



CONSEJO SUPERIOR
DE INVESTIGACIONES
CIENTÍFICAS



Balearic Islands
Coastal Observing
and Forecasting
System

GLIDER MISSION REPORT

Reference: *GF-MR-0012*



Platform: *GLIDER SEAGLIDER*

Platform ID: *sdeep02 (Unit538)*

Mission: *JERICO TNA SARDINIA OCT12*

Dates: *October, the 23st, 2012* **to** *October, the 30st, 2012*

Issue: *Glider Post-mission Report*

Description: This document summarizes the mission definition, preparation, logistics and results obtained from the mission *JERICO TNA SARDINIA OCT12* in line with SOCIB glider facility monitoring operations and CSIC contribution to JERICO and PERSEUS projects.

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Involved Personnel: *Simó Cusí, Marc Torner, David Roque, Miguel Martínez, Benjamín Casas, Carlos Castilla, Irene Lizarán, Guillermo Vizoso, Joan Pau Beltran, Sebastián Lora, David March, Emma Heslop, Simón Ruiz, Ananda Pascual, Jose Luís Lopez Jurado, Rosa Balbín Chamorro, Joaquin Tintoré, Alberto Ribotti, Antonio Olita*



DOCUMENT

VERIFICATION AND DISTRIBUTION LIST

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| Approved and Accepted by | J. Tintoré | OD | |



GLIDER MISSION REPORT

Reference : GF-MR-0012

Mission : JERICO TNA SARDINIA OCT12

Date : October, the 23st, 2012

Platform : sdeep02 (Unit538)

CHANGE RECORD

| Issue | Date | Description of Change | Author | Checked By |
|-------|----------------------|---------------------------------------|-------------|------------|
| 0 | November, 10 2012 | Creation | S. Cusí | |
| 1 | December, 18 2012 | Revision | M. Martínez | |
| 2 | January, 23 2013 | Revision | S. Cusí | |
| 3 | March, 15 2013 | Revision after Director's comments | S. Cusí | |
| | | | | |
| | | | | |
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| | | | | |
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APPLICABLE AND REFERENCE DOCUMENTS

Applicable Documents

| | Ref | Title | Date / Issue |
|-------------|--------------|---|------------------|
| DA 1 | SG UserGuide | 1KA SeagliderTM User's Guide | Revision D, 2012 |
| DA 2 | SG Endurance | iRobot – Seaglider Mission Endurance Estimator | Version 1 |
| DA3 | SG Trim | iRobot – Trim Sheet for Seaglider 538 | 10/01/2012 |
| DA 4 | Calibration | sg_calib_constants.m – Calibration values for sg538 | |

Reference Documents

| | Ref | Title | Date / Issue |
|--------------|------------------|--|---------------------------|
| DR 1 | GF-MR-0002 | Post Mission Report - 'First Seaglider Water Test' | 11/11/2011 |
| DR 2 | GF-MR-0003 | Post Mission Report - 'Shallow dives with two seagliders' | 14/02/2012, 16/02/2012 |
| DR 3 | GF-MR-0004 | Post Mission Report - 'Altimeter testing with two seagliders' | 6/03/2012 |
| DR 4 | GF-MR-0005 | Post Mission Report - 'sdeep02 trimming, depth tests and first navigation experiences' | 12/03/2012 |
| DR 5 | GF-MR-0006 | Post Mission Report - 'Canales apr12' | 27/03/2012 |
| DR 6 | GF-RR-0002 | Internal Repair Report – 'BaseStation Setup' | 22/02/2012 |
| DR 7 | GF-MD-0012 | Mission Definition Report – 'Jerico TNA Sardinia oct12' | 23/10/2012 |
| DR 8 | 20121227-IS-538 | Intervention Sheet - 'Sudden 24V battery voltage drop' | 27/12/2012 |
| DR 9 | 20121023-GPC-538 | Glider Preparation Checklist | 23/10/2012 |
| DR 10 | 20121023-GMB-538 | Glider Mission Blog | 23/10/2012 |



MISSION SUMMARY

| | |
|---------------------------------|--|
| Area | Western Mediterranean Sea (East Menorca to Sardinia) |
| Project | JERICO |
| Objective | JERICO TNA Agreement CSIC-CNR |
| Glider | sdeep02 (Seaglider 1KA-Unit 538) |
| Start Date | 23/Oct/2012 |
| End Date | 30/Oct/2012 |
| Total Days | 7 days |
| Total Navigation Miles | 36,8 |
| Number of Profiles | 48 |
| Number of Iridium Connections | 171 |
| Data transmitted trough Iridium | 1,51 MB |
| Raw data downloaded from glider | 2,78 MB |
| Total mission data stored in DC | 127 MB |
| Initial Batteries Voltage | 23,8 V / 10,1 V |
| Final Batteries Voltage | 18,9 V / 9,8 V |
| Battery Consumption | 5,61 Ahr / 5,45 Ahr |
| Events | Glider mission aborted due to a bad 24V battery behaviour |
| Variables stored | 'time' 'latitude' 'longitude' 'pressure' 'conductivity' 'temperature' 'chlorophyll' 'cdom' 'backscatter 650nm' 'oxygen' |



INDEX

| | | |
|-------------|--|-----------|
| I | MISSION OBJECTIVE..... | 6 |
| II | MISSION DEFINITION | 7 |
| III | ENVIRONMENTAL PROPERTIES | 8 |
| IV | MARITIME ROUTES | 11 |
| V | INSTRUMENTAL SETTINGS | 12 |
| VI | LOGISTICS..... | 14 |
| VII | DATA MANAGEMENT | 17 |
| VIII | GLIDER SETUP..... | 19 |
| IX | MISSION RESULTS | 22 |
| | ANNEX I: GLIDER TECHNICAL INFORMATION | 41 |

I MISSION OBJECTIVE

The mission is part of a research proposed by CNR IAMC in Oristano (P.I. Mr Alberto Ribotti) to the First TNA call of project JERICO (<http://www.jerico-fp7.eu/>).

The central part of the Algero-Provençal sub-basin, where the glider mission is planned, is a buffer area between the northern Provençal sub-basin and the southern Algerian one, and is mainly characterized by the presence of the Balearic Front (interactions between more recent MAW and MW).

The purpose of the research is contributing to understand exchanges between the two sub-basins and the complex interactions through eddies. The area of work covers a transect between the Balearic Islands and Oristano (Sardinia). The Group in Oristano, in collaboration with the Institute of Marine Sciences of CNR in La Spezia, is annually repeating with CTD and current-meter casts for the last ten years during oceanographic cruises to study the inter-annual variability of physical and biochemical properties of water masses and understand the circulation, the exchanges through the sub-basins and the transport of salt and heat in the western Mediterranean.

In particular, the proposed research wants to identify the physical properties of the surface and intermediate water masses between Balears and Sardinia with the aim of:

- i) study the variability of the physical properties of surface and intermediate water masses between the Algerian and the Provençal sub-basins;
- ii) evaluate the transport of water, salt and heat through the area and verify if the interannual variability of the surface and intermediate water masses is due to climatic changes;
- iii) validate the operational hydrodynamic numerical model of the western Mediterranean (<http://www.seaforecast.cnr.it/en/fl/wmed.php>) through the use of in-situ and satellite data.



Proposed mission route

II MISSION DEFINITION

Mission Area: Western Mediterranean Sea - Mallorca to Sardinia

Mission Objective: JERICO TNA Agreement CSIC-CNR

Deployment date: 15 October 2012

Recovery date: 10 December 2012 -tentative-

Mission Duration: 57 days

Glider: sdeep02 (Unit 538)

Glider backup: sdeep03 (Unit 541)

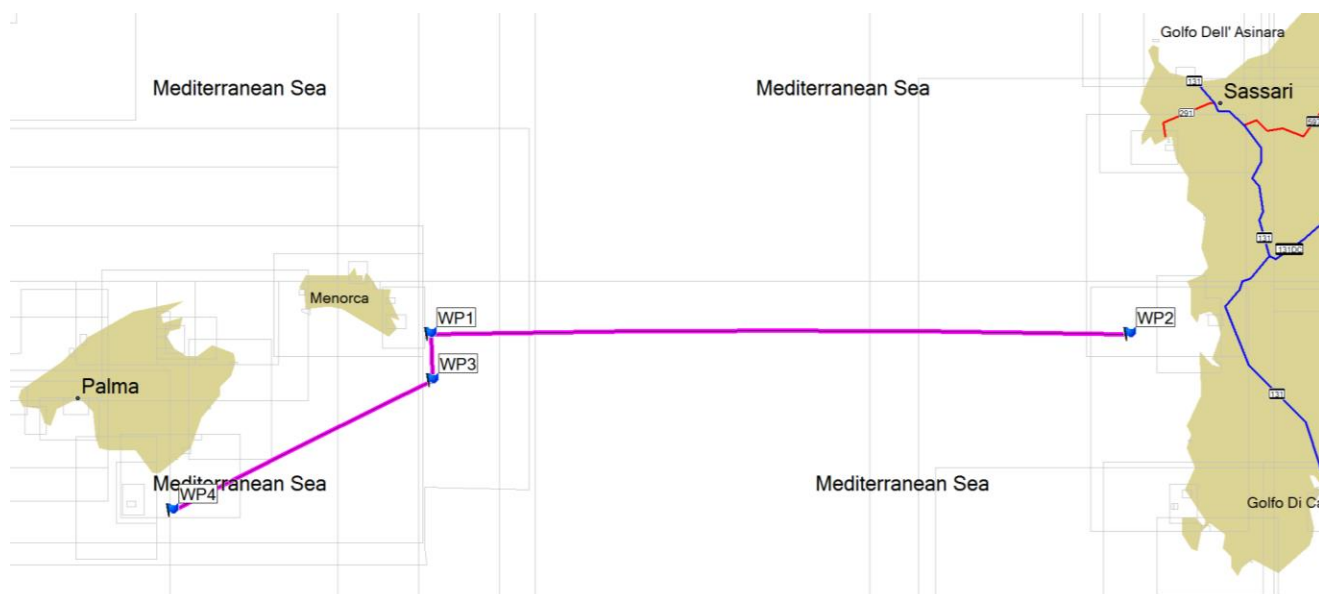
Route Distance: 414nm (766km)

Profiles: 550 approx.

Mission Waypoints

| Latitude | Longitude | Name |
|---------------|--------------|------------|
| 39° 49.457' N | 4° 28.855' E | WP1 |
| 39° 49.457' N | 8° 05.486' E | WP2 |
| 39° 49.457' N | 4° 28.855' E | WP1 |
| 39° 38.603' N | 4° 29.442' E | WP3 |
| 39° 07.617' N | 3° 08.910' E | WP4 |

Minimum Distance to Shore: 8.4nm (at Wp1)



Mission route

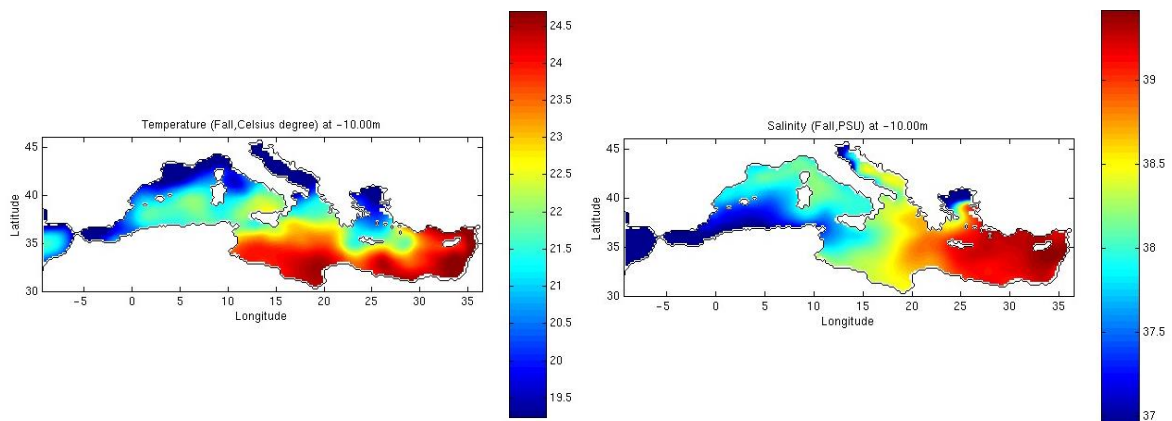
III ENVIRONMENTAL PROPERTIES

Expected water properties

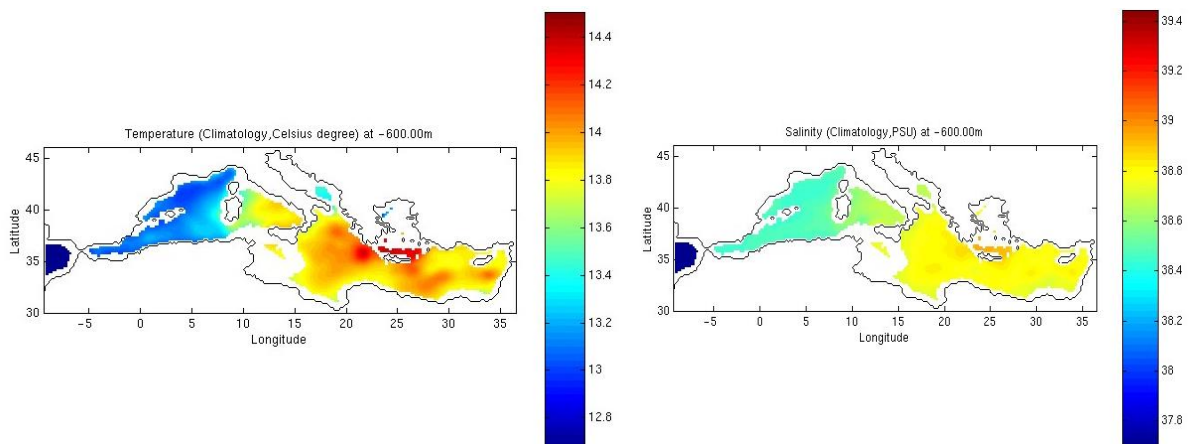
- Surface in-situ Density: 1025.95 Kg/m³
(given by CNR: Oct. 2007, 22.44°C, 37.44psu, 0m)
- Bottom in-situ Density: 1033.48 Kg/m³
(given by CNR: Nov. 2011, 13.12°C, 38.49psu, 1000m depth)
- Average Density: 1029.71 Kg/m³

Glider Ballasting

- Glider Density Range: [1025,4 1033,3]Kg/m³
- Glider Average Density: 1029,35 Kg/m³



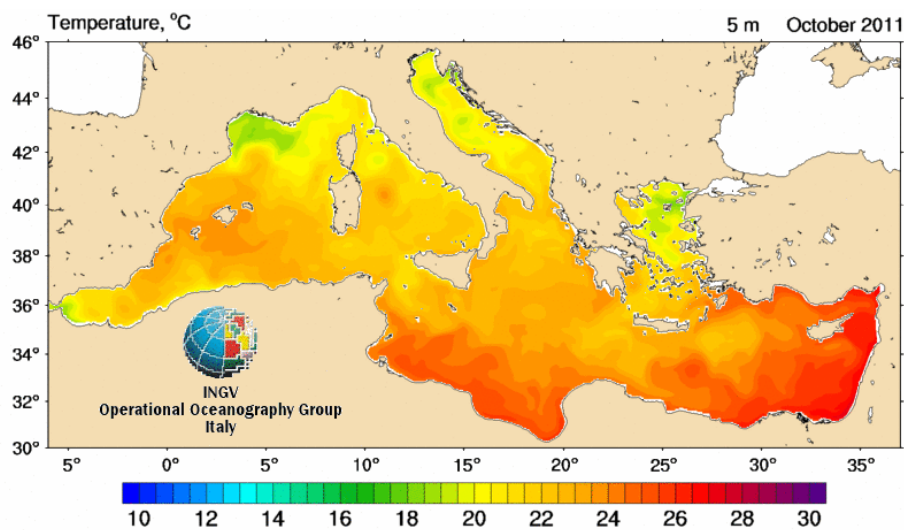
Seasonal (Autum) Temperature and Salinity MEDAR Climatology at ~10m depth



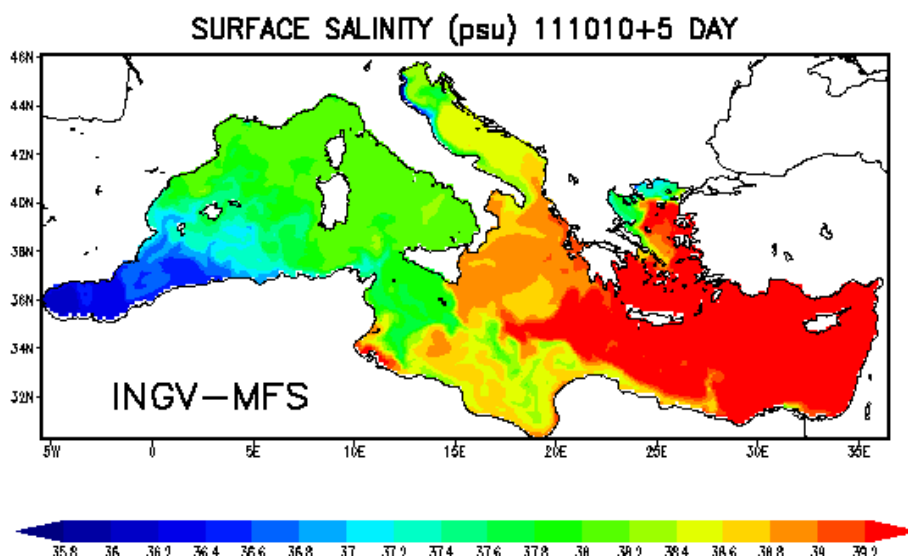
Temperature and Salinity MEDAR Climatology at ~600m depth

Note:

Seaglider densities must be computed with in-situ temperature and salinity at surface (0 dbar) because of its isopicnal hull.

