TYRRMOUNT09 GLIDER EXPERIMENT:

SETUP, MISSION AND PRELIMINARY RESULTS

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SUMMARY:

1. Introduction

The “Tyrrhenian Seamounts ecosystems: an Integrated Study” (TySEc) experiment took place in the Tyrrhenian Sea in late Spring 2009 with the aim of studying the geomorphologic characteristics and the hydrodynamics of the area over and around a Seamount. In general, a seamount is a mountain rising from the ocean seafloor that does not reach the water surface, and thus is not an island. The seamount investigated is the Vercelli Seamount located in the middle of the Northern Tyrrhenian Sea off the Olbia coast at about 41°05.000'N and 10°53.000'E (see Fig. 1). It is an independent features rising abruptly from a seafloor of about 1500/2000 meters depth, with a main peak about 55 meters below the surface.

A dedicated oceanographic cruise was organized in the period spanning from the 19th of May to the 3rd of June 2009 onboard the R/V Urania (CNR). As part of the TySEc experiment, the OGS glider Trieste-1 was operated in an area over the Vercelli Seamount for a period of about 8 days (from the 23rd to the 31st of May). The glider mission was named Tyrrmount09.

This report describes all the glider operations conducted before and during the Tyrrmount09 mission. In particular, after a brief description of the OGS glider (section 2), the Tyrrmount09 glider mission is presented in section 3. The glider testing, ballasting and mission set-up are described in section 4 and the glider deployment, piloting and recovery are summarized in section 5. Finally, the preliminary results derived from the glider measurements are presented in section 6.

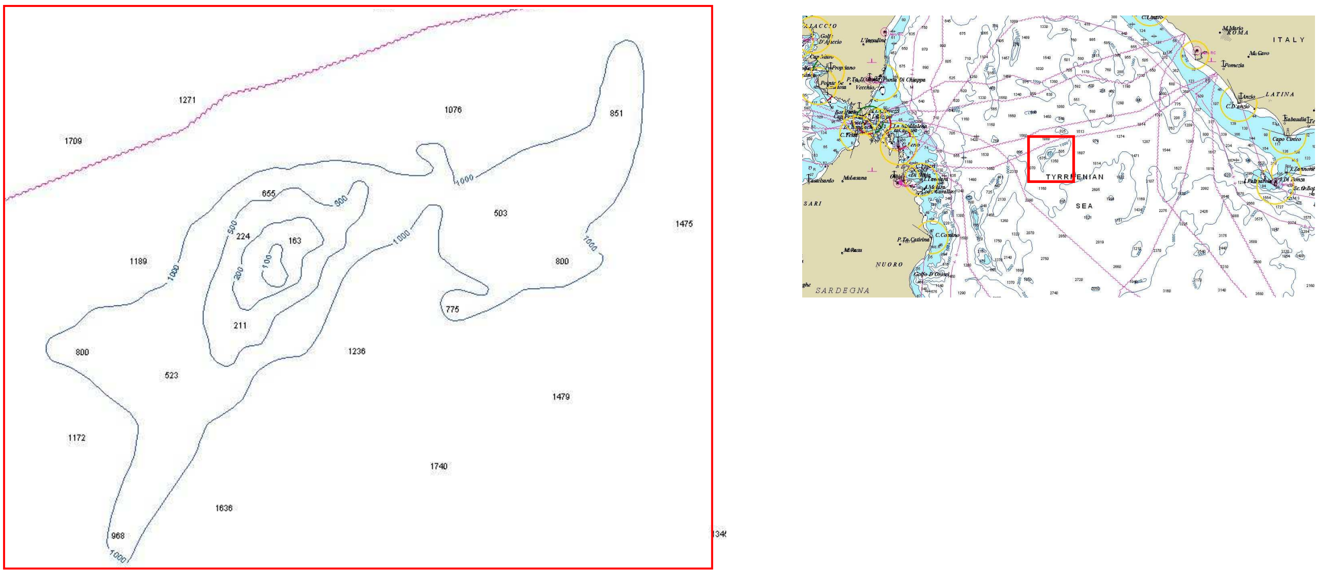


Fig. 1 The Vercelli Seamount: location and bathymetry.

2. The OGS glider

The OGS glider is a Slocum glider from Webb Research Corporation. It is named Trieste-1 in honour of the famous bathyscaphe Trieste designed by August Piccard in the 1950's. In particular, it is the electric coastal model, specifically designed to work in littoral areas (down to 200 m depth) along prescribed routes. It is equipped with several oceanographic sensors for the measurement of temperature, salinity, oxygen, turbidity and chlorophyll (see specifications in Gerin et al., 2007 and in Teledine Operators Guidebook, 2009).

3. The Tyrrmount09 glider mission planning

An area of roughly 750 km^2, described by a 33 km x 22 km rectangle around the Vercelli Seamount, was delimited for the glider sampling. The initial scheme proposed by CNR (Fig. 2) consisted of a zig-zag path crossing the Seamount.

