientific sensors at its maximum performance. Although sampling seemed to have been successful during most of the mission-time (only 58 oddities and 1 warning by science-super), there were some critical setbacks: (1st) FLNTU data is useless since this sensor was deployed with a sun-protective tape on its optical diodes resulting in dark measurement only. (2nd) The entire science-bay stopped reporting (at all), due to a problem known as "Ring Buffer Overflow", between 18/Jul@21:52utc (being at 82 meters of depth) and 19/Jul@13:59utc (when science-bay was reset due to a configuration file transmission). No sensor (any sensor) data during that 'frozen' period of time. This is a known problem and it is related to the computational capability of the Glider. However, there is not a clear solution but to reset the Science payload and expecting the system to flush the buffer and eliminate the overflow. (See Figure 6 and Figure 8a for details on this issue).*

- ***Engineering***
  - *Power Source: (Alkaline TWR battery pack). It performed very well.*
  - *Electro-Mechanical: actuators and sensors exhibited an acceptable performance. Besides normal Oddities raised by Digifin, numerous (but known) oddities raised by the Buoyancy-Pump. This 'out of deadband' are due to the imprecision of the micro-positioning of the pump which is probably a cause of fatigue and age of the device.*
  - *Communication Systems: were reliable and fluent.*
  - *Electronic Modules: (processors, memory cards, control boards,...) revealed no evidences of problems but the mentioned "Ring Buffer Overflow" problem occurred in Science-Super.*
  - *Contextual/Awareness Sensors: pressure transducer, internal vacuum and internal temperature seemed to have worked correctly. Compass also reported coherent values. Altimeter detected the bottom correctly.*
  - *Hull/Hydrodynamics: no signs of problems.*
  - *Device Error-Statistics: 0 Errors ; 5 Warnings (2 GPS, 1 attitude_rev, 1 science_super, 1 Iridium) and 1002 Oddities (40 Pitch_motor, 58 Science_Super, 271 Digifin, 386 Iridium, 31 coulomb, 216 Buoyancy-Pump). Out of those, the most worrying ones are from Science_Super. Those from Pitch_motor and Buoyancy_Pump are known and accepted for this vehicle (the oldest of the fleet).*
  - *Mission Runs: multiple missions runs due to 2 behavior-type aborts experienced due to incorrect GOTO files (much more than usual loaded during this mission). Mission numbers were: #144 (13/Jul, "status.mi"), #145 (13/Jul, "overtime.mi"), #146 (13/Jul, "ovrdepth.mi"), #147 (13/Jul, "ALNI2016.MI"), #148 (15/Jul, "ALNI2016.MI"), #149 & #150 (20/Jul, "ALNI2016.MI")*

Recovery

In this case, since the coupling between the glider and the turtle had expired, the recovery was full standard. On the 25th-July, at 20:35-utc, ICOAST00 was commanded to abandon the pursue and to return close to SOCIB-I home-port. The next day, July the 26th, 1ETD and 1GF members, on-board SOCIB-I, recovered the vehicle at 08:50am-utc in location N39° 15.091 E02° 17.350. All tactical and operational aspects of this intervention were executed according to the specific and generic objectives. The only setback was the finding of the FLNTU being covered with the sun-protective tape which meant the invalidity of this sensor's measurement during the concluded survey.

Conclusion

This phase started on the 29th of July. It was concluded on the next day with the following headlines: (1) vehicle's hull was disassembled, flight-mechanisms and electronics revised and batteries removed&stored; (2) external surfaces and sensors cleaned and refurbished (significant evidences of biofouling growth, specially over the nose-cone, considering the short duration of the deployment); (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). After sitting on the bench due to a vacation period of the personnel, ICOAST00 was returned to the storage shelf on Aug-7th.

Summary: (1) The Alkaline battery pack could be used for a second short deployment although the greater the gap (in between two usages) the less battery remaining-capacity. (2) This glider has exceeded the working period of 2 years prior to the next factory refurbishment. Nevertheless, (3) it is in very good state and ready to be used again on mission.

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 (special and more intense actions taken in that aspect. Contact dmarch@socib.es and outreach@socib.es for specific information); and also for accounting.