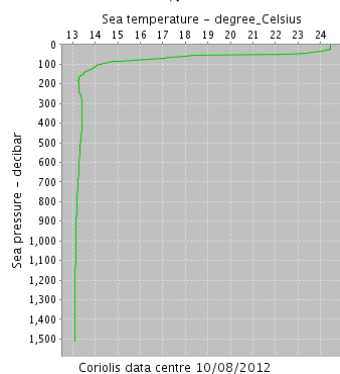


Temperature October 2011 from http://gnoo.bo.ingv.it/mfs/analysis_archive.htm

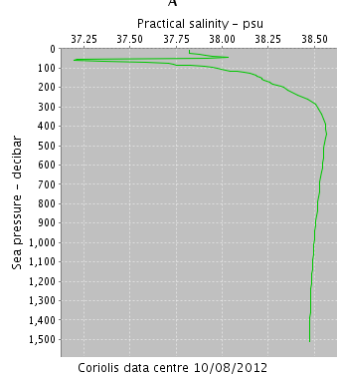


Salinity October 2011 from <http://poseidon.ogs.trieste.it/cgi-bin/opaopech/myocean?20111015SRS>

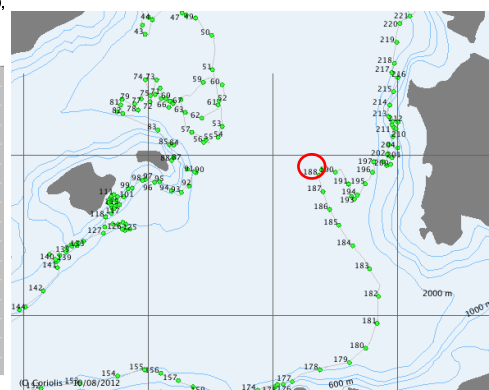
Float 6900700, Cycle #189, 25/09/2011 00:33:00, Float 6900700, Cycle #189, 25/09/2011 00:33:00,



Coriolis data centre 10/08/2012



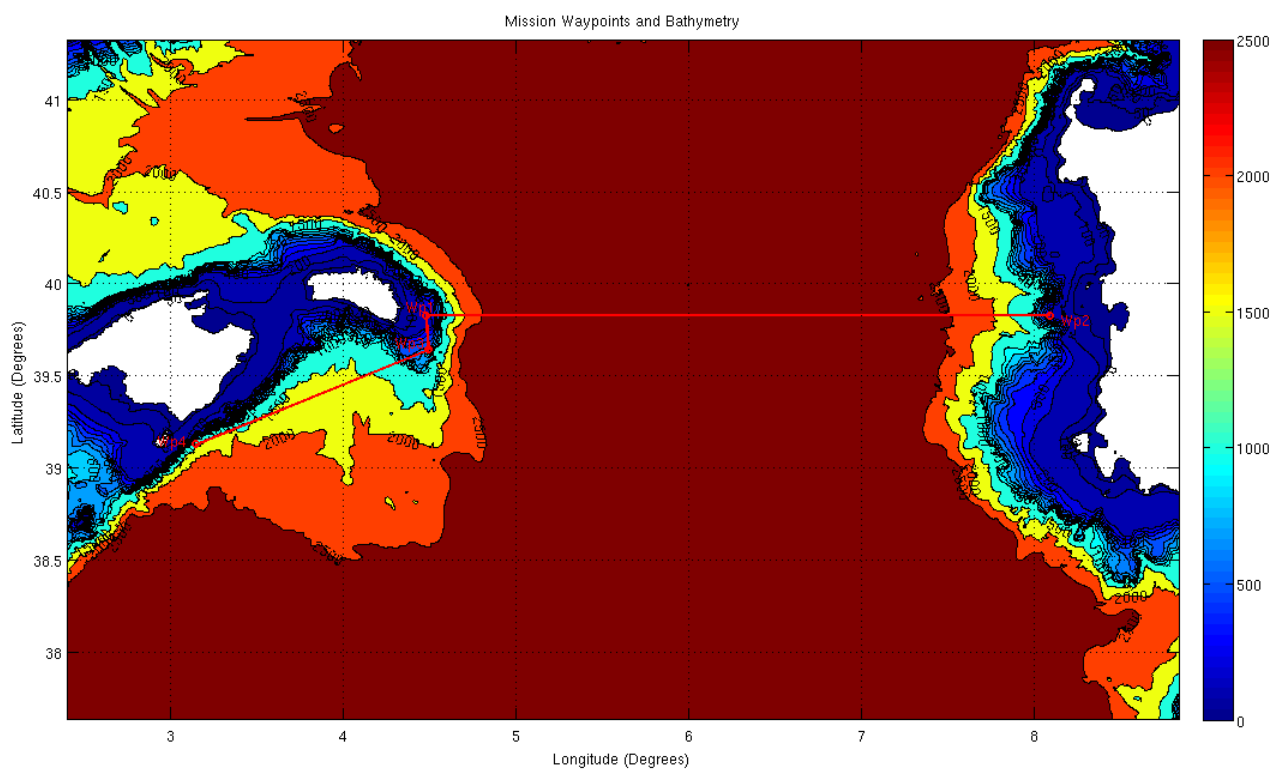
Coriolis data centre 10/08/2012



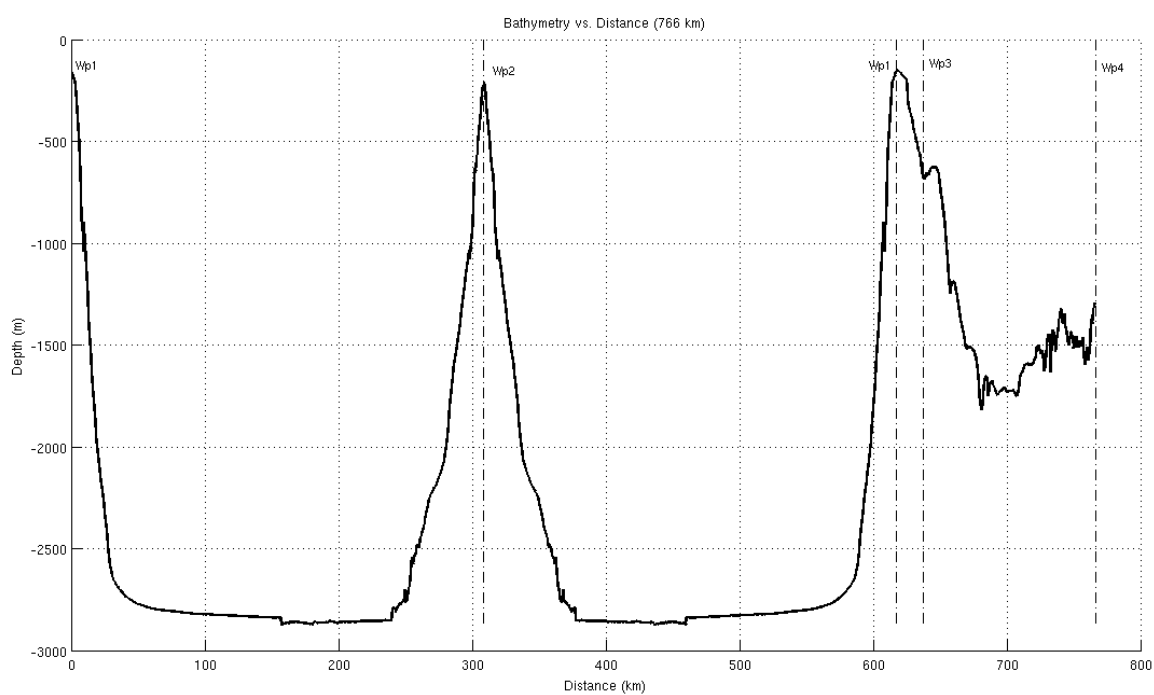
PROVOR Profiling Float 6900700 Temperature, Salinity and Position for 25 Sept. 2011 from <http://www.ifremer.fr/co-cartography/jsp/cartography.jsp?mode=float&ptfCode=6900700&lang=en>

Mission Depth

- Depths: min 150.0 [m], max 2874.4 [m]

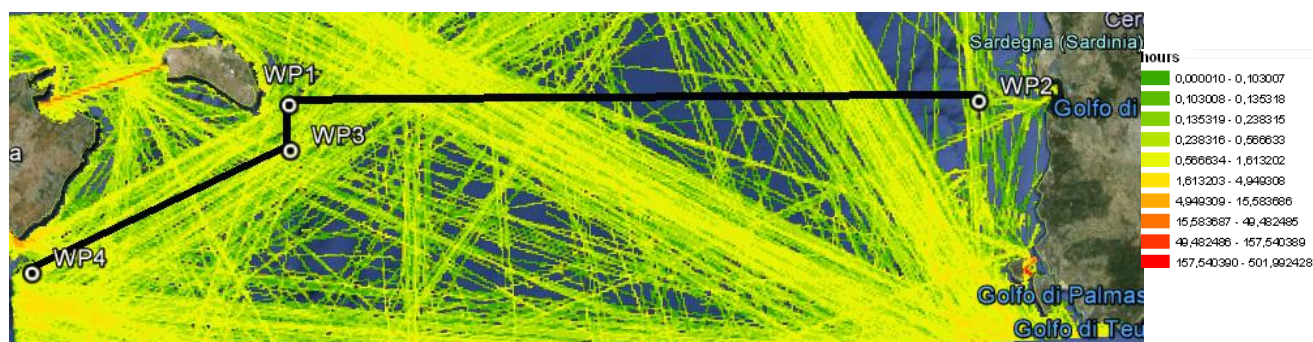


Mission bathymetry

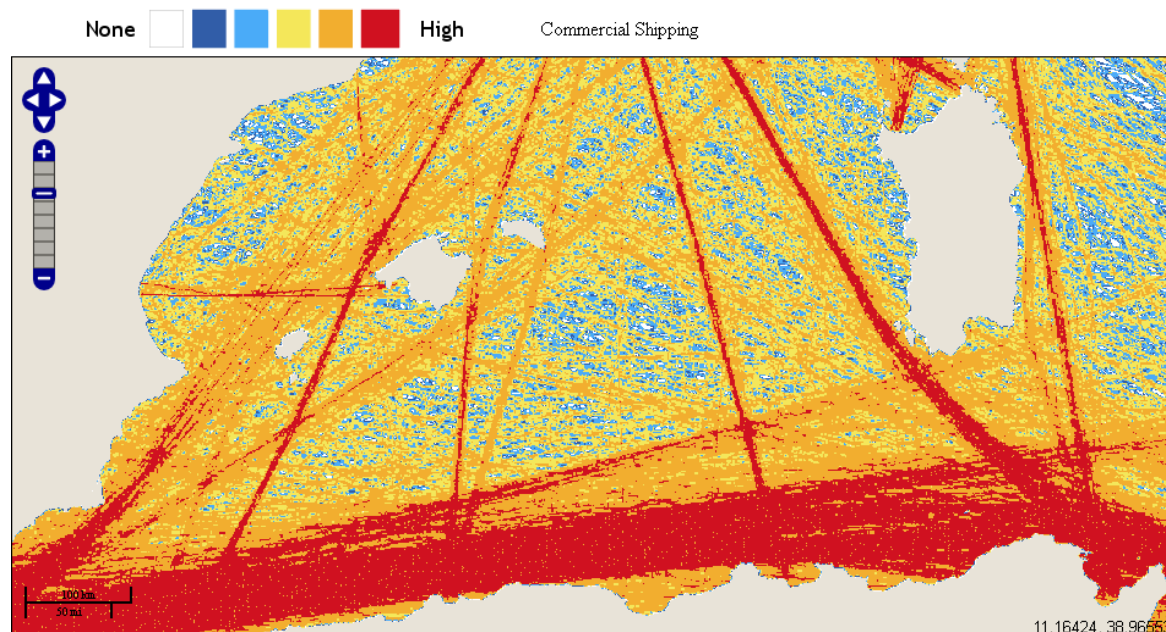


Mission depth vs. distance

IV MARITIME ROUTES



Marine traffic density (number of hours occupied by ships in every cell of 1km x 1km) between Mallorca and Sardinia (one month of AIS data, August 2012)



Commercial shipping routes (available at: <http://globalmarine.nceas.ucsb.edu/>)

V INSTRUMENTAL SETTINGS

Navigation Behaviour

Surfacing events

- Every inflection
- Mission aborted

Movement

- Distance to seabed: 30.0 m
- Maximum depth: 975.0 m (see Note 1)
- Angle of inclination: 20° (see Note 2)
- Approx. vertical speed: 0.1 m/s (see Note 2)
- Approx. horizontal speed: 0.17 m/s (see Note 2)

Scientific Data Sampling and Transmission

Sensors Sampling (see Note 3)

CTD (conductivity, temperature and pressure)

- Sampling state: diving and climbing
- Sampling frequency: 1/4 Hz (approx. 1 sample/0.4m)
- Sampling depths: [0, 1000]m

Oxygen

- Sampling state: diving and climbing
- Sampling frequency: 1/4 Hz (approx. 1 sample/0.4m)
- Sampling depths: [0, 300]m (see Note 4)
- Sampling frequency: 1/8 Hz (approx. 1 sample/0.8m)
- Sampling depths: [300, 1000]m (see Note 5)

FLNTU (fluorescence and turbidity sensor)

- Sampling state: diving and climbing
- Sampling frequency: 1/8 Hz (approx. 1 sample/0.8m)
- Sampling depths: [0, 300]m (see Note 5)

Sensors Transmission (Real-Time mode)

Data measured will be transmitted through Iridium to verify sensors, sampling and navigation behaviour of the glider. Real time data transmission will be done at least every day (approximately 1 dive transmitted every 4 dives performed) to minimize costs and surface time. All data will be downloaded by cable once mission finishes (delay mode).