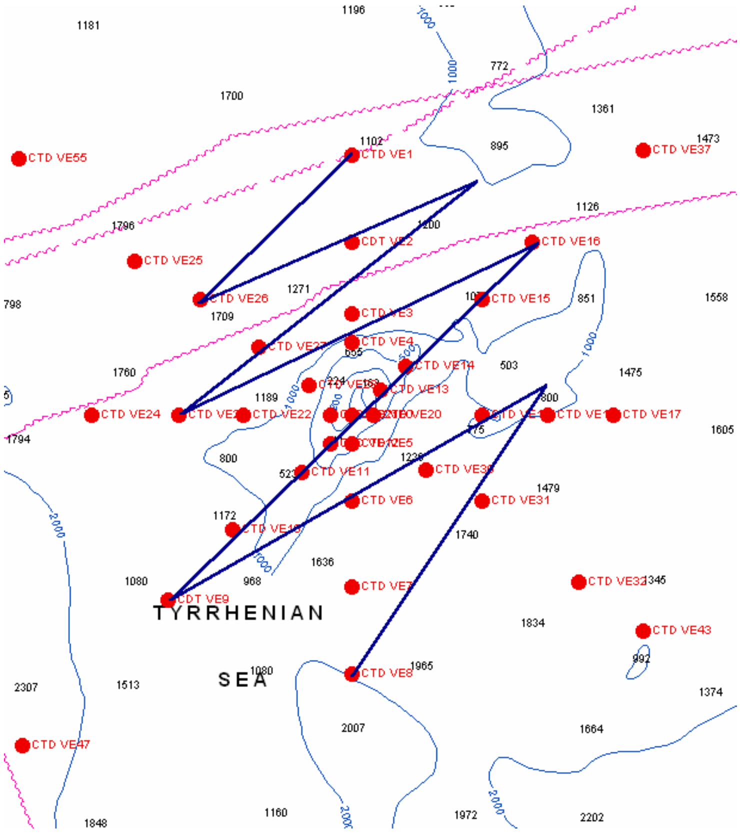


Fig. 2 The initial sampling scheme proposed by CNR: glider track (dark blue lines from north to south) and CTD stations (red dots). The bathymetry is depicted with light blue isobaths.

This path was optimized minimizing the surfacings and considering the mean currents of the area and the route of the ship (to avoid wasting time in case of eventual recovery and redeployment procedures). Additionally, due to the poor knowledge of the bathymetry of the area over the main peak of the Vercelli Seamount, the glider was kept safe from a possible impact with the seamount by adding two waypoints about one mile east and west of the estimated position of the main peak. The final survey scheme (Fig. 3) consisted of one continuous 225 km long patrol track, with scheduled surfacings at 14 specified locations (waypoints) interspersed by additional surfacings at 6 hour intervals. The glider was configured to provide scientific data during the ascending phase of each "yo", its typical saw-tooth path in the vertical while in motion underwater. The settings employed were capable of providing one water-column profile of all measured environmental variables for every 0.75 km of track covered, i.e. 300 separate profiles.

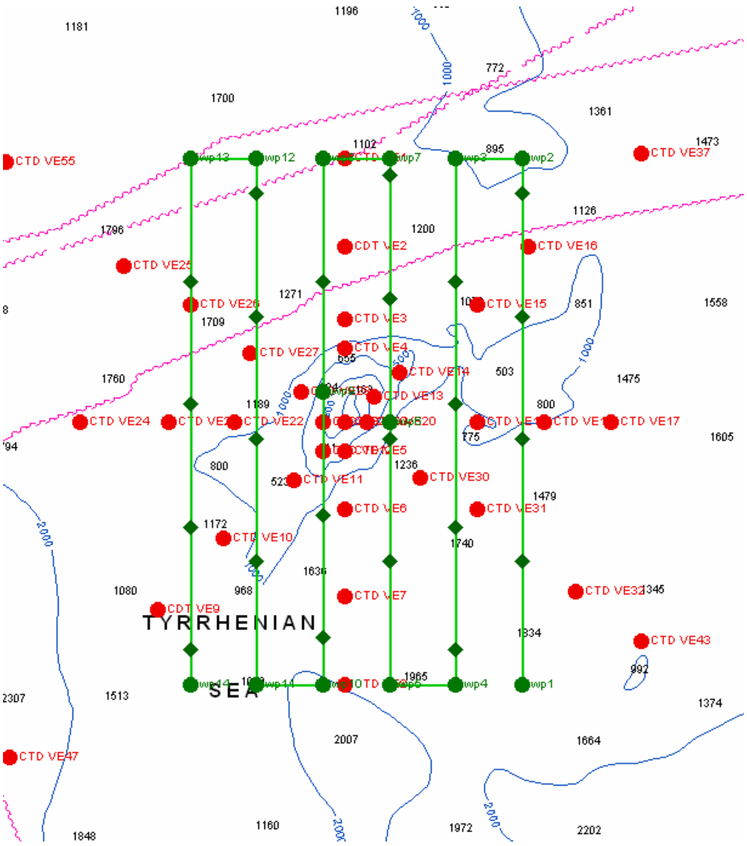


Fig. 3 The optimized Tyrrmount09 glider sampling scheme: glider track (green lines from the southeastern corner to the southwestern one), waypoints (green dots), surfacings (green diamonds) and CTD stations (red dots). The bathymetry is depicted with light blue isobaths.

Starting in March 2009, OGS did all the formalities to obtain all the authorizations required to operate the glider in the area of study. In particular, the “Istituto Idrografico” (c/o CF Demarte) and the “Stato Maggiore” (c/o CF Casula) of the Italian Navy and the “MARIDIPART” of La Spezia were contacted for all necessary authorizations. On the 13th of May OGS received the clearance from these Marine institutions.

4. Glider testing, ballasting and mission set-up

Given the missed Iridium communications and the other problems that occurred in the previous missions (see Gerin, 2008), the OGS glider was thoroughly tested for the Iridium communications and the the swagelok connector was definitively repaired at the CTO (“Centro Taratura Oceanografica”), the OGS calibration laboratory during March 2009.