HHRR

Once more, the novelties and exigencies of this mission required of an extraordinary team coordination (with more people involved and number of intra-communications) .Nevertheless,

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coordination amongst multiple participants (glider-techs, field-techs, scientists & outreachers) was fluent and efficient. There were no personal damages 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 -which was more intense than usual-). Interaction with external partners (Alnitak, Palma-Aquarium,...) was also very fruitful. The most relevant outcome on this aspect was the proved capability of executing a near-real-time adaptive sampling and navigation.

Detailed Charts:

13/Jul@(M.S.) [1]	*05*	*190*	*14400*	*20*	*∞*	*04*	*disabled*	*50*

[1]: This strategy ruled during the whole deployment. Only diving angles were modified on July-15th (to +-22deg) to improve very shallow navigation

(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)

Date (utc)	*SEN*	*fSMP*	*DRNG*	*MDIV*	*MCLI*
13/July/2016 (from Mission Start to Mission End)	*CTD*	*0,5000*	*[-5, 2000]*	*yes*	*yes*
	OXY	*0,5000*	*[-5, 2000]*	*yes*	*yes*
	FLNTU	*0,5000*	*[-5, 250]*	*yes*	*yes*

SEN: Sensor type
fSMP: Frequency of sampling (Hz)
DRNG: Depth range this configuration applies (m)
MDIV: Sampling during Diving maneuver
MCLI: Sampling during Climbing maneuver

Chart 2 Summary of Commanded Sampling Strategies

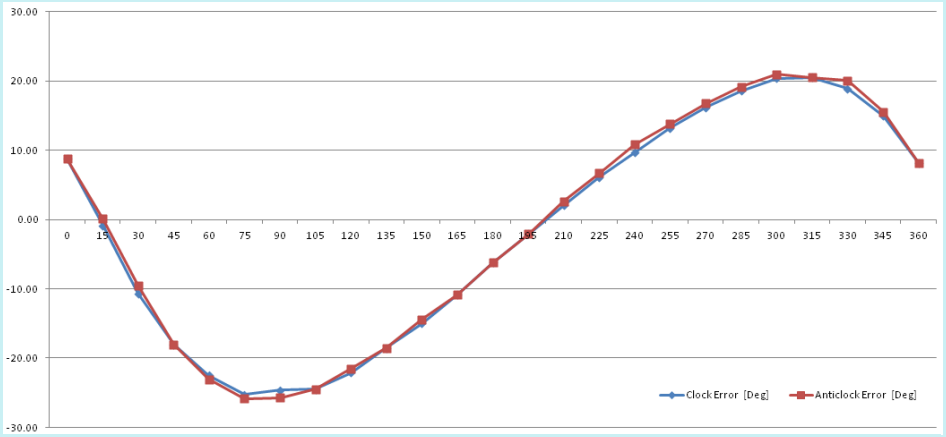

Figure 2-Error measured during Compass Error Check procedure in an electromagnetic-field-free environment located in a forest close to IMEDEA (in Esporles)

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Principal Investigator (e-mail or contact phone/address)	• *PhD. David March Morlà* *dmarch@socib.es (+34 971439764)*
Institute	*SOCIB in collaboration with IMEDEA*
Project Affiliation (web-site)	*http://www.socib.eu*
Partnership / Participation	• *SOCIB (www.socib.eu)* • *IMEDEA (www.imedea.uib-csic.es)* • *Alnitak (http://www.alnitak.info/es/)*
Glider Software Version	*Nav : v7.13 Acomms, Payload: 3.17*
Data Retrieval (real-time [RT] / delayed-mode [DM])	• *RT: not implemented to minimize surface-risk* • *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 2).* *Re-calibration is needed.*
Battery Type	*Factory Alkaline Battery Pack (143Ah-nominal capacity) (Brand new)*
Battery Consumption (Ah)	*58.6618Ah (reading from 1.6012Ah to 60.263Ah)*
Data Available From	*http://thredds.socib.es/thredds/fileServer/auv/glider/icoast00-ime_slcost000/L2/2016/dep0006_icoast00_ime-slcost000_L2_2016-07-13_data_dt.nc*
Further Details	*glidertech@socib.es*

General Map

Figure 3 - Map providing general overview of the Survey Area

On-line Track: *http://apps.socib.es/dapp/?deployments=644-14-100-CCCC99,524-22-0-FF3300&layers=isobaths,ocean_basemap&units=scientific*