Notes

1. During deployment the navigation depth will be increased in consecutive changes (increases of 200m approx.) to ensure correct glider behaviour and navigation minimizing the probability of damage of the glider in case of error.
2. The piston buoyancy and pitch angle will be changed during mission to optimize glider flight, reduce consumption and to adapt the glider velocity to the currents of the mission zone. Those changes will vary the vertical and horizontal velocities. These commands transferred to the glider will be recorded and accessible after the mission.
3. To verify correct sensor measurement and behaviour all sensors will be measured up to 1000m (at least during one dive). The configuration of the sensors sampling will be changed during mission to verify glider and sensors integrity and behaviour.
4. The Oxygen sensor will be measured at a frequency of 1/4Hz up to 300m and at 1/8Hz from 300m to 1000m to reduce power consumption. FLNTU (Wetlabs) sensor will be measuring up to 300m to minimize the power consumption.
5. The Oxygen and FLNTU sensor sampling frequency and depth might have to be changed during mission to reduce power consumption depending on battery capacity.

VI LOGISTICS

Deployment: 15 October 2012
Recovery: 10 December 2012 –tentative–
Mission Duration: 57 days
Glider: sdeep02 (Unit 538)
Glider backup: sdeep03 (Unit 541)

Tasks and Calendar

Mission preparation

| Task | Personnel | Date |
|--------------------------------|--|-----------------|
| Glider ballasting verification | Simó Cusi, Joaquin Tintoré | 24-28 September |
| Glider verification | Simó Cusi, Miguel Martinez | 8-10 October |
| Navigational Warning | David Roque, Guillermo Vizoso | 8 July |
| Deployment material load | Simó Cusi, David Roque, Benjamin Casas, Miguel Martínez | 10 July |

Deployment (Menorca)

| Task | Personnel | Date |
|-------------------------------|---|------------|
| Glider deployment | Carlos Castilla, David Roque, Benjamin Casas, Guillermo Vizoso, Miguel Martínez | 15 October |
| Glider remote control | Simó Cusi, Simón Ruiz, Ananda Pascual | 15 October |
| Vessel | TMOOS Valiant | 15 October |
| Vessel pilot | David Roque, Benjamín Casas | 15 October |
| Vehicle | SOCIB Mercedes Sprinter | 15 October |
| Calibration CTD Cast - SBE 25 | David Roque, Guillermo Vizoso | 15 October |

Mission tracking

| Task | Personnel | Date |
|---|---|--------------------------|
| Glider following, control and mission updates responsible | Simó Cusi, Miguel Martínez, Benjamín Casas, Guillermo Vizoso, Joaquin Tintore | 15 October - 10 December |
| Glider pilot backup | Marc Torner, Simón Ruiz, Ananda Pascual | 15 October - 10 December |

Data Management

| Task | Personnel | Date |
|---|---|--------------------------|
| Real Time Data retrieval | Simó Cusi, Guillermo Vizoso, Miguel Martínez | 15 October - 10 December |
| Real Time Data verification | Marc Torner, Emma Heslop, Simon Ruiz, Ananda Pascual, Joaquin Tintoré | 15 October - 10 December |
| Delay Mode Data retrieval | Simó Cusi, Benjamín Casas, Guillermo Vizoso, Miguel Martínez | 10 December |
| Delay Mode Data verification and export | Marc Torner, Emma Heslop, Simon Ruiz, Ananda Pascual, Joaquin Tintoré | 10 December |

Recovery (South Mallorca)

| Task | Personnel | Date |
|-----------------------|---|-------------|
| Glider recovery | Marc Torner, David Roque, Benjamin Casas, Guillermo Vizoso, Miguel Martínez | 10 December |
| Glider remote control | Simó Cusi, Simón Ruiz, Ananda Pascual | 10 December |
| Vessel | SOCIB ZODIAC | 10 December |
| Vessel pilot | David Roque, Benjamín Casas | 10 December |



| | | |
|---------|-------------------------------|-------------|
| Vehicle | IMEDEA TMOOS Nissan PickUP | 10 December |
|---------|-------------------------------|-------------|

Emergency plan

| Task | Personnel | Date |
|--|---|-----------------------------|
| Emergency Decision | Miguel Martínez, Benjamin Casas, Joaquin Tintoré, Guillermo Vizoso | 15 October - 10 December |
| Emergency recovery glider pilot | Marc Torner, David Roque, Benjamín Casas, Miguel Martínez | 15 October - 10 December |
| Emergency recovery glider remote control | Simó Cusí, Simón Ruiz | 15 October - 10 December |
| Emergency Vessel and Vehicle | -Depending on disposability- | 15 October - 10 December |

Notes

1) Deployment:

The deployment will be carried out by Benjamín Casas, Miguel Martínez, Guillermo Vizoso, David Roque and Carlos Castilla at East Menorca to reduce the consumption of the glider and minimize the scientific mission start-up time. This deployment will be done using the vessel TMOOS Valiant on date 15 October. The material will be carried by ferry using the SOCIB Mercedes Sprinter on 8 Oct. The material will be: two Seaglidors (538 and 541), power supply, communication cables, magnets, tools, Benthos pinger and CTD SBE-25. A CTD cast will be done during deployment.

2) Recovery:

The recovery will be done at South Mallorca approximately day 10 December. The vessel SOCIB ZODIAC must be available for recovery during these dates. The vessel would departure from Calanova Station to East Cabrera Island. The vehicle IMEDEA TMOOS Nissan PickUp must be available.

In case of low battery capacity, the recovery will be done near Menorca as soon as possible. Vehicles and vessels needed for an emergency recovery will be available.



VII DATA MANAGEMENT

Communications

Basestation Primary: 67.207.130.126
Basestation Secondary: 67.207.130.126
Primary Iridium Phone: 881600005201 (Rudics)
Secondary Iridium Phone: 881600005201 (Rudics)

The data from this mission will be available in Real Time and Delay Mode.

Real Time

The data will be received at the iRobot Basestation through Iridium satellite communications every glider surface. The log and binary data obtained will be then transferred to SOCIB Data Center for mission tracking. Pre-processing of log files will be carried out creating NetCDF files and images that will be available for public download at SOCIB thredds data discovery portal. The scientific sensors data will be processed by glider technicians that will represent the scientific variables and generate images for verification.

All files from basestation will be synchronized according to the following properties:

- Origin: ftp://67.207.130.126/./sg538
- Target:
/home glider_public/deployments/sg538/20121015/basestation_01
- Download frequency: every 60 minutes.

The data will be accessible for the general public at the following location with read only access:

- Host: ftp://ftp.socib.es
- User: glider_public
- Password: **** (hidden)

The data files will be transmitted in the future to EGO server, Coriolis, and MyOcean2 portal (when available). Attention will be given for all theses data to be available to the GTS (Global Telecommunication System, WMO).



Delay Mode

Once the mission is finished, the data will be downloaded to the SOCIB Data Center where pre-processing and Quality Control and Validation will be carried out and NetCDF files and images will be created (process at present ongoing, estimate to be available at the end of 2013).

The data files will be finally included in JERICO portal.

VIII GLIDER SETUP

Batteries

Battery endurance is calculated with the Excel Spreadsheet provided by iRobot (SG Endurance). The estimation is done for the scientific valuable navigation transects (WP1-WP2-WP1) as the glider could be recovered after completing these transects without the need of reaching WP4.

Glider navigation and behaviour parameters are set as follows:

| | Inputs | | Units | Description |
|-------------------|-----------------------|-------|---------|---|
| Dive Profile | vertical velocity | = 0,1 | m/sec | Desired vertical velocity during ascent and descent. This and \$MAX_BUOY determine \$T_MISSION for respective \$D_TGT |
| | \$MAX_BUOY | = 200 | CCs | Multiply MAX_BUOY*2 for total number of CCs pumped at Apogee due to error in calculations used later |
| | \$SM_CC | = 400 | CCs | Surface Maneuver minimum buoyancy |
| | \$N_NOSURFACE | = 0 | int | 0 to disable; must be > 1 (-1 and 1 illegal values) |
| | Roll retries | = | float | Average number of retries per roll event. |
| | Pitch retries | = | float | Average number of retries per pitch event. |
| Pump Config | \$T_BOOST | = 0 | sec | Time (seconds) to run boost pump. (must be 0 if SBE) |
| | \$D_BOOST | = 0 | m | The depth (meters) above which only the boost pump will run. |
| | VBD retries apogee | = | float | Average number of retries per pump event. |
| | VBD retries surface | = | float | Average number of retries per pump event. |
| | EBE or SBE | = 1 | | 0=SBE 1=EBE |
| Navigation Config | \$NAV_MODE | = 2 | int | select navigation method (values 0 - 3) |
| | \$KALMAN_USE | = 2 | int | Kalman filter use 0 - 2 (2 to disable) |
| Comms | \$CALL_NDIVES | = 1 | int | The number of profiles (dive/climb cycles) to perform before attempting communications. (range 1 - 10) |
| | \$CAPUPLOAD | = 0 | int | upload capfile for current dive (0 = no, 1 = yes) |
| Battery Config | 24V Starting Capacity | = 53 | Amp/hrs | Standard (new battery) = 145 |
| | 10V Starting Capacity | = 34 | Amp/hrs | Standard (new battery) = 95 |

Glider science parameters are set as follows:

| Science File (all cells need to be defined) | | | |
|--|-----------------|-------------------|-------------|
| Depth | Sample Interval | Sample Multiplier | GC Interval |
| 50 | 5 | 1 2 1 0 0 0 | 60 |
| 100 | 5 | 1 2 1 0 0 0 | 60 |
| 150 | 5 | 1 2 1 0 0 0 | 60 |
| 300 | 5 | 1 2 1 0 0 0 | 60 |
| 500 | 5 | 1 0 2 0 0 0 | 300 |
| 1000 | 5 | 1 0 2 0 0 0 | 300 |

The resulting consumption estimated for both batteries is:

| depth | 50 | 100 | 150 | 300 | 500 | 1000 | |
|-----------------|----------|----------|----------|----------|----------|----------|------------------|
| 24V: Ahr/dive | 0,083339 | 0,097464 | 0,105339 | 0,116464 | 0,130808 | 0,166667 | |
| 10V: Ahr/dive | 0,025082 | 0,045628 | 0,066839 | 0,130475 | 0,185276 | 0,243969 | |
| mission dives | 12 | 4 | 8 | 16 | 12 | 144 | TOTAL Ahr |
| consumption 24V | 1,00007 | 0,389857 | 0,842713 | 1,863425 | 1,569693 | 24,00004 | 29,6658 |
| consumption 10V | 0,30099 | 0,18251 | 0,534715 | 2,087595 | 2,223314 | 35,13149 | 40,460616 |

With the planned setup, the glider will consume 29,7 Ahr of the 24V battery pack, meaning that a 16% of the 24V battery capacity will remain as a backup. The 10V battery pack needs 40,5 Ahr so that it is missing 6,5 Ahr to complete the mission.

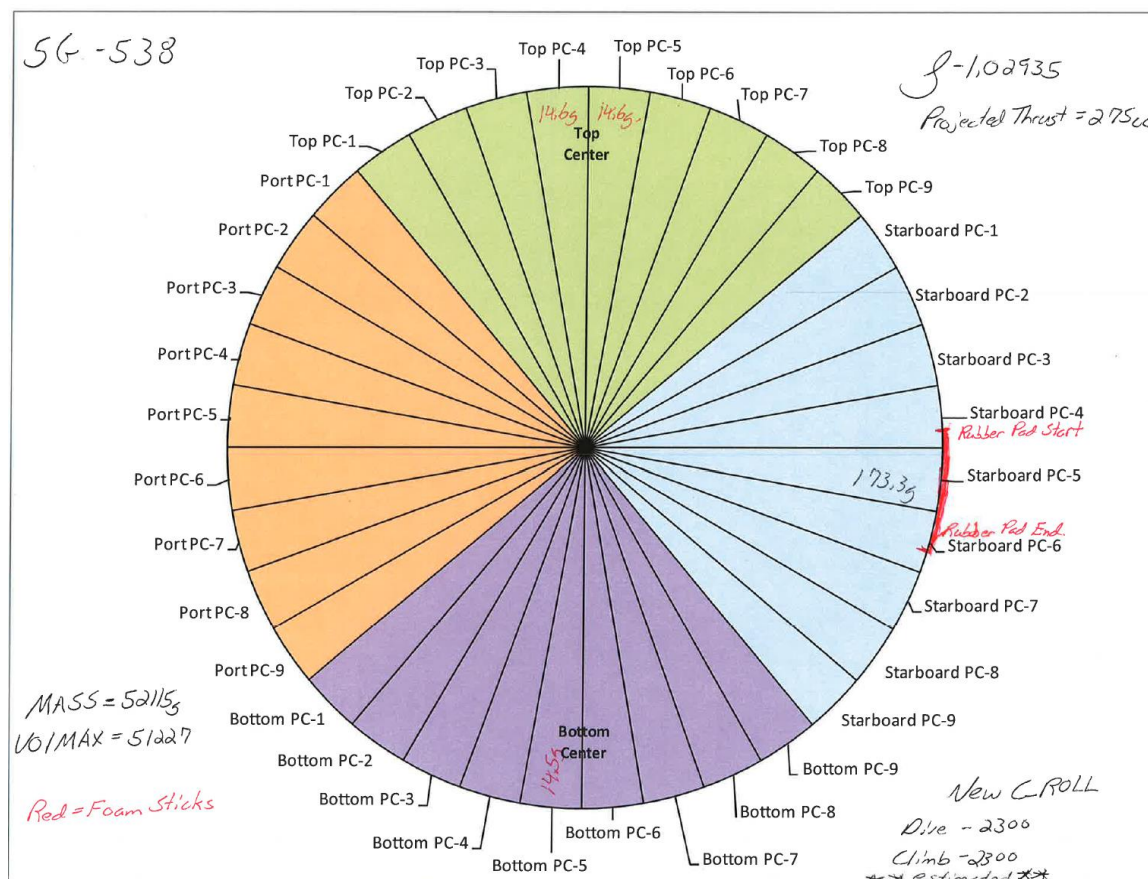
Previous missions (DR4, DR5) showed that this sensor configuration was consuming the 10V battery pack at the same rate as the 24V battery pack so that the 40,5 Ahr hour estimation seems too conservative. However, this mission configuration and consumption estimation was verified by iRobot, indicating we can perform the mission with the remaining batteries.

The mission allows flexibility in sampling frequencies and depths for both WetLabs and Aanderaa sensors (the most consuming ones). This gives a margin to correct excessive 10V battery consumption during the mission.

Ballasting

The expected average density for the waters the glider will dive is $1029,71 \text{ kg/m}^3$ and current glider's density is $1029,35 \text{ kg/m}^3$. Therefore, there is no need to reballast the glider.

In the next figure it can be seen the pinwheel diagram performed by iRobot showing where the weights and foams are placed on the pupa. Also it shows the glider's total mass (52115 g) and the glider's maximum volume, with oil bladder inflated (51,227), that gives a minimum density for the glider equal to $1017,33 \text{ kg/m}^3$. The final glider density range is from $1025,4 \text{ kg/m}^3$ to $1033,3 \text{ kg/m}^3$. All glider weights and their distribution are shown in (SG Trim).