The glider was initially ballasted for the water of the Gulf of Trieste (σ: 26.7 Kg/m^3; nose weight of 51 g) and the standard tests and two short missions were performed in the area off Miramare (Grignano, Gulf of Trieste) on the 27th of April. The two missions consisted in two short navigations between two waypoints (Fig. 4).

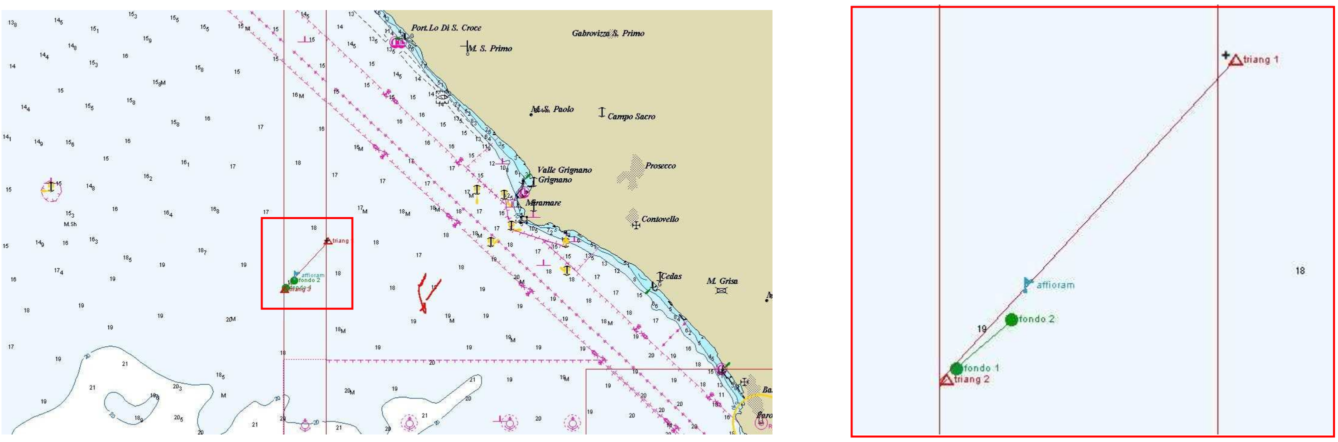


Fig. 4 Left: the test mission area in the Gulf of Trieste. Right: waypoints of the first mission (from north to south, red triangles), surfacing point (light blue flag) and waypoints of the second mission (from south to north, green dots).

In the first mission (named “formic09.mi”; red line in Fig. 4), the waypoints were separated by about 0.55 nm and a surfacing was scheduled after 30 minutes. The aim of this mission was mainly to check the Iridium transmission. In the second mission (named "fondo09.mi"; green line in Fig. 4; less than 200 meters between the two waypoints) the glider performed about 3 "yo". The "d_target_depth" parameter was set to 30 m to check the functioning of the pinger and the reaction of the glider to depths lower (about 18 m) than the programmed ones. The glider operated correctly during both missions sending the data to the ogadock at OGS (see Medeot and Gerin, 2007) and veering without touching the seafloor.

The water characteristics of the study area were monitored by collecting all the available and recent CTD profiles performed near the Vercelli Seamount and by repeatedly checking the temperature and salinity forecasts provided by the Istituto Nazionale di Geofisica e Vulcanologia, INGV (http://gnoo.bo.ingv.it/mfs/). A mean density was estimated and the glider was ballasted for a density of 1027.4 Kg/m^3 by adding a total weight of about 65 g inside the nose dome.

The optimized mission was written by compiling the "tyrr09.mi", "yo17.ma" and "goto_l17.ma" files. Extreme attention was given to the positioning of the two safety waypoints east and west of the main peak of the Vercelli Seamount by considering the estimated topography and currents. In particular, they were located a bit south (eastern point) and north (western point) the peak so as to adjust in advance any possible deviation from the straight meridional route (Fig. 5).

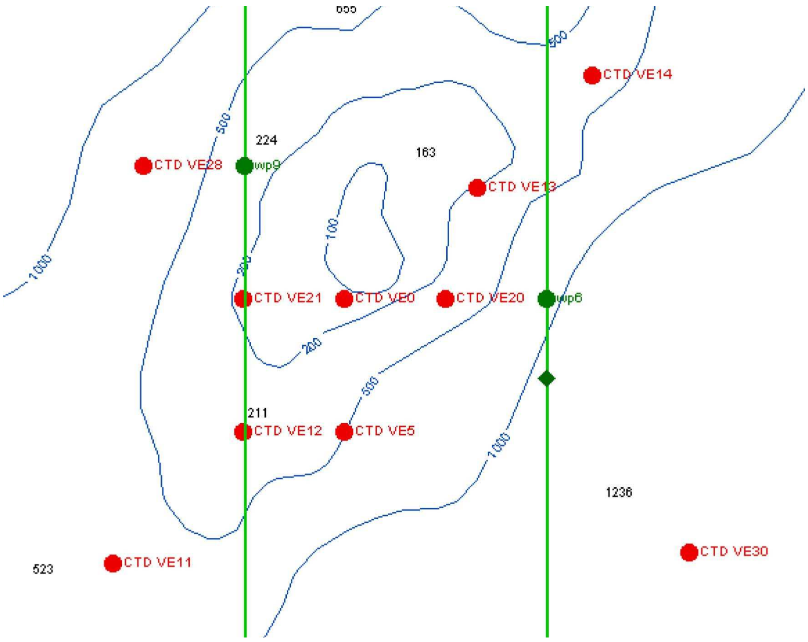


Fig. 5 Close up of the optimized glider mission: glider track (green lines; northward on the left side and southward on the right), safety waypoints (green dots), surfacings (green diamonds) and CTD stations (red dots). The bathymetry is depicted with light blue isobaths.