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Detailed Maps

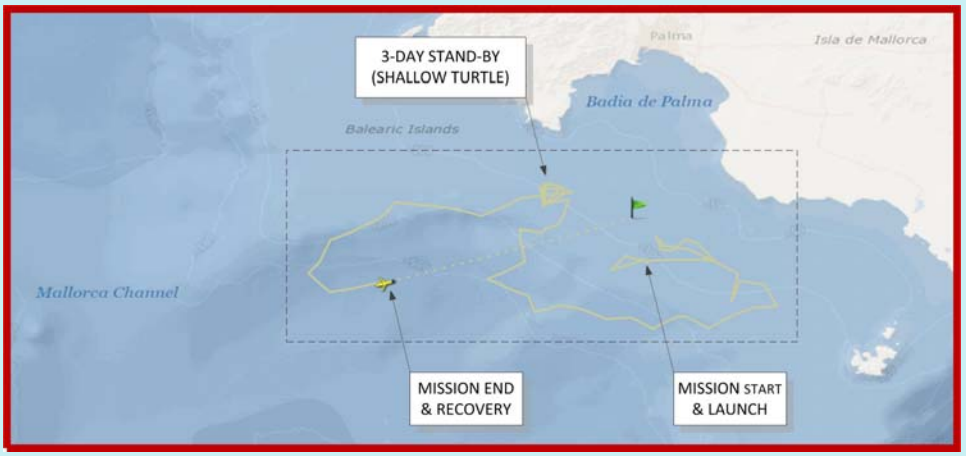

Figure 4 - Overview of Survey Area and traced Flight Path

Figure 5 - Overlapping of Glider (Yellow) and Turtle (Red) traced-paths

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

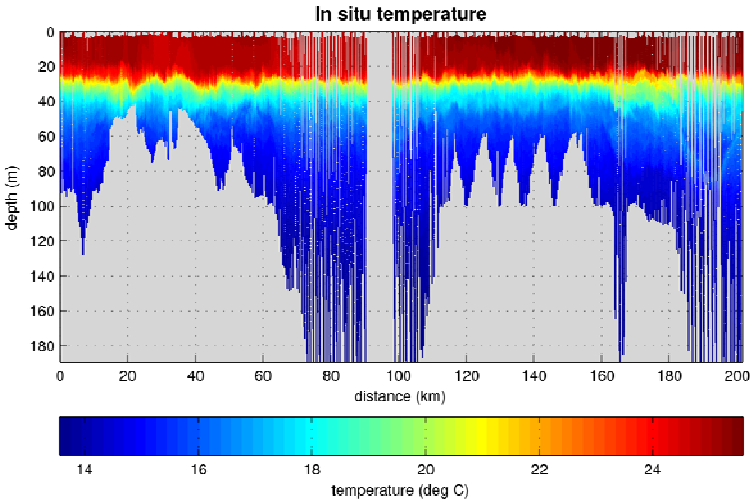

Figure 6 - In-situ temperature (full depth range)

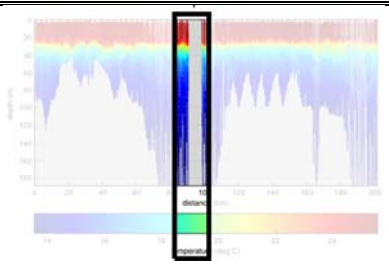

Figure 8a

The sampling gap observed in the middle of the plot above is result of the "Ring-Buffer Overflow" problem encountered by the glider between 00:49utc and 13:43utc of July-19th.
See "Data Logging" review in "Mission Summary" of this report for further details and/or contact glidertech@socib.es

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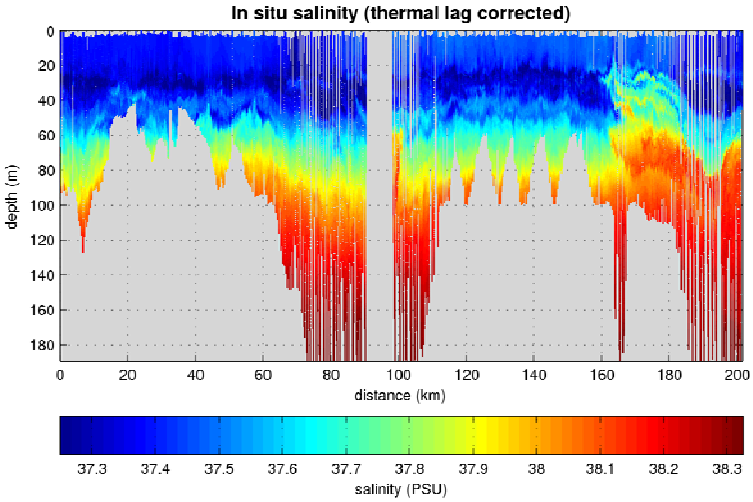