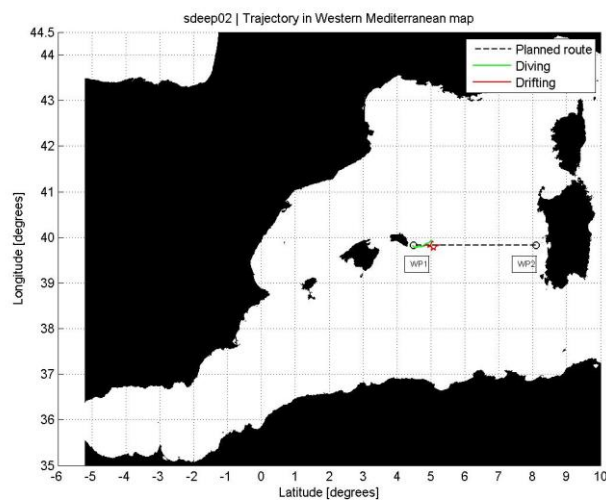
Pinwheel diagram of ballasting for determining the weights and foams and their location

IX MISSION RESULTS

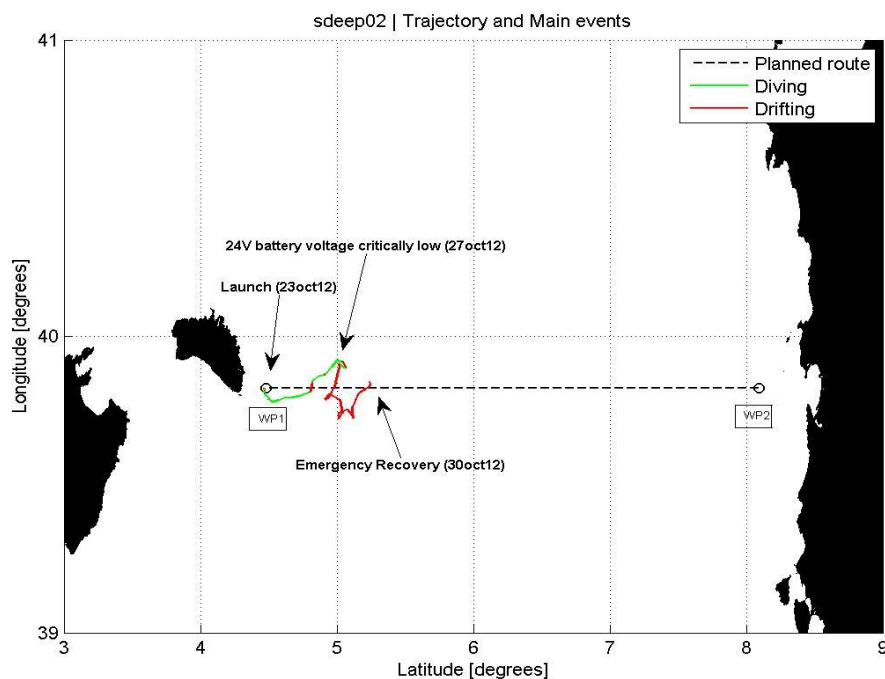
Mission Trajectory

The following images represent the mission trajectories commanded and the real glider track during mission.

The mission was aborted due to an unexpected battery low level and recovered during its 7th mission day with the collaboration of SASEMAR (Spanish Search-and-Rescue public organization dependent of the Ministerio de Fomento, Spanish Government).

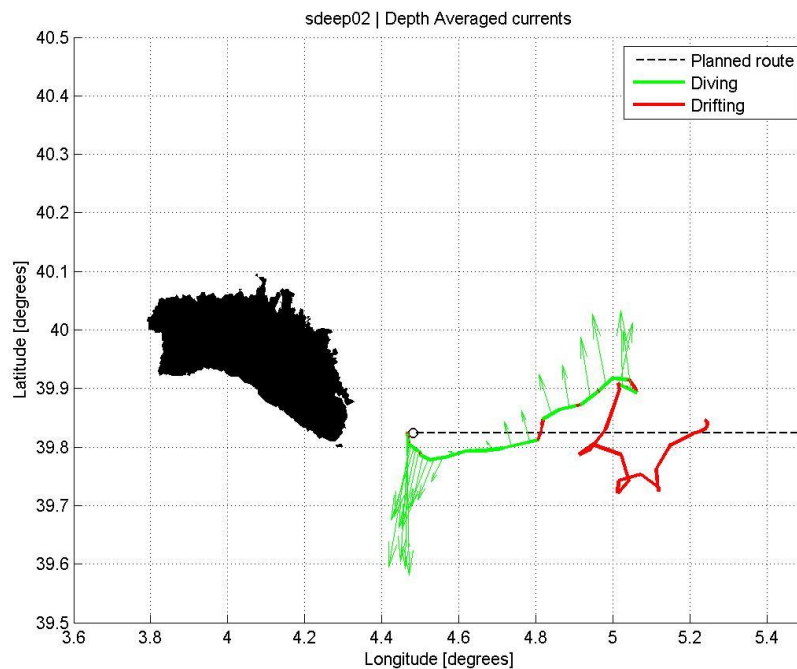


Overall mission trajectory and surface positions

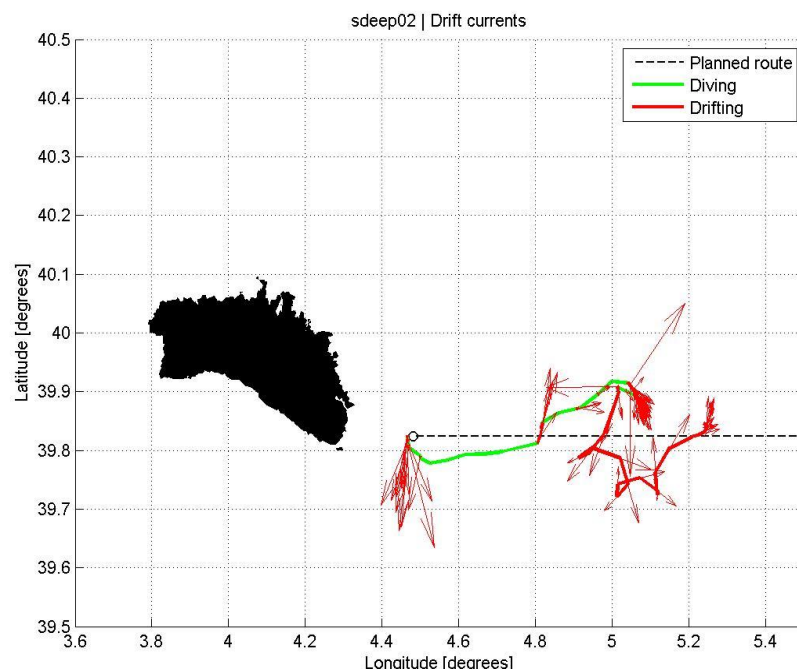


Mission trajectory and glider track (green colour indicates glider diving, red colour drifting at surface)

Currents



Depth average currents (DAC) measured (water column integrated currents)



Surface currents measured (drifting currents at surface)

Depth Average Currents (DAC) and Drift currents head S-SW during the beginning of the mission. At about 4,6 longitude degrees DAC currents change to W and decrease their intensity. From there, they gradually move to N and increase their strength. Highest DAC encountered is 28,8 cm/s and lowest is 1,9 cm/s. During the 3 days drifting, intensities and directions vary. The highest registered value is 74,6 cm/s and the lowest is 2,17 cm/s.

Scientific Data

Sensors

The scientific data of this mission was gathered using the following sensors:

- CTD:
SeaBird unpumped CT-Sail,
S/N: 0168, Last calibrated: 2011-02-20
Paine pressure sensor,
S/N: 264060, Last calibrated: 2011-02-09
- FLUOROMETER:
WetLabs Triplet,
S/N: BBFL2VMT-778, Last calibrated: 2010-10-13
- OXYGEN:
Aanderaa Oxygen Optode 4330F,
S/N: 464, Last calibrated: 2010-12-14

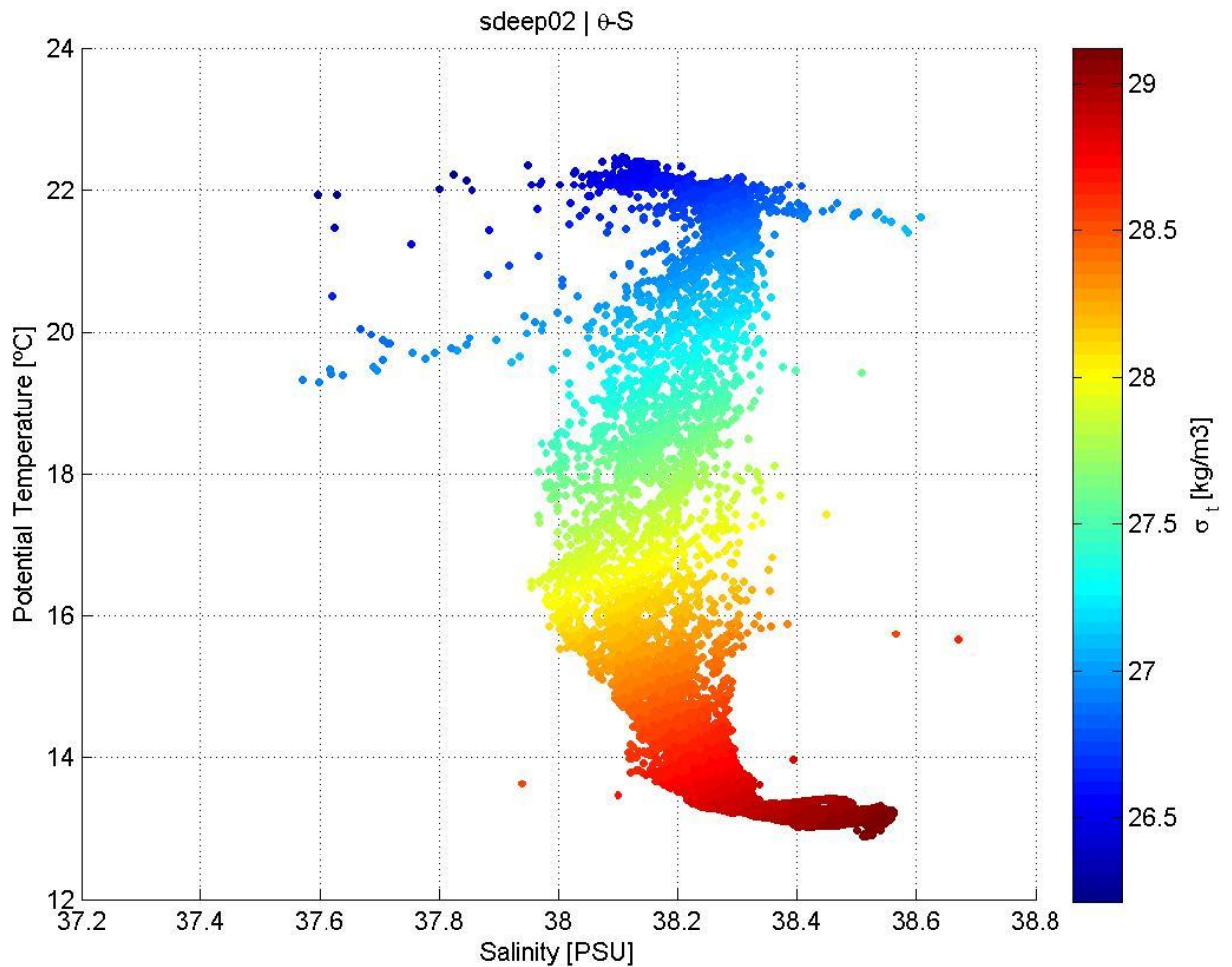
Data Filtering

Data coming from the sensors are filtered using low and high limits to avoid spikes and non-realistic values (i.e. negative values) in visualization plots. The following table indicates the outside bands that are dismissed (including the discarded percentage of data). No other filter or data processing has been applied to obtain the following pictures.

| Sensor | Variable | Low filter | Too low | High filter | Too high | % Discarded |
|-------------|--------------|------------------------|---------|-------------------------|----------|-------------|
| CTD | Conductivity | 3,0 S/m | 17 | 8,0 S/m | 1 | 0,030 % |
| | Pot. Temp. | - | - | - | - | 0,000 % |
| | Depth | - | - | - | - | 0,000 % |
| | Salinity | 37,0 PSU | 31 | 39,0 PSU | 7 | 0,062 % |
| | σ_t | 26,0 kg/m ³ | 31 | 29,5 kg/ m ³ | 5 | 0,059 % |
| Fluorometer | Chlorophyll | 0,0 µg/l | 8 | 1,0 µg/l | 1 | 0,072 % |
| | CDOM | 0,0 ppb | 15 | 3,0 ppb | 3 | 0,144 % |
| | Scatter 650 | 0,0 m-1sr-1 | 5 | 3*10-4 m-1sr-1 | 20 | 0,199 % |
| Oxygen | Oxygen | 0,0 ml/l | 8 | 8,0 ml/l | 548 | 1,292 % |

The next figures also represent the mission mean plots: the mean and standard deviation of the gathered data of all dives performed in the mission. To compute those statistical curves the data was grouped in 3 meter deep bins and averaged. A detail image on the left shows the first 100 meters and the complete depth range image is shown on the right.

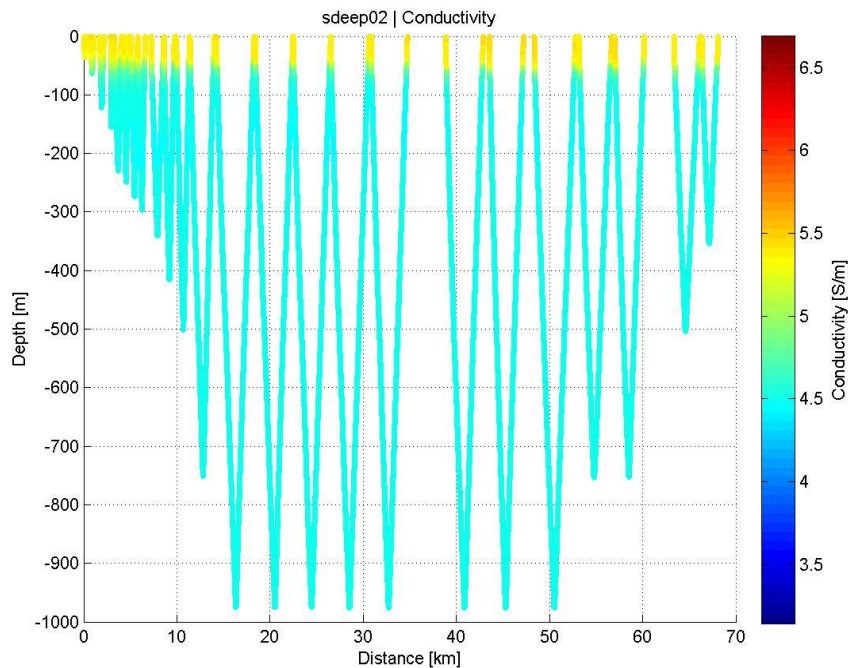
θ -S Plot



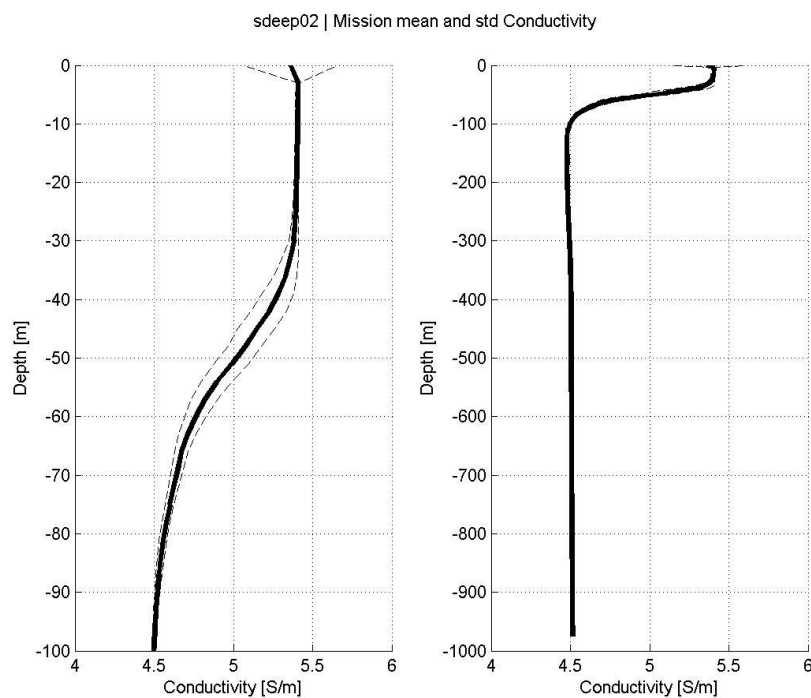
θ -S diagram

The θ -S diagram (with salinity values discarded if lower than 37,0 PSU or higher than 39,0 PSU) shows deep waters had a salinity of about 38,5 PSU and 13 °C. Surface waters were slightly above 22 °C with salinity values ranging from 38,0 to 38,4 PSU. This salinity range contains most of the mission data.