Additionally, another precaution was taken by setting the "d_target_altitude" parameter equal to 25 meters so as to avoid any crash with the unexplored and possibly uneven seafloor and by setting the "c_target_depth" parameter equal to 8 meters to maintain the glider underwater even in case of denser surface waters.

5. Glider mission

5.1 Monitoring of the essential parameters

The glider was shipped to the R/V Urania at the beginning of May and part of the OGS glider Team (A. Bubbi, R. Gerin and R. Nair) embarked on the 19th of May at Favignana. Once onboard, the piloting station (through the freewave and the internet access) and the freewave antenna were installed. During the days before the deployment, the vacuum and the seawater density were repeatedly monitored and several tests were conducted to check the freewave and iridium transmissions. The seawater density was highly variable in the first meters (Fig. 6). The programmed density was considered good and no nose weight adjustments were needed.

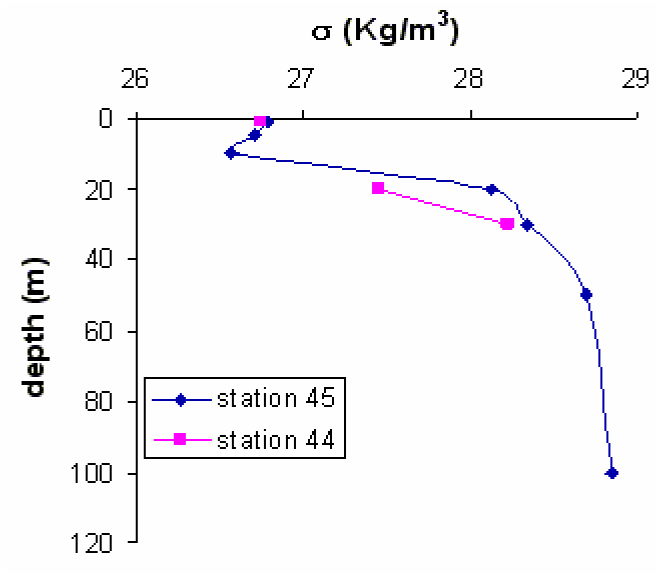


Fig. 6 Density profiles at two CTD stations in the Vercelli Seamount area.

5.2 Deployment

On the 23rd of May, after the on-air and in-water tests, the glider was deployed at 12:54 (local time = GMT + 2) about 1.2 nm far away from the initial waypoint (gps fix: 40°58.2078N

– 11°02.0105E) so as to permit the glider to compute the mean currents before starting the true mission. The first communication (at wpt1, the initial waypoint) was missed (but the glider reached this point as revealed by the after-recovery analysis of the “Trieste_1-2009-142-6-0.dbd file; see Fig. 7) and the glider surfaced after about 6 hours close to the first predicted surfacing point (southeastern green diamond on Fig. 3).

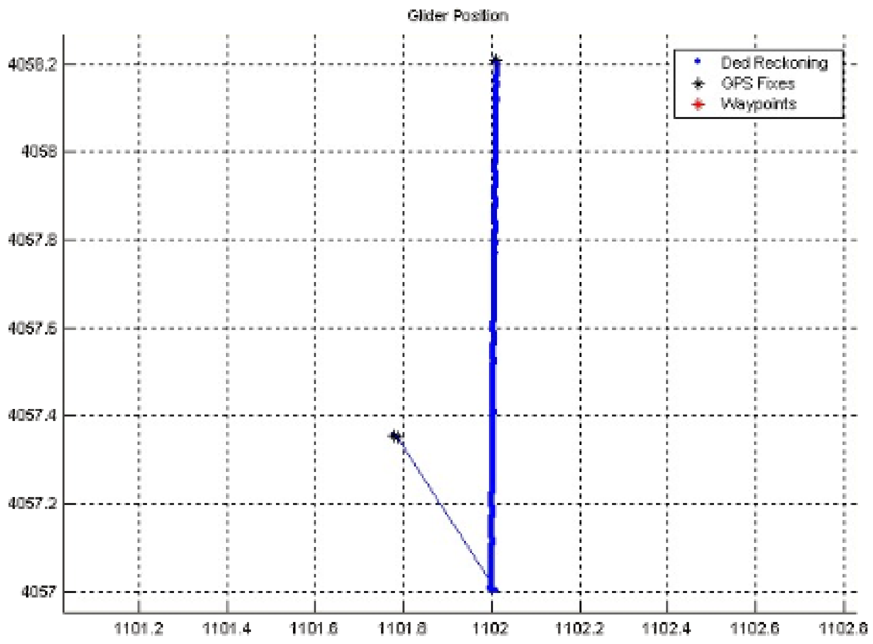


Fig. 7 Analysis of the glider position after the deployment (northern asterisk). Even if we do not received any communications from the glider, it sailed southward reaching the initial waypoint. The glider drifted a bit northwestward when at surface.

5.3 Piloting

The glider mission was monitored by interfacing with the dockserver (see Medeot and Gerin, 2007) through the onboard internet connection. The glider communications are summarized in Tab. 1 and the surfacings are depicted in Fig. 8.