Figure 7 - Corrected salinity (full depth range)

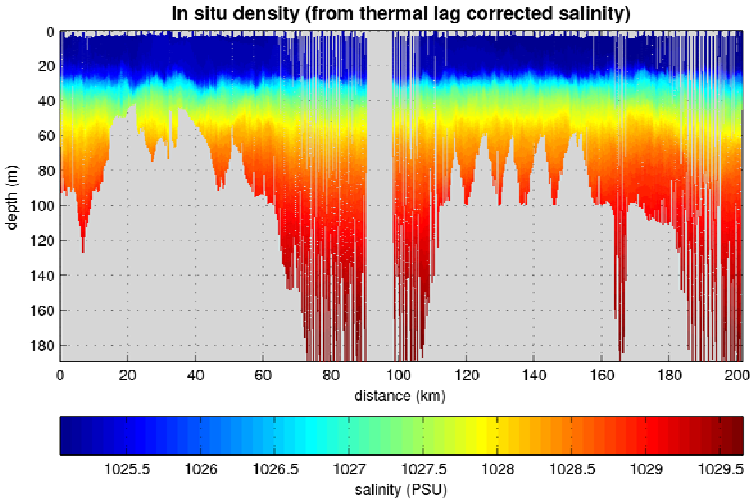
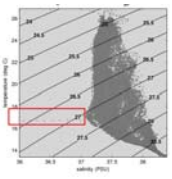
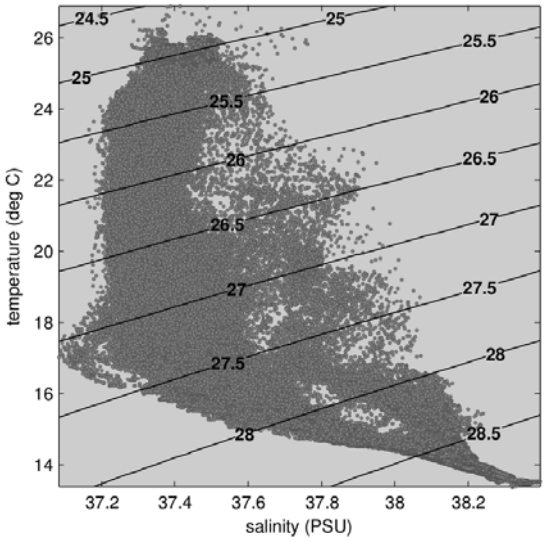


Figure 8 - Density derived from corrected salinity and temperature (full depth range)

(Plot4 shown here is the result of a Quality-Control method applied by SOCIB's Data-Center to filter suspicious horizontally-aligned outliners -see a miniaturization of the original-plot below-.

Contact data.center@socib.es for further info.)