Variable: Conductivity



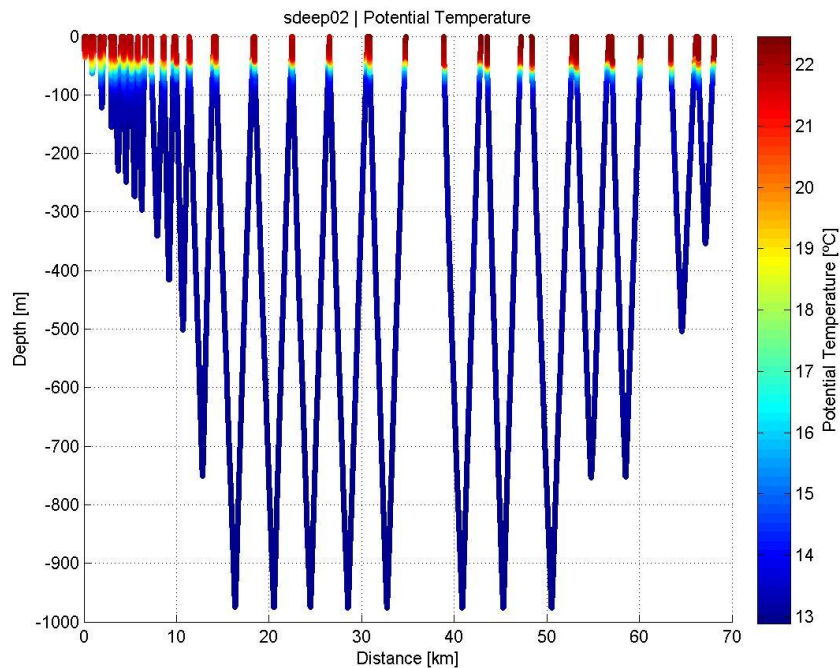
Conductivity section



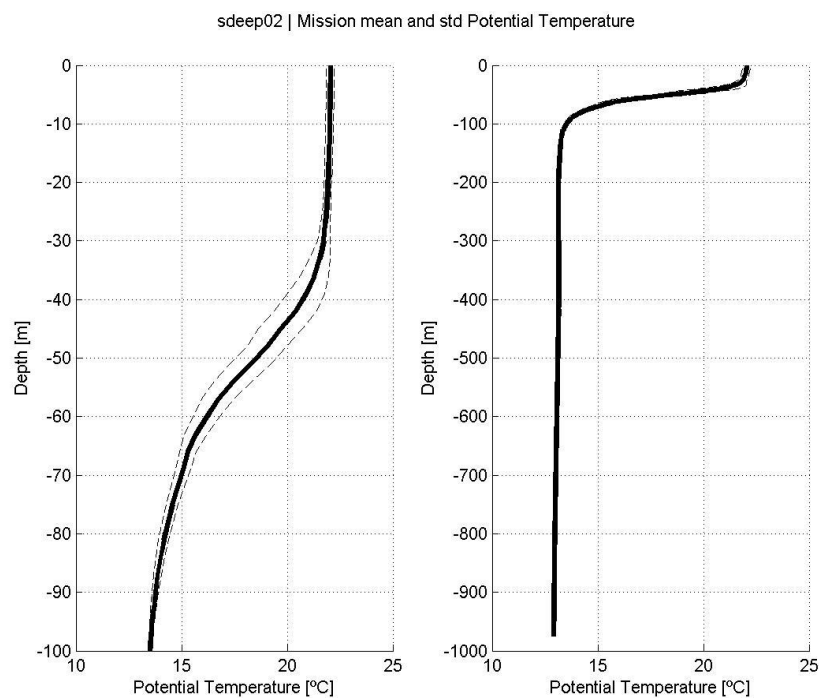
Conductivity mean and standard deviation (right - 100m depth zoom, left - full depth plot)

Conductivity shows a high variation in the first 3 meters where the glider gains vertical velocity and its pitch is unstable, and also between depths of 30 m (22 °C) and 80 m (14 °C). The sensor response in this high temperature gradient is $\pm 0,16$ °C/m (positive climbing and negative diving).

Variable: Potential Temperature



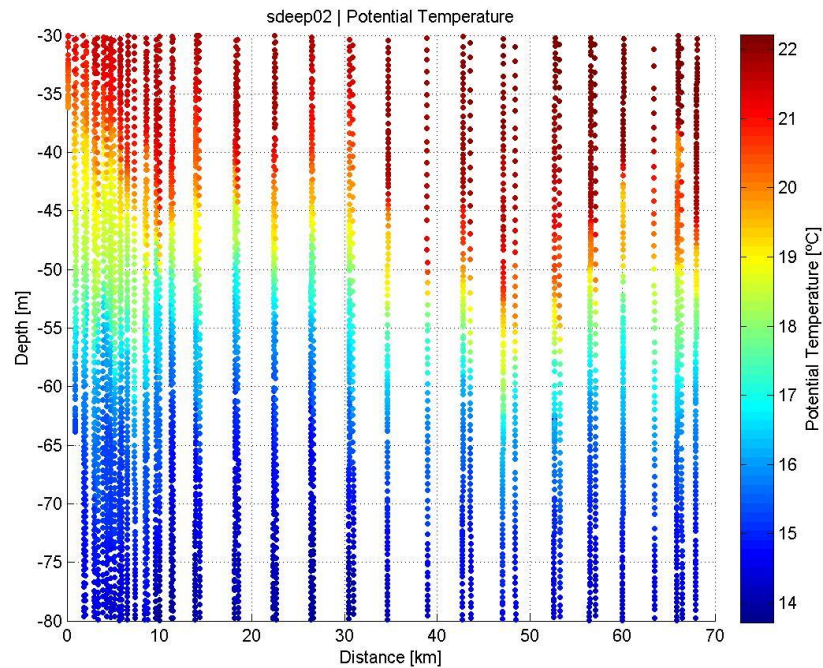
Potential Temperature section



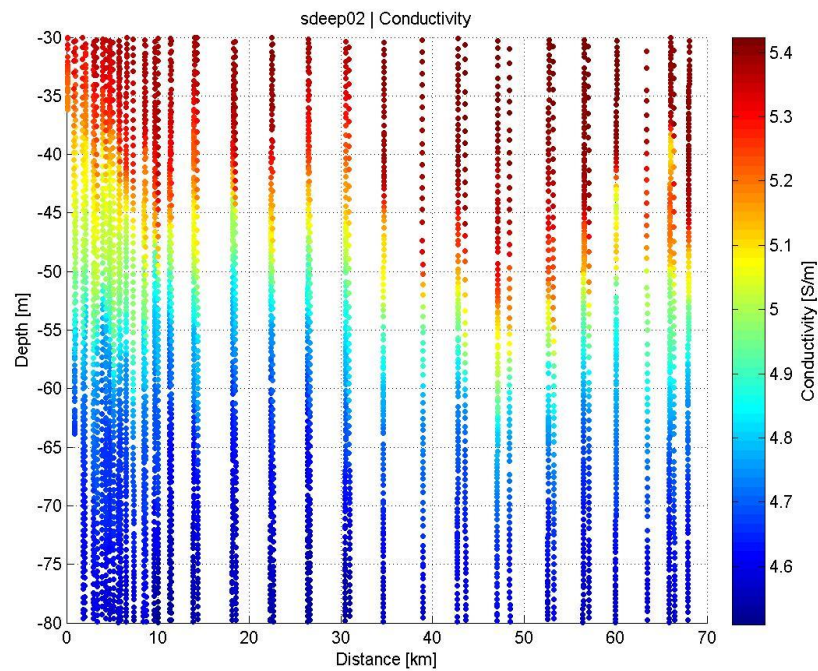
Potential Temperature mean and standard deviation (right - 100m depth zoom, left - full depth plot)

Temperature sensor is very reliable and does not show spikes. Therefore no filter is applied to temperature values. The sensor's lag is corrected but some deviation is found between 30 m and 80 m depth.

Having a closer look on the data obtained (first plot below), it can be observed that, as the glider moves east, the warm layer gets deeper causing the observed deviation. Thus, conductivity deviation is not only explained by the thermal lag effect but mainly by the real water change as the glider went further east (second plot below).

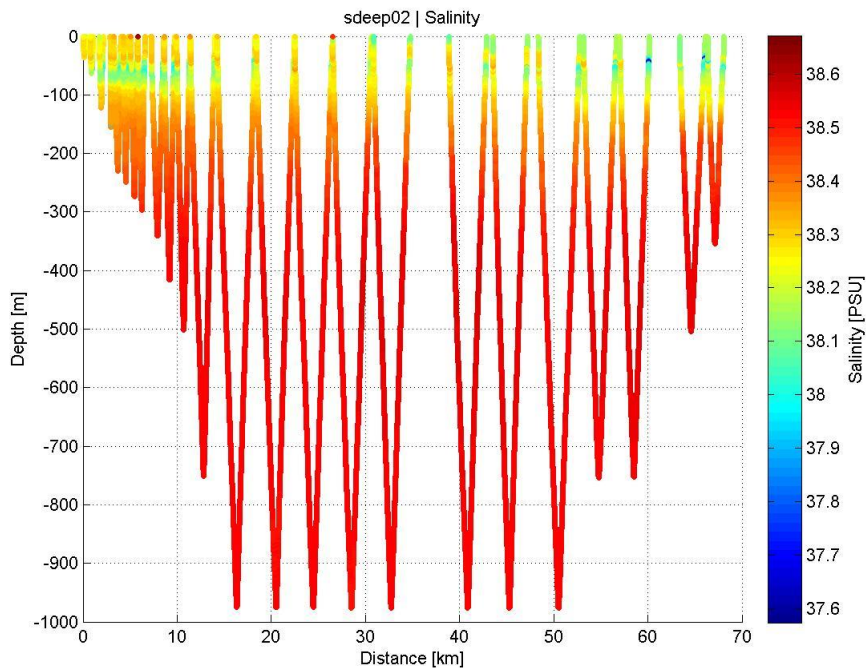


Potential Temperature section (zoom at 80m depth)

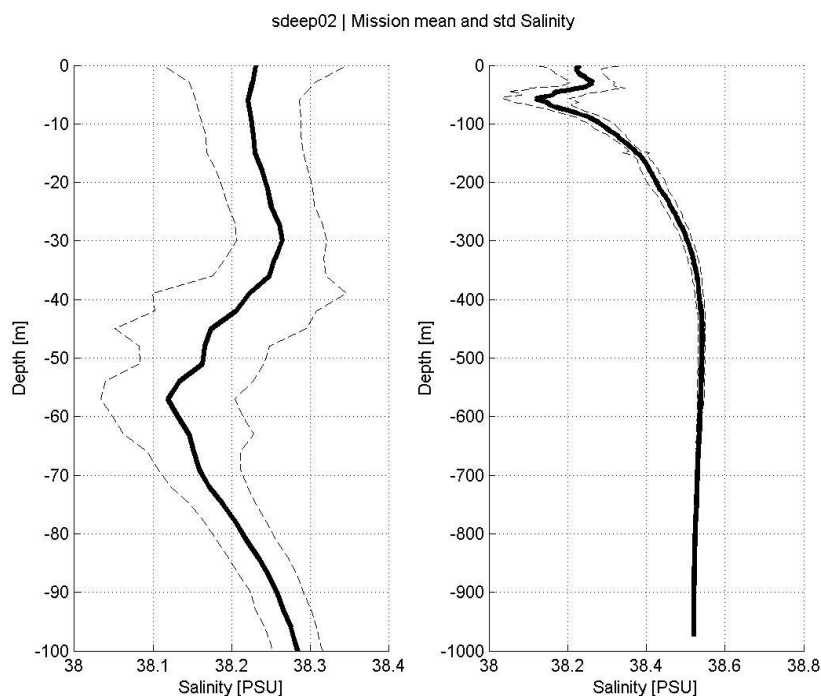


Conductivity section (zoom at 80m depth)

Variable: Salinity



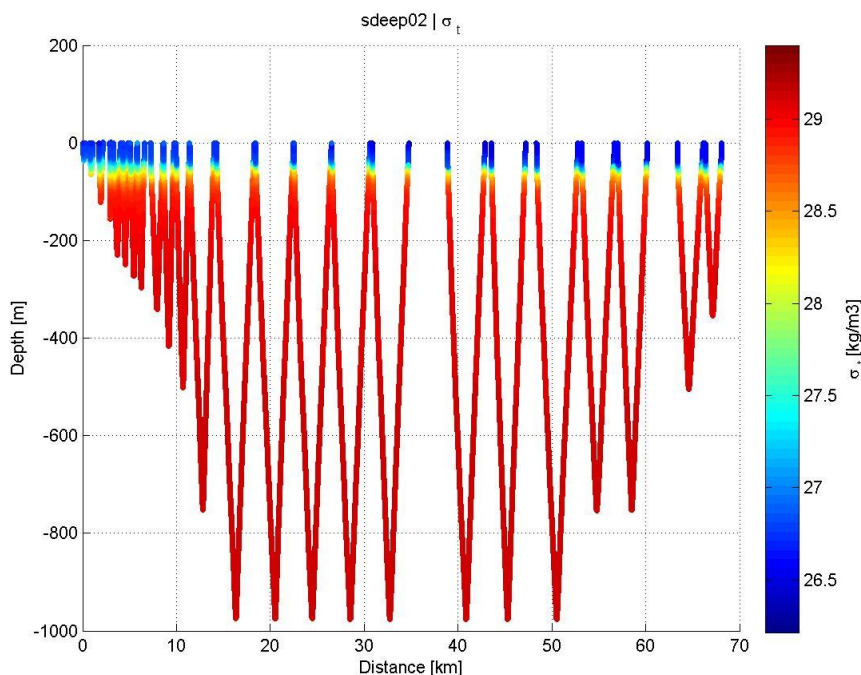
Salinity section



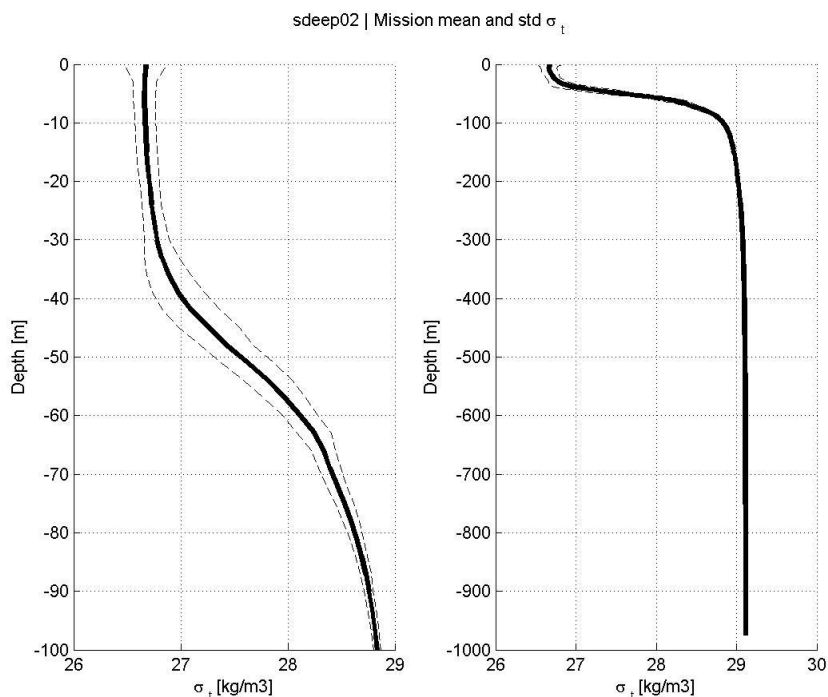
Salinity mean and standard deviation (right - 100m depth zoom, left - full depth plot)

Salinity is derived from conductivity, temperature and pressure. Therefore all these sensors' uncertainties add up in the salinity measure. Accepted values are the same shown in the T-S plot, those between 37,0 and 39,0 PSU. Salinity shows deviation until about 400m depth due to water change and thermal lag, which is very noticeable in salinity as conductivity is lagged with respect to temperature and pressure readings.