There were no warnings from the glider. Only an initial excessive battery consumption was recorded. It is important to note that the batteries were quite old. Therefore, the voltage was thoroughly monitored during the first three days (Fig. 9). After three days, the battery consumption decreased, and calculated voltage estimates were well within threshold values necessary for the safe completion of the mission.

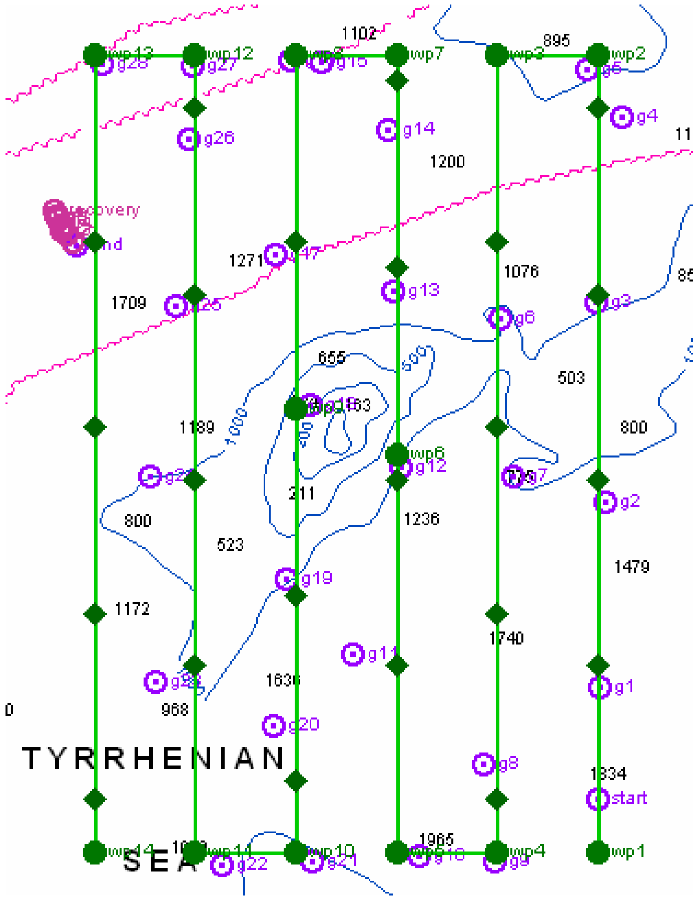


Fig. 8 Glider surfacings (open circle symbols with dots).

Day and time (local time)	where	note
23/5 @ 12:50	start	deployment
23/5 @ 19:08	g1	
24/5 @ 01:08	g2	
24/5 @ 07:26	g3	
24/5 @ 13:45	g4	
24/5 @ 16:14	g5	close to wp2
25/5 @ 04:26	g6	
25/5 @ 10:29	g7	
25/5 @ 22:41	g8	
26/5 @ 03:16	g9	close to wp4
26/5 @ 06:22	g10	close to wp5
26/5 @ 12:42	g11	
26/5 @ 19:03	g12	close to wp6
27/5 @ 01:22	g13	beginning of bad sea state
27/5 @ 07:51	g14	

Day and time (local time)	where	note
27/5 @ 13:44	g15	
27/5 @ 15:12	g16	close to wp8
27/5 @ 21:29	g17	wind > 50 kn
28/5 @ 02:56	g18	close to wp9
28/5 @ 09:14	g19	
28/5 @ 15:39	g20	
28/5 @ 21:50	g21	close to wp10
29/5 @ 01:12	g22	
29/5 @ 07:32	g23	
29/5 @ 13:57	g24	
29/5 @ 20:19	g25	
30/5 @ 02:44	g26	
30/5 @ 06:14	g27	close to wp12
30/5 @ 09:20	g28	close to wp13
30/5 @ 15:49	end	end of mission

Tab. 1 Glider communications.

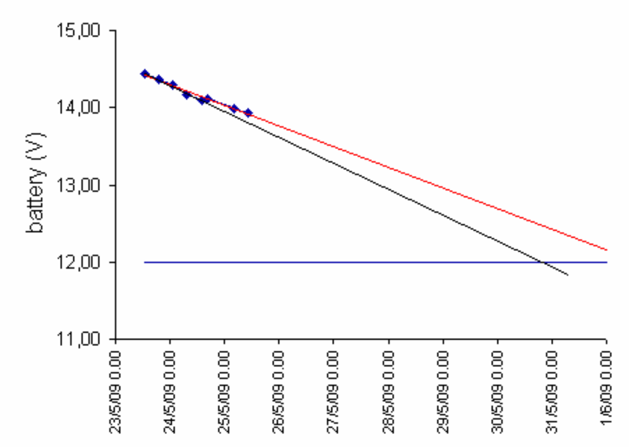


Fig. 9 Monitoring of the battery voltage. Estimate computed from the initial consumption (black line) and estimate after 3 days (red line). The blue line of 12 V indicate the abort mission limit.

At each surfacing the glider was programmed to send the SBD files to the ogadock. These files were correctly sent starting from g7 (see Fig. 8 for the location) after the reboot of the server at OGS on the 25th of May. A total of 23 full SBD files were sent by the glider to the ogadock through Iridium. They were immediately downloaded onboard the R/V Urania so as to check the values, produce (by ODV, see example on Fig. 10) the transect plots and have a first comparison with the CTD data collected by the ship.