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

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OXYGEN

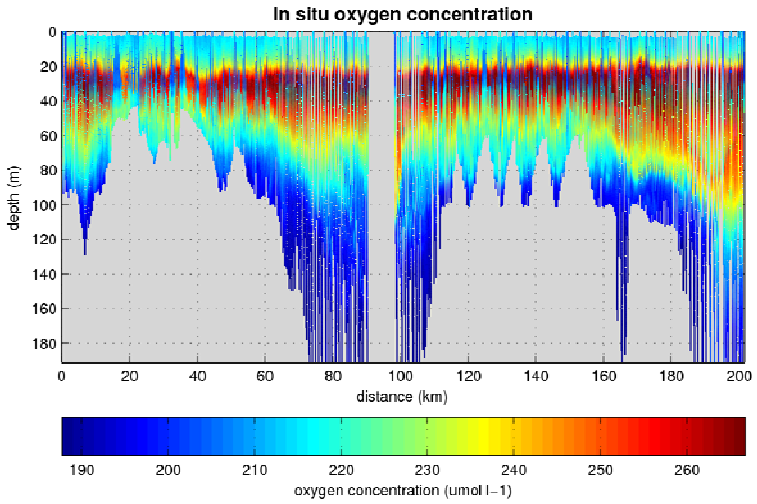

Figure 9 - In-situ oxygen concentration

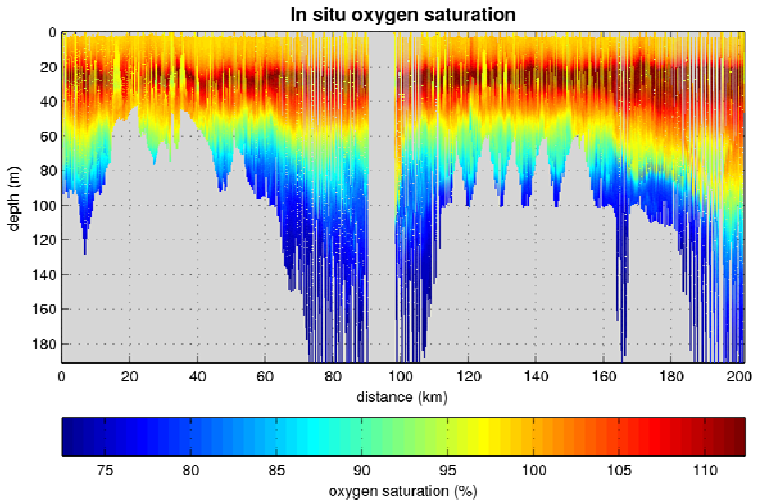

Figure 10 - In-situ oxygen saturation

TURBIDITY & CHLOROPHYLL

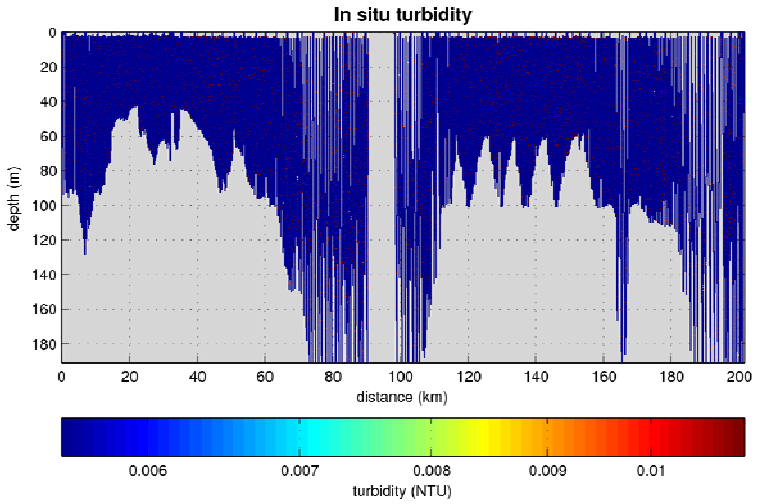

Figure 11 - Blank turbidity measurements due to the mistake of having deployed the glider with a sun-protective tape used during storage

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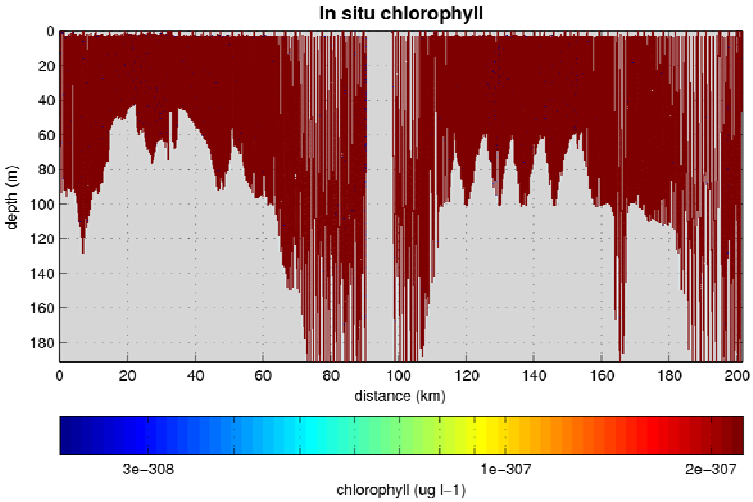

Figure 12 - Blank chlorophyll measurements (same reason as Turbidity)

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