Variable: σ_t



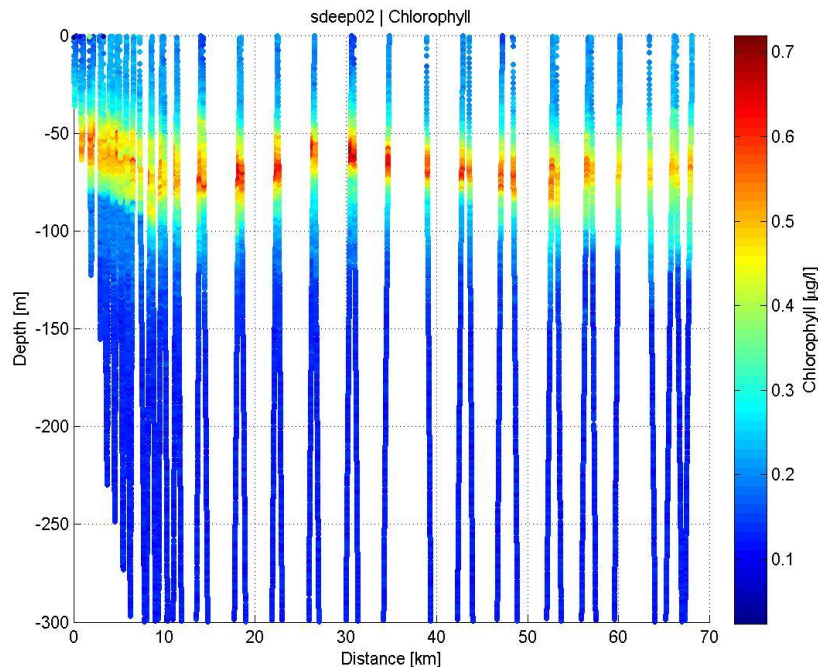
σ_t section



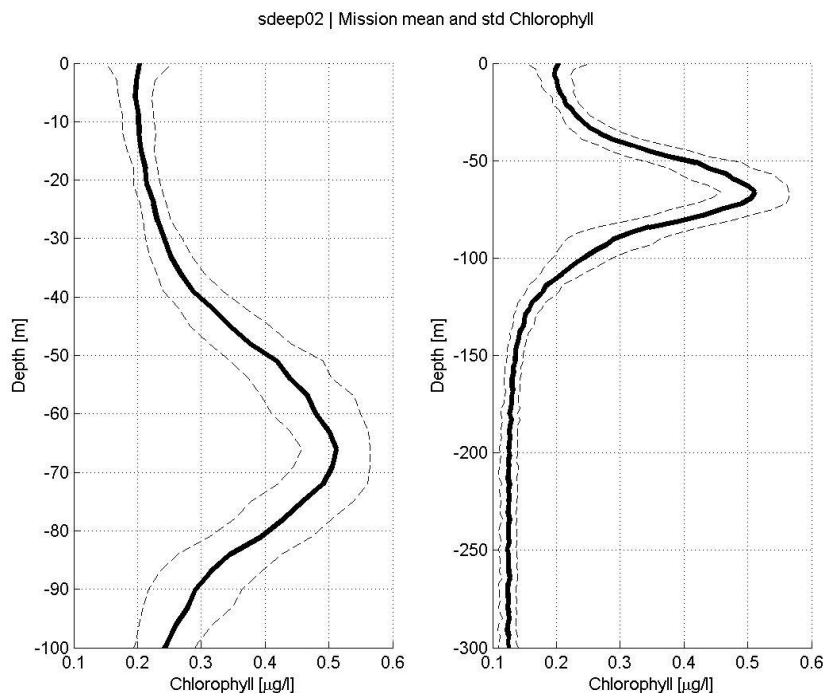
σ_t mean and standard deviation (right - 100m depth zoom, left - full depth plot)

σ_t is obtained from salinity and temperature. Therefore, deviation is encountered where it is encountered in salinity, until 400m. Values are filtered to only accept the range 24 kg/m³ to 30 kg/m³.

Variable: Chlorophyll



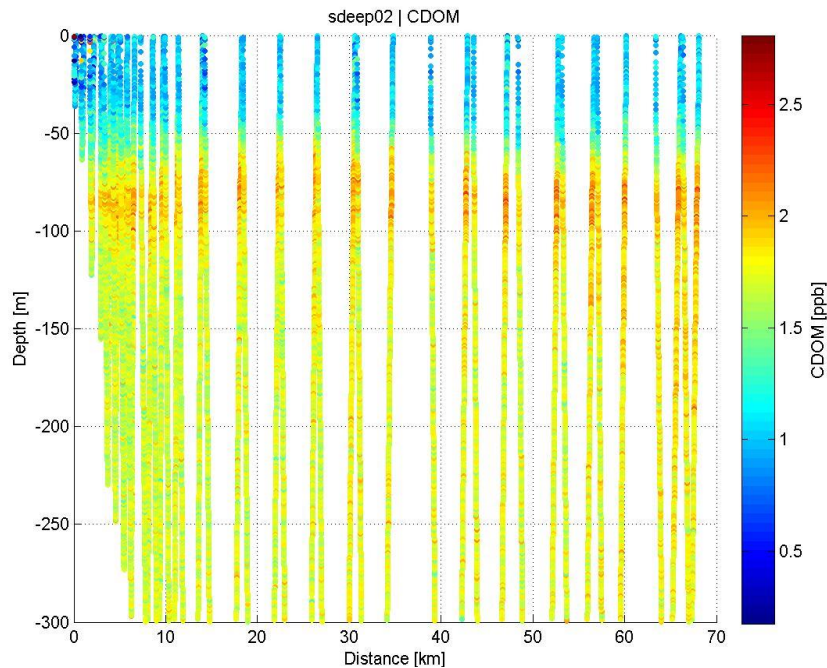
Chlorophyll section (measured up to 300m depth)



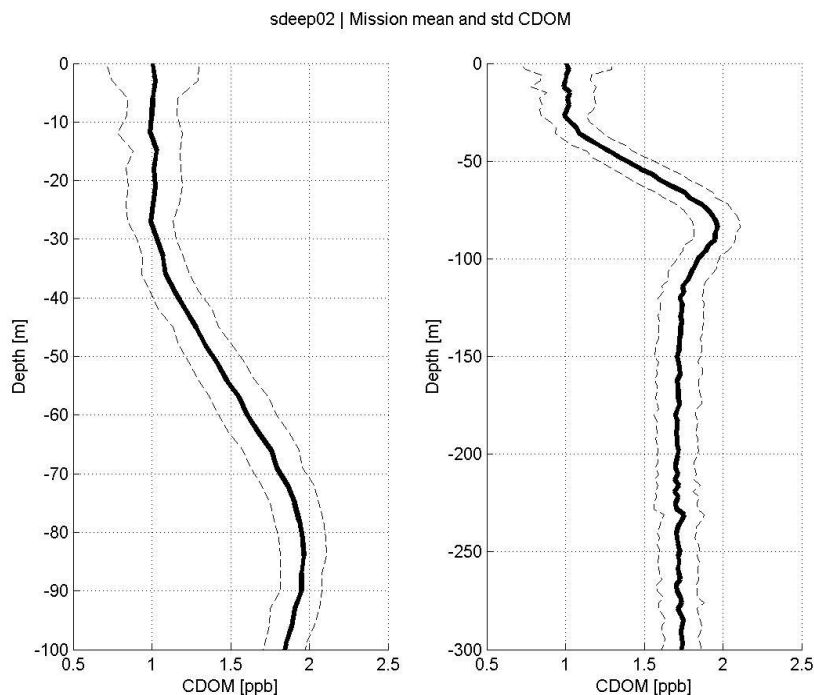
Chlorophyll mean and standard deviation (right - 100m depth zoom, left - full depth plot)

Values accepted for chlorophyll are those between 0 and 1 $\mu\text{g/l}$. Its concentration reaches the peak at about 65 m depth. Below 150 m depth, concentration values remain quite stable and close to 0,1. The WetLabs sensor has an undetermined delay with respect to the depth reading that can be of about 8 seconds and that is not corrected. At 10 cm/s vertical speed, the lag between downcast and upcast readings can be of 160 cm.

Variable: CDOM



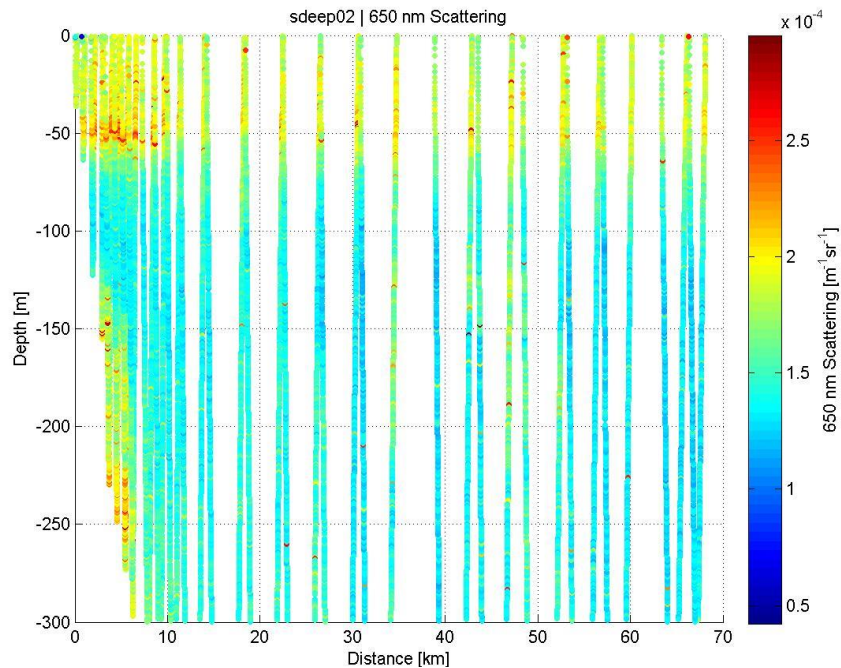
CDOM section (measured up to 300m depth)



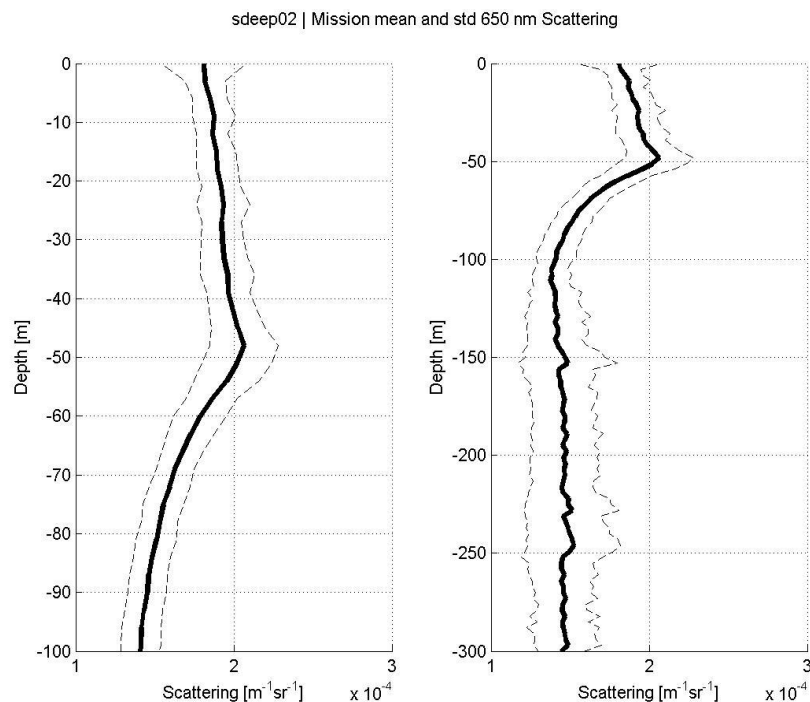
CDOM mean and standard deviation (right - 100m depth zoom, left - full depth plot)

Values accepted for CDOM are those between 0 and 3 ppb. CDOM reaches its peak at about 85 m depth. Deviation remains quite stable during the mission for all depths. CDOM is measured with the WetLabs sensor and the lag explained for Chlorophyll also applies.

Variable: 650 nm Scattering



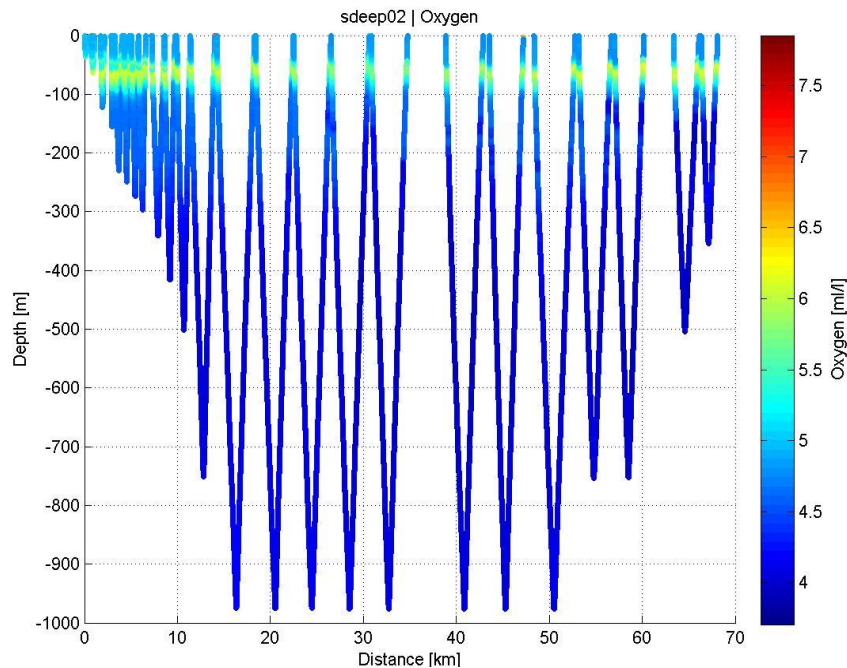
Scattering section (measured up to 300m depth)



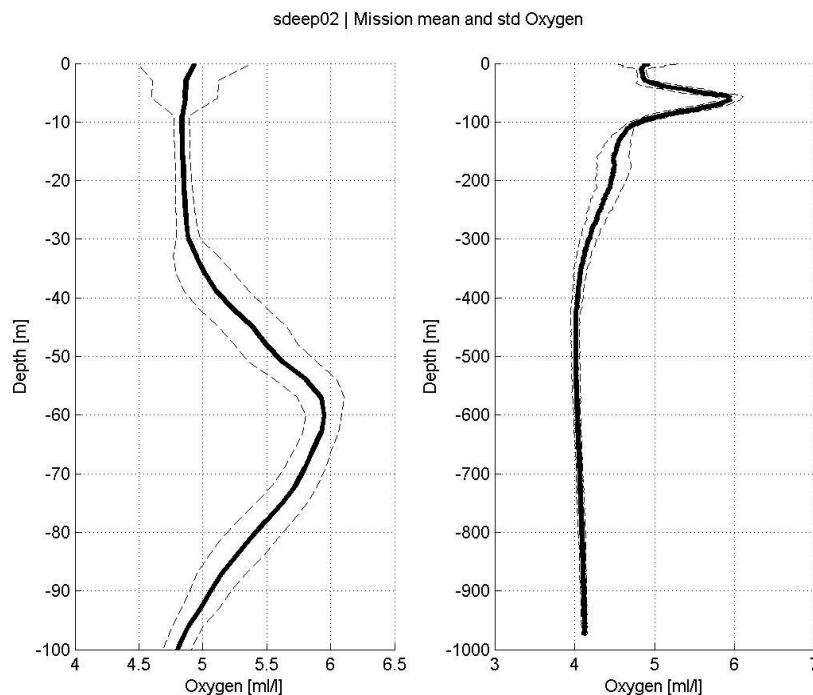
Scattering mean and standard deviation (right - 100m depth zoom, left - full depth plot)

The scattering sensor shows linearly growing scattering at the first 50 m depth and then it decreases exponentially until 100 m where it stabilizes at about $1,5 \text{ m}^{-1}\text{sr}^{-1}$. During the first 10 km, the glider was getting close to the seafloor (20 m) and scattering measures are high when approaching it. Scattering is measured with the WetLabs sensor and the lag explained for Chlorophyll also applies.