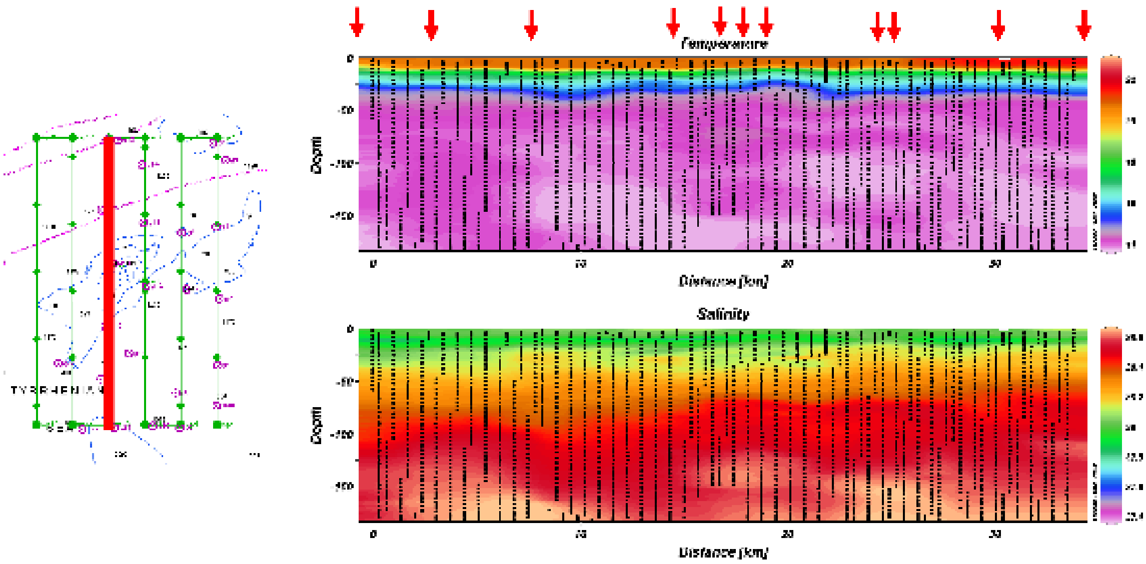


Fig. 10 First data plots of the SBD files sent by the glider to the ogadock: transect location (on the left) and temperature and salinity contour plots (on the right). The red arrows on the upper part of the temperature plot indicate the CTD stations performed by the ship. Black dots indicate the actual data points. Temperature is in °C.

5.4 Recovery

The glider mission was stopped by sending a “Ctrl C” command through Iridium on Saturday 30/05/2009 at 15:49 (local time), south of wp13 (see Fig. 8) about 18 hours ahead of the scheduled recovery because of the worsening sea conditions. After the “Ctrl C” command, the contact with the glider was maintained and its position was repeatedly updated by using the “callback” command and by allowing the glider to perform the “lastgasp.mi” mission (for the details see Medeot and Gerin, 2007). At 17:50 (local time) the glider was recovered at 41°11.468'N, 10°45.830'E (see Fig. 11 and Tab. 2).

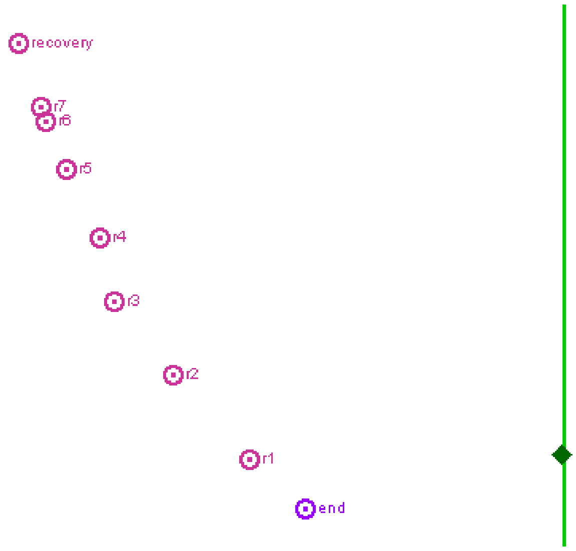


Fig. 11 Close up of the final phase of the Tyrrmount09 glider mission: planned track (green line); planned surfacing (green diamond); mission interruption (end); positions at surface (r1-r7) and recovery.

Day and time (local time)	where	lat and lon
30/5 @ 15:49	end	41°10.714'N – 10°46.448'E
30/5 @ 15:58	r1	41°10.794'N – 10°46.328'E
30/5 @ 16:16	r2	41°10.931'N – 10°46.164'E
30/5 @ 16:34	r3	41°11.048'N – 10°46.036'E
30/5 @ 17:05	r4	41°11.153'N – 10°46.004'E
30/5 @ 17:20	r5	41°11.263'N – 10°45.933'E
30/5 @ 17:29	r6	41°11.340'N – 10°45.887'E
30/5 @ 17:33	r7	41°11.363'N – 10°45.878'E
30/5 @ 17:50	recovery	41°11.468'N - 10°45.830'E