Variable: Oxygen



Oxygen section

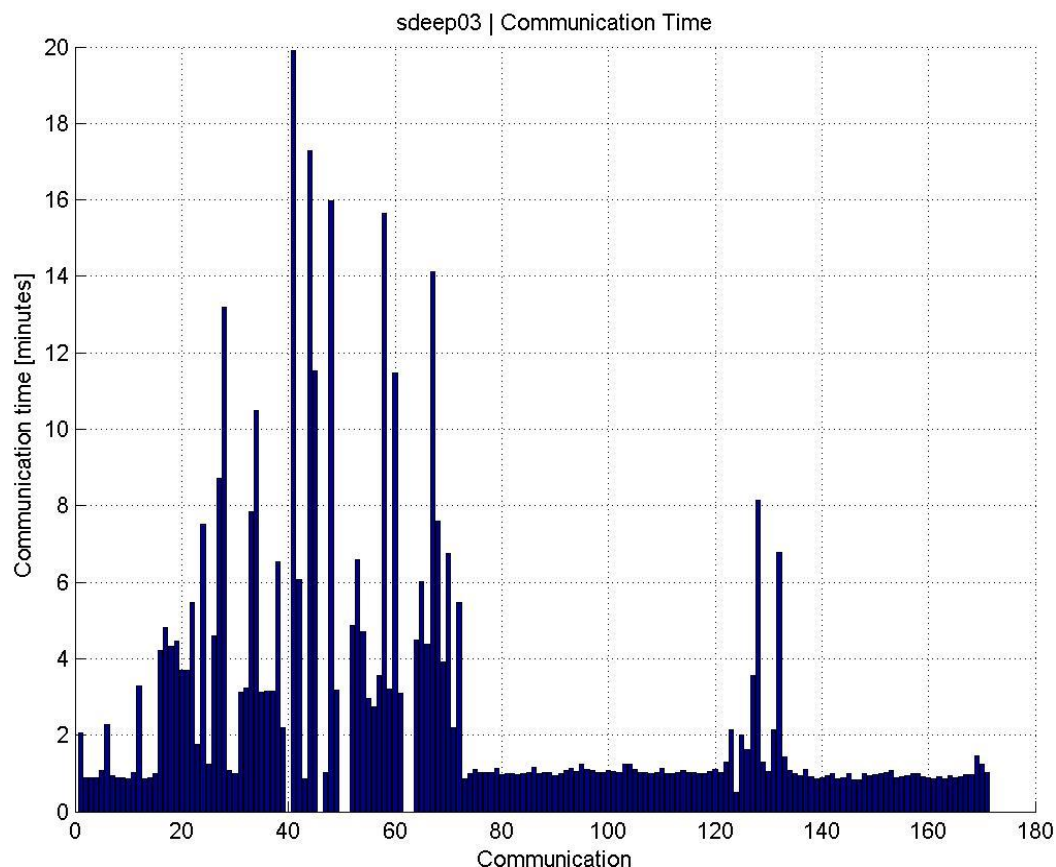


Oxygen mean and standard deviation (right - 100m depth zoom, left - full depth plot)

Oxygen is the 'noisiest' variable and 1,292% of the values have been filtered for these plots. The concentration peak is at about 60 m depth and then the concentration keeps decreasing until 400 m depth where it stabilizes at about 4 ml/l. The Aanderaa sensor also has an undetermined delay with respect to the depth reading that can be of about 8 second. This lag is not corrected.

Technical Data

Iridium



Iridium communication time

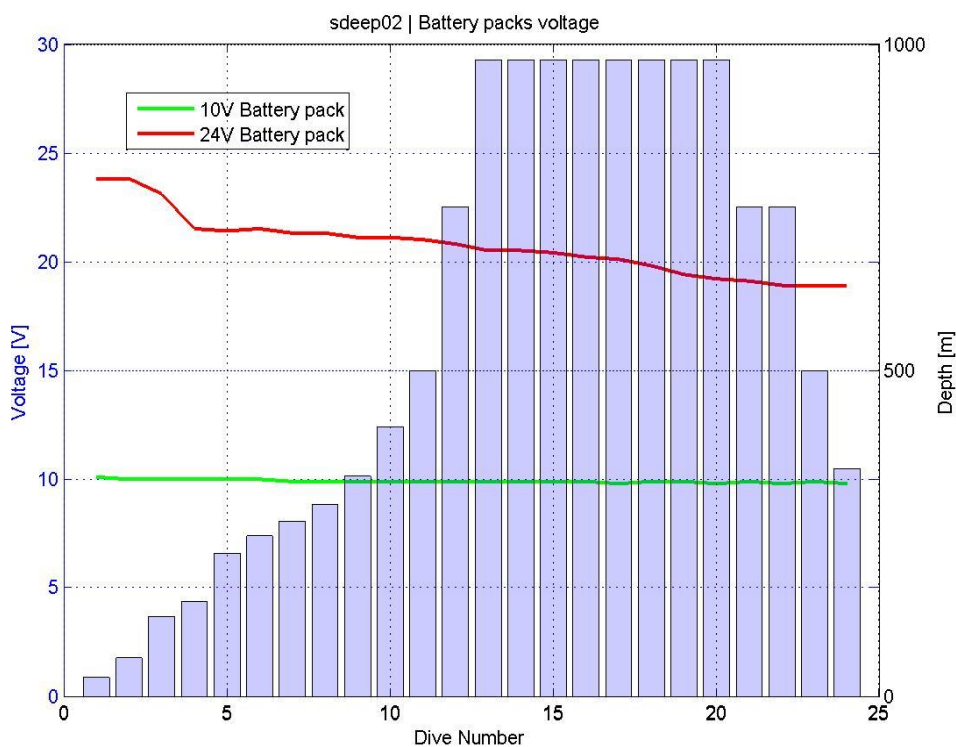
Iridium communications worked fine during the whole mission. The longest communication session lasted about 20 minutes and the shortest less than 1 minute. Sessions in which no data is transmitted last around 1 minute.

It can be seen that the glider was configured to transmit very few data when the mission aborted due to the battery problem. Since that event, the glider was configured to transmit only the tracking information every four hours (to follow the drifting of the glider at surface and minimize battery consumption).

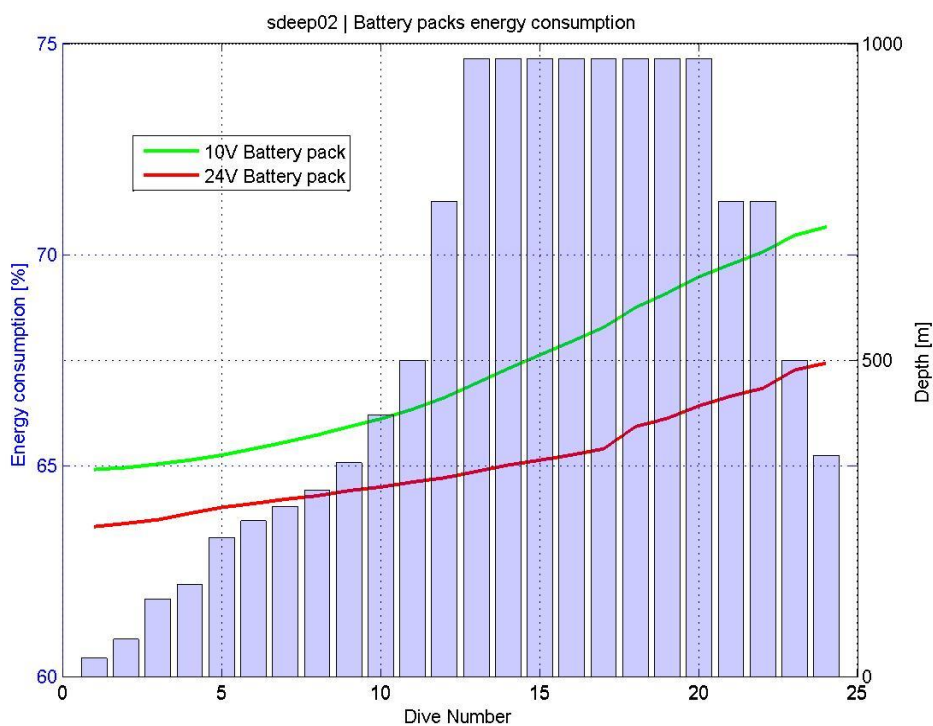
Some statistics on the communications through Iridium:

| | |
|--|-------------------------------|
| -Total number of communications: | 171 [num] |
| -Total communication time: | 441 [min] |
| -Mean communications per dive: | 7,1 [calls] |
| -Mean communication time: | 2 [min] 34 [s] |
| -Mean data transferred per comm.: | 9,04 [kB] |
| -Total data transferred through Iridium: | 1,51 [MB] |
| -Mean Iridium coverage (out of 5): | 4,76 [bars] |
| -Iridium battery consumption: | 3.99 [% of total consumption] |

Energy



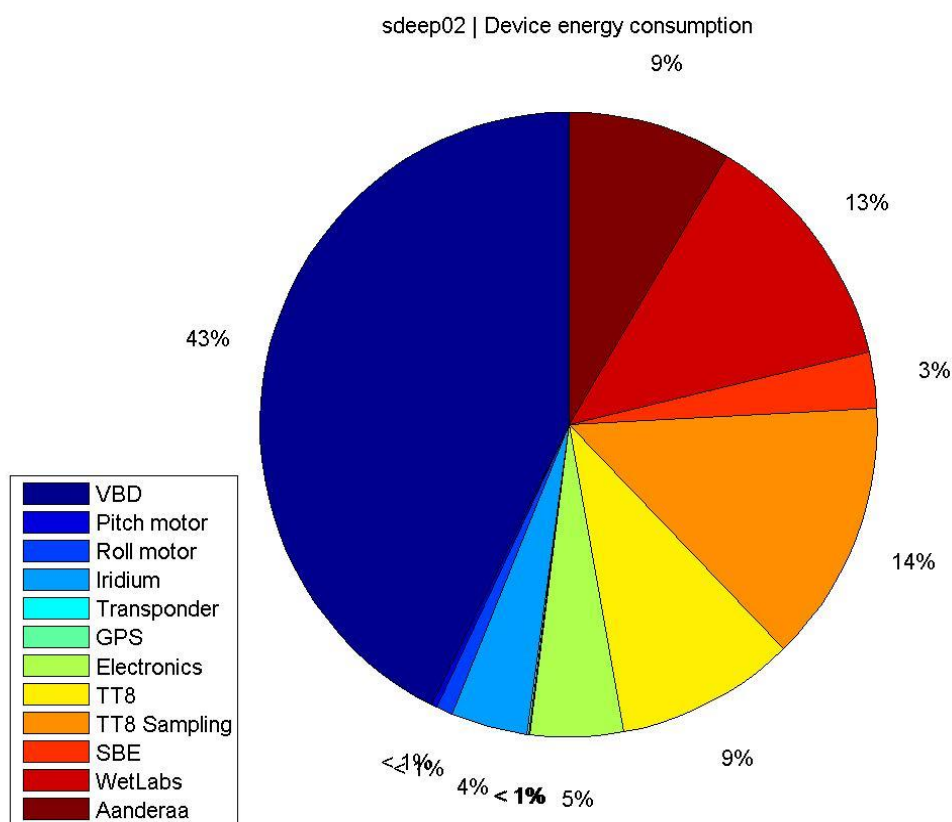
Battery voltage per dive (dive depth in bars)



Battery energy consumption per dive (dive depth in bars)

The mission was aborted and an emergency recovery was needed due to a sudden voltage drop suffered by the 24V battery pack. This voltage drop can be observed in solid red in the previous figure. Dive 2 registered 23,8 V, dive 3 gave 23,1 V and dive 4 showed 21,5 V. After this sudden drop, known as 'knee' in lithium battery packs, the voltage decreased linearly at 0,15 V/dive approximately until dive 20 where the abort limit of 19,0 V was reached and the glider went into recovery mode with a VOLTAGE_CUTOFF_24V message.

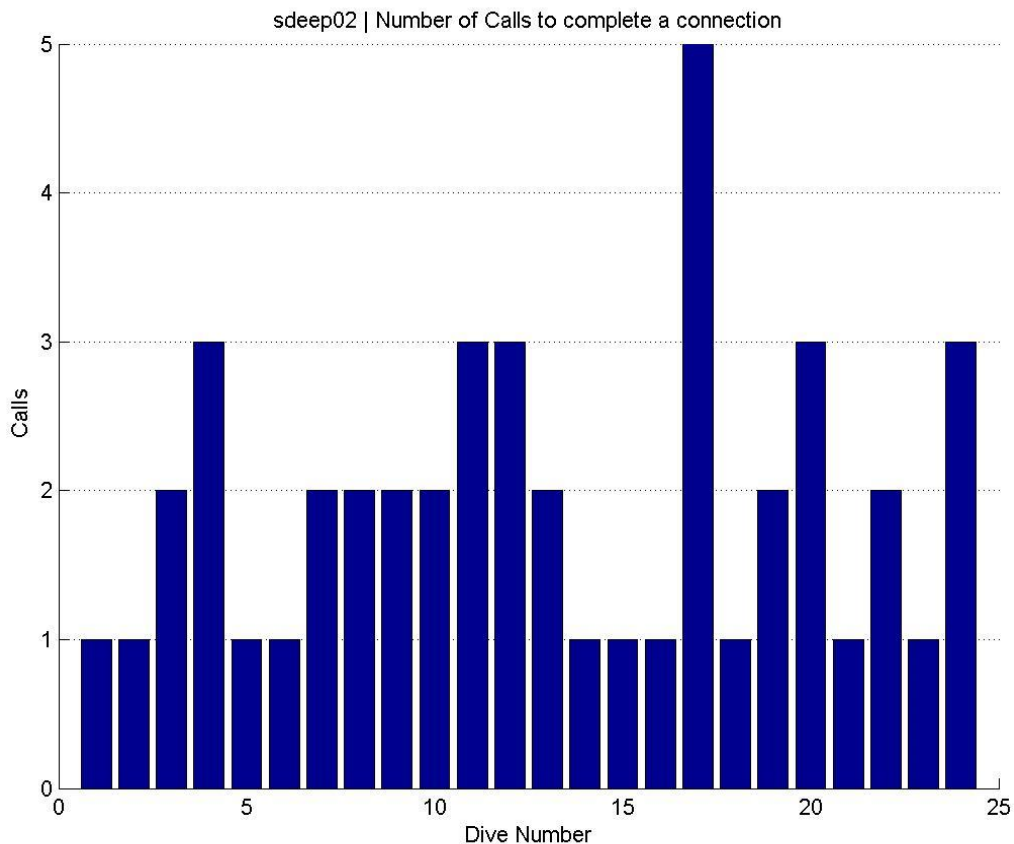
The glider's energy counter indicated that just a 67% of the capacity had been used, as shown in dashed red, but as iRobot recommended later, the voltage needs to be monitored as well.



Overall mission energy consumption percentage per device

Regarding the consumption by device estimated by the glider, the VBD buoyancy pump took a 43% of the total consumption. Iridium consumed a 4 %. The sampling (sensors and computer dedicated to sample) cost a 39%. The Anderaa consumption (9%) sampling down to 1000m was close to that of the WetLabs (13%) sampling down to 300m. The SBE CT-Sail consumption was very low compared to the other sensors. 10V devices consumed a 48% of the total energy, almost the same as 24V devices, which means the 10V battery pack was being consumed faster.