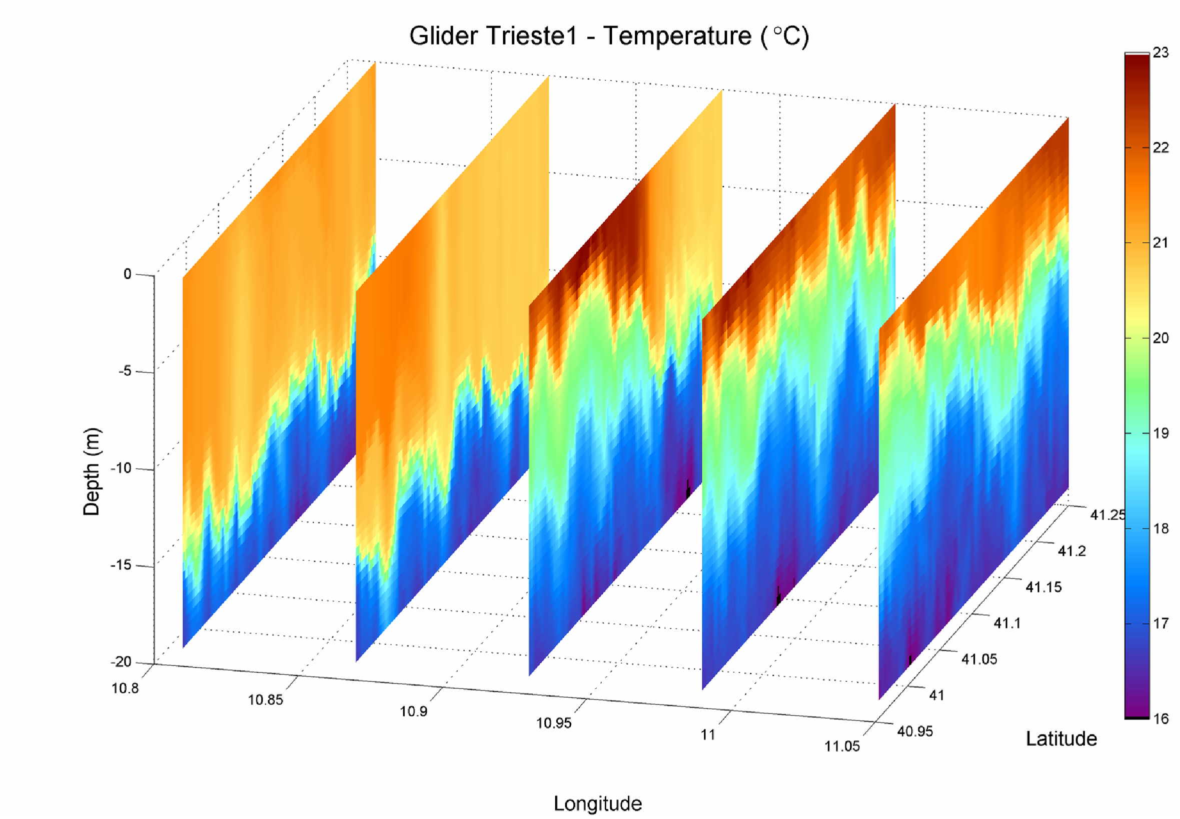
Tab. 2 Glider positions during the recovery procedure.

6. Preliminary results

A shallow (5-10 m deep) mixed-layer with maximum temperature of 23 °C was present until the 27th of May, when the temperature at the surface abruptly decreased to 21°C and the mixed layer deepened to over 15 m (Figs. 12 and 14). Satellite sea surface temperature images (Fig. 17) reveal that this change corresponds to the expansion/intrusion of a relatively cold near-surface plume originating from the Strait of Bonifacio (between Corsica and Sardinia). Due to the wind there is an increase of the double gyre structure. In particular, the southern anticyclonic gyre strengthen on the 27th of May advecting cold water which reaches the study area.

The salinity (Figs. 12 and 14) which was essentially minimal (around 37.7) near the surface before the 27th of May, increases to 38.0-38.1 in the surface mixed layer, while a layer with minimum salinity develops near the base of the mixed layer (10-20 m). Contemporarily the dissolved oxygen maximum deepens from the surface to the base of the mixed layer (10-20 m) (Figs. 13 and 15).

In addition to the above evolution of the water mass properties, high frequency (with periods of 0.5 day or less) variations are ubiquitous and are mostly apparent near the base of the mixed layer. They correspond to mesoscale and sub-mesoscale structures crossed by the glider and to tidal/internal waves ((Figs. 12 and 15). Below the mixed layer, the salinity and oxygen distributions show correlated structures (high salinity corresponding to low oxygen) all the way down to 180 m. A sub-surface maximum in chlorophyll concentration and turbidity is also seen between 60 and 80 m (Fig. 16). We can conclude that apparently the Vercelli Seamount has little effect on the water mass properties measured by the glider.