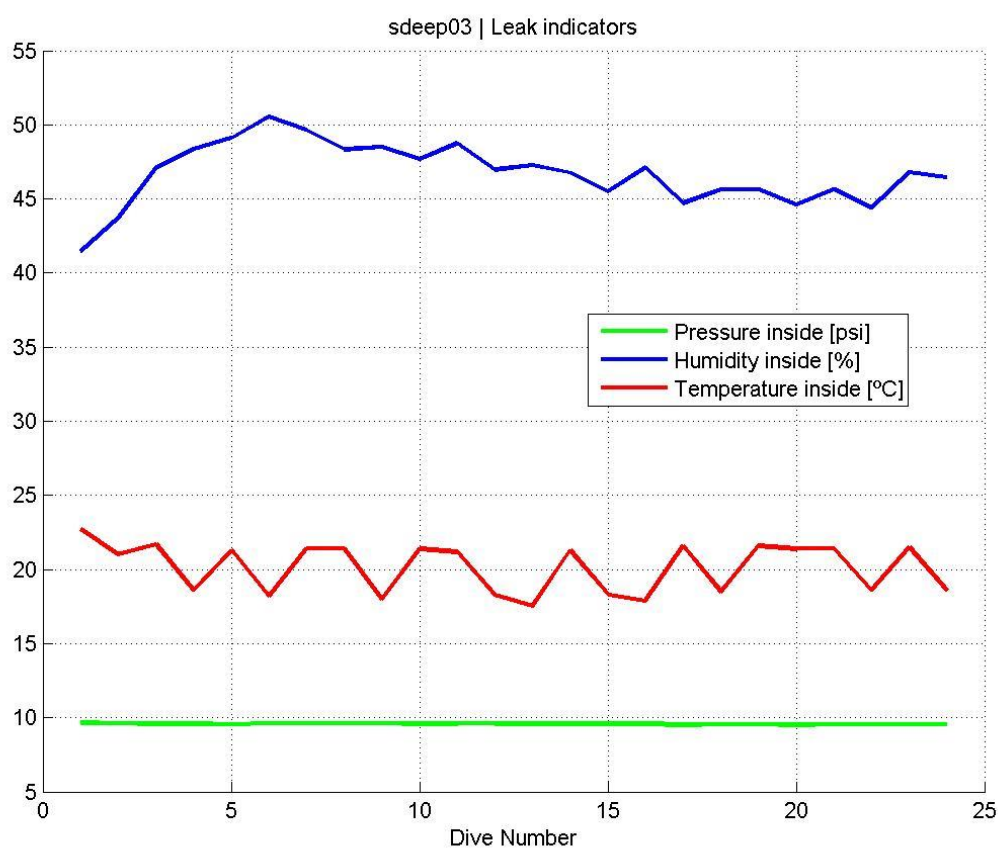
Safety



Number of calls done by the glider to establish connection

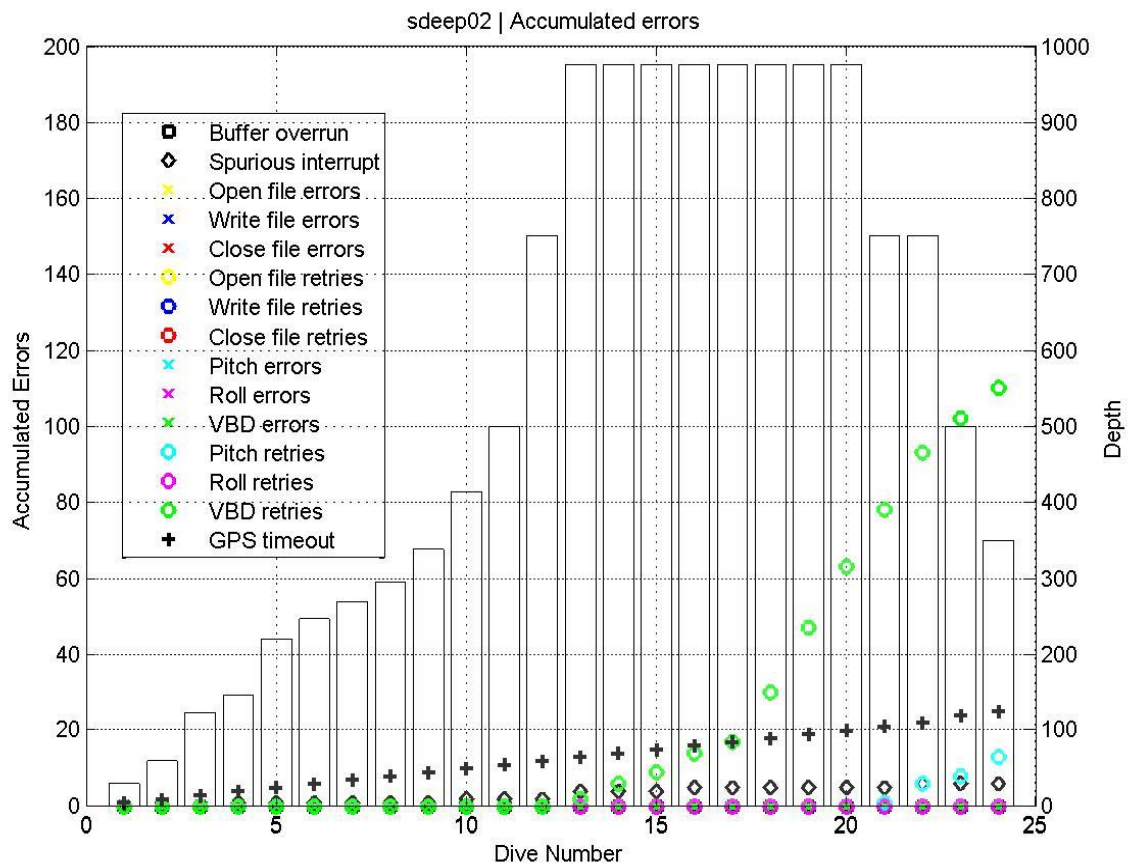
The glider manufacturer recommends the monitoring of the number of calls done by the glider to establish a connection with the basestation. The maximum number of calls it does per dive is 5 and the minimum is 1. iRobot recommends having less than a 15% of connections established at the 5th call and more than a 55% of connection established at the 1st call.

In this mission, sdeep02 had a 4,2% of connections at the 5th call and a 41,7% of connections at the 1st call. The glider, however, communicated when it had to and no anomalies were detected. The one week checkpoint for communications was not reached and therefore this issue showed up during the post mission analysis.



Glider internal safety sensors (Pressure, Humidity and Temperature)

Regarding possible leaks, the three indicators (pressure, humidity and temperature inside the hull) held steady values during the entire mission.



Internal glider errors (number and type) per dive

The first VBD retry, showed in green circles in the figure above, happened during the apogee phase of dive 13 and then VBD retries became more and more common. On dive 13, voltage for the VBD was 20,5 V and the depth was 1000m for the first time. The first retries (2) were a sign the battery had some issues but the pilot and iRobot were focusing on the VBD pump itself. The 'knee' (sudden voltage drop) had not been detected and that is why the mission kept going. A pdos command (capvec HVBD DEBUG BOTH) was issued in order to record what was happening with the pump. On dive 20, with more than 60 VBD retries, the knee was detected and iRobot suggested decreasing \$VBD_PUMP_RATE_APOGEE from 4 to 3 in order to get rid of the retries. This command was not issued. On dive 21 depth was lowered to 750m and the retries per dive stopped growing and the voltage stabilized to 18,9 V. On dive 23 \$MINV_24V,18 was issued in order to avoid aborts and dive back at relatively low depth (<500m) to WP1. iRobot recommended not diving as there existed the risk the VBD pump could not work at depth with that bad battery state. The glider was kept drifting until it could be recovered.

It can be observed that on dive 21, with 19,1V, the pitch motor also started showing retries (turquoise circles). GPS timeouts showed up almost every dive and a few spurious interrupts were detected. These have been found in every mission and are a normal behaviour.

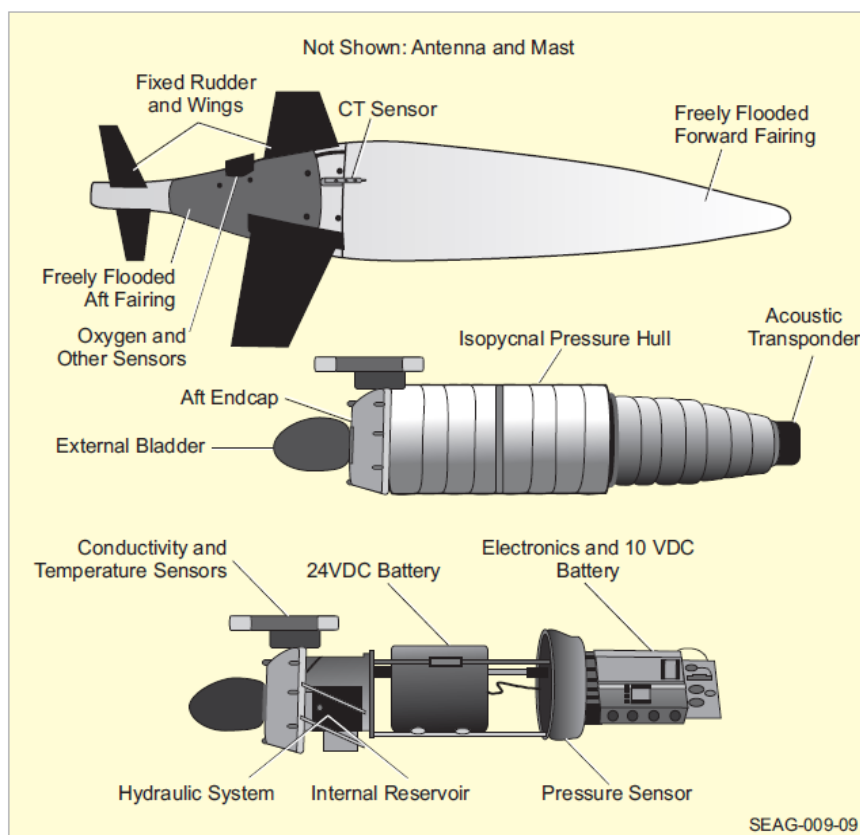
ANNEX I: GLIDER TECHNICAL INFORMATION

iRobot Seaglider 1KA

The Seaglider is neutral in water when the external bladder has a certain amount of oil inside. When the glider wants to dive, the bladder deflates (oil moves into a reservoir) and the glider becomes denser than water. While diving, the wings give the glider lift and forward propulsion. As the glider goes deeper, the pressure on the hull increases making the hull smaller and therefore increasing the glider's density. This change in glider density is similar to the change in density the water experiments thanks to the isopycnal hull design. This way, vertical velocity remains stable.

To climb, the glider uses the hydraulic system to inflate the external bladder and thus gain buoyancy. This is done during the apogee phase and it is the most energy consuming manoeuvre.

Once on the surface, the glider gets a GPS fix and calls via Iridium satellite into the basestation to receive new orders (navigation, sampling, waypoints) and upload data (scientific and technical). With the new instructions, the glider gets another GPS fix, makes some calculations to find the direction to the next waypoint and dives again.



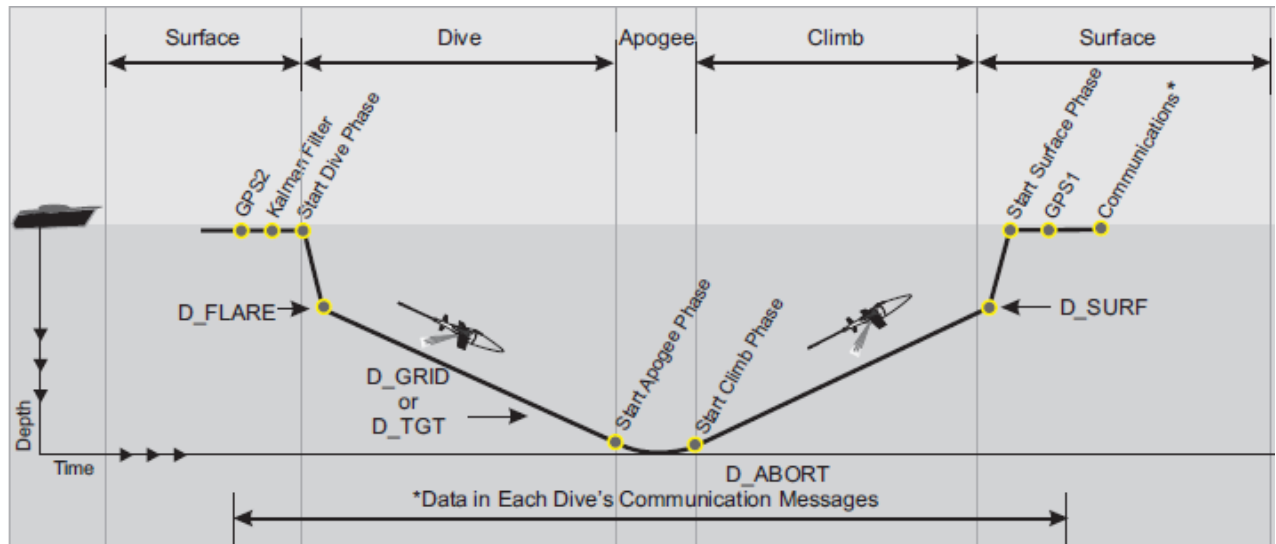
Seaglider parts. Source: iRobot (DA 1)



iRobot Seaglider 1KA specifications

| | |
|-----------------------|---|
| Weight in air: | 52 Kg |
| Weight in water: | Neutrally buoyant |
| Hull Diameter: | max 30 cm |
| Hull material: | Aluminium |
| Width including Wings | 100 cm |
| Vehicle Length: | 1.8 meters |
| Depth Range: | 0 - 1000 meters |
| Speed, projected: | 0.25 m/sec horizontal |
| Energy: | Lithium Sulfuryl Chloride primary batteries, 17 MJ. |
| Endurance: | Dependent on navigation and sampling. Typically 4 months. |
| Range: | 3000 km |
| Navigation: | GPS, internal dead reckoning, altimeter |
| Sensor Package: | Conductivity, Temperature, Depth, Chlorophyll, CDOM, backscatter 650nm and oxygen |
| Communications: | Iridium satellite, external ARGOS transmitter, Serial cable, Pinger for recovery |

Glider Behaviour



Seaglider dive phases. Source: iRobot (DA 1)

Distance travelled:

$$\text{Vertical speed} = w_d = (2 * \$D_TGT * 100\text{cm/m}) / (\$T_DIVE * 60\text{s/min})$$

$$\text{Distance} = \$D_TGT * (1 / \tan(\text{Down Angle}) + 1 / \tan(\text{Up Angle}))$$

If Up Angle = Down Angle = 20°

$$1 / \tan(20^\circ) = 2,75$$

Then **Distance = Depth * 5,5**

Horizontal Speed (theoretical - without currents):

$$\text{Speed} = 0,25 [\text{meter/sec}] * (1 \text{ mile} / 1852 \text{ meter}) * (3600 \text{ sec} / 1 \text{ hour}) =$$

$$0,486 [\text{miles} / \text{hour}]$$

Inflection Time (Up and Down)

$$\text{Time} = \text{Distance} / \text{Speed} = \text{Depth} * 5,5 / 0,25 = \text{Depth} * 22 [\text{sec}]$$

For example:

Depth = 1000 meter

Distance = 5500 meter

$$\text{Time} = \text{Distance} / \text{Speed} = 5500 [\text{m}] / 0,25 [\text{m/sec}] = 22000 [\text{sec}] =$$

$$366 [\text{min}] = 6 [\text{h}] + 6 [\text{min}]$$



GLIDER MISSION REPORT

Reference : *GF-MR-0012*

Mission : *JERICO TNA SARDINIA OCT12*

Date : *October, the 23st, 2012*

Platform : *sdeep02 (Unit538)*

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