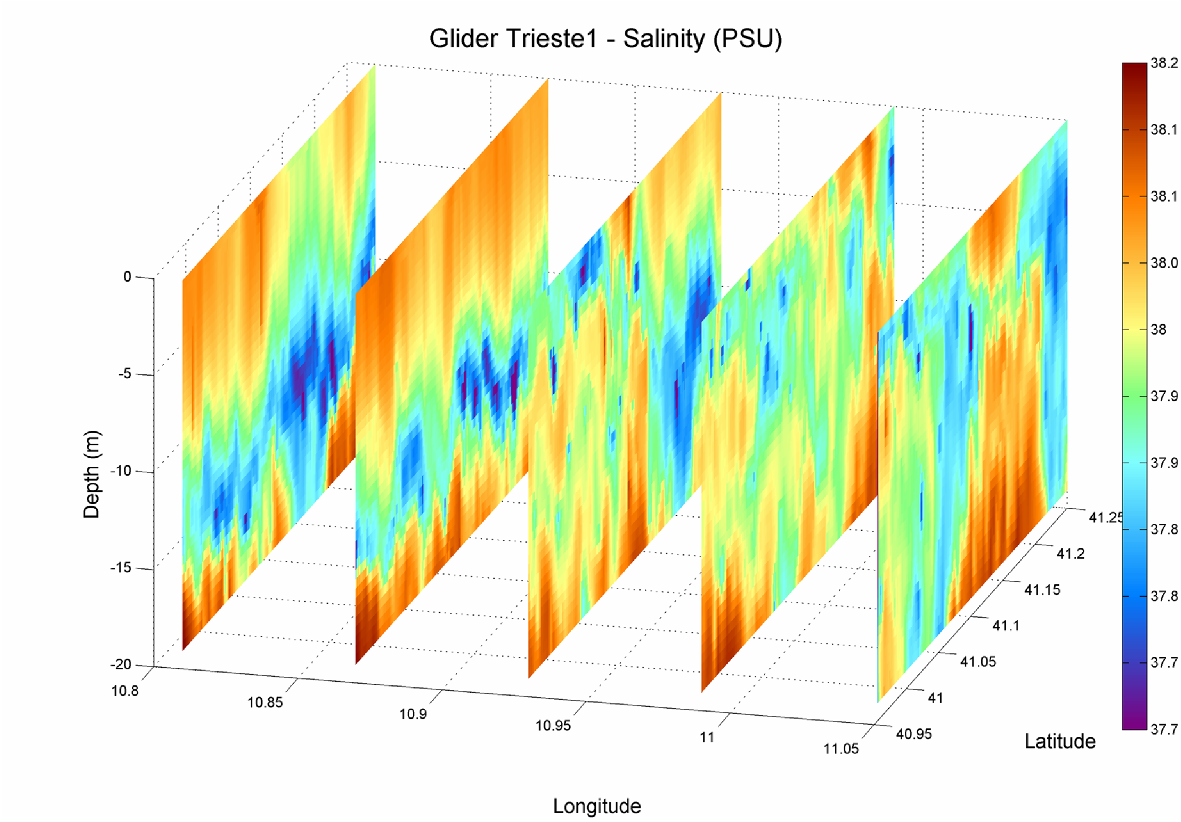
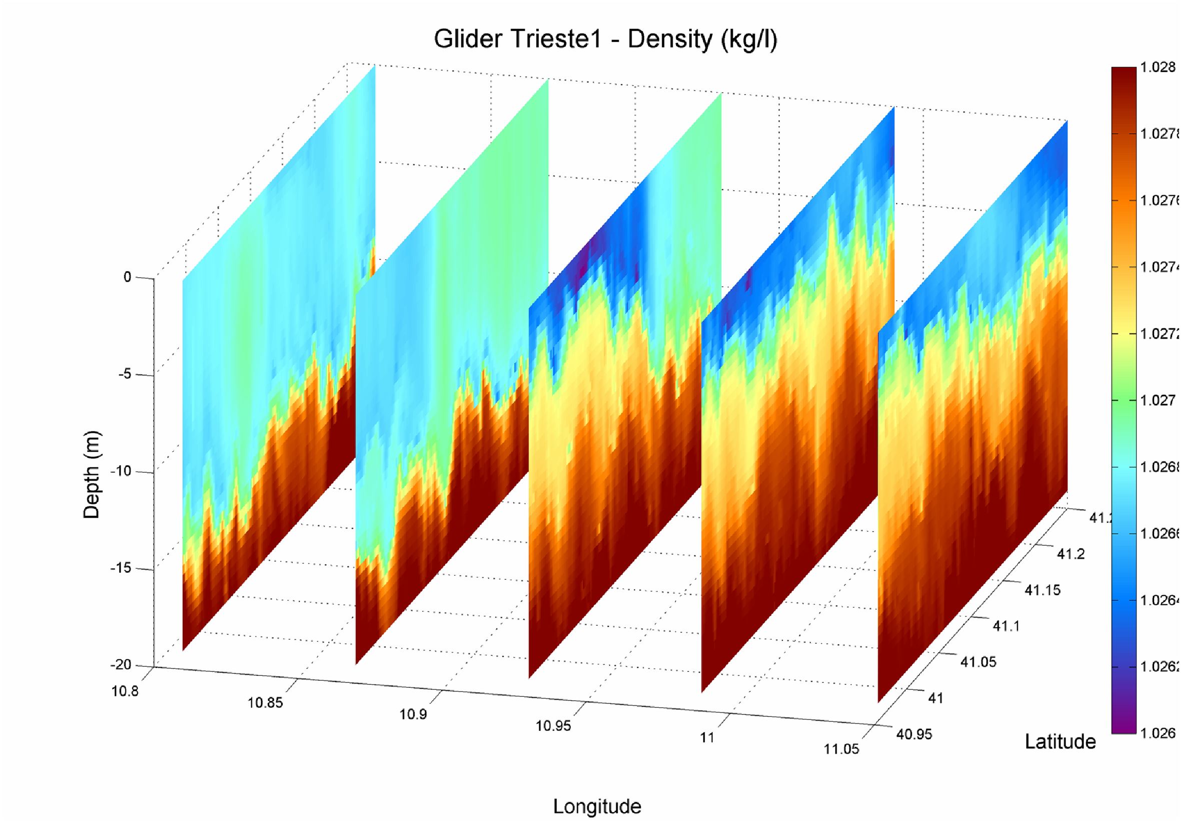


Fig. 12 Color-coded contours of temperature (°C) and salinity along the drifter track between 4 and 20 m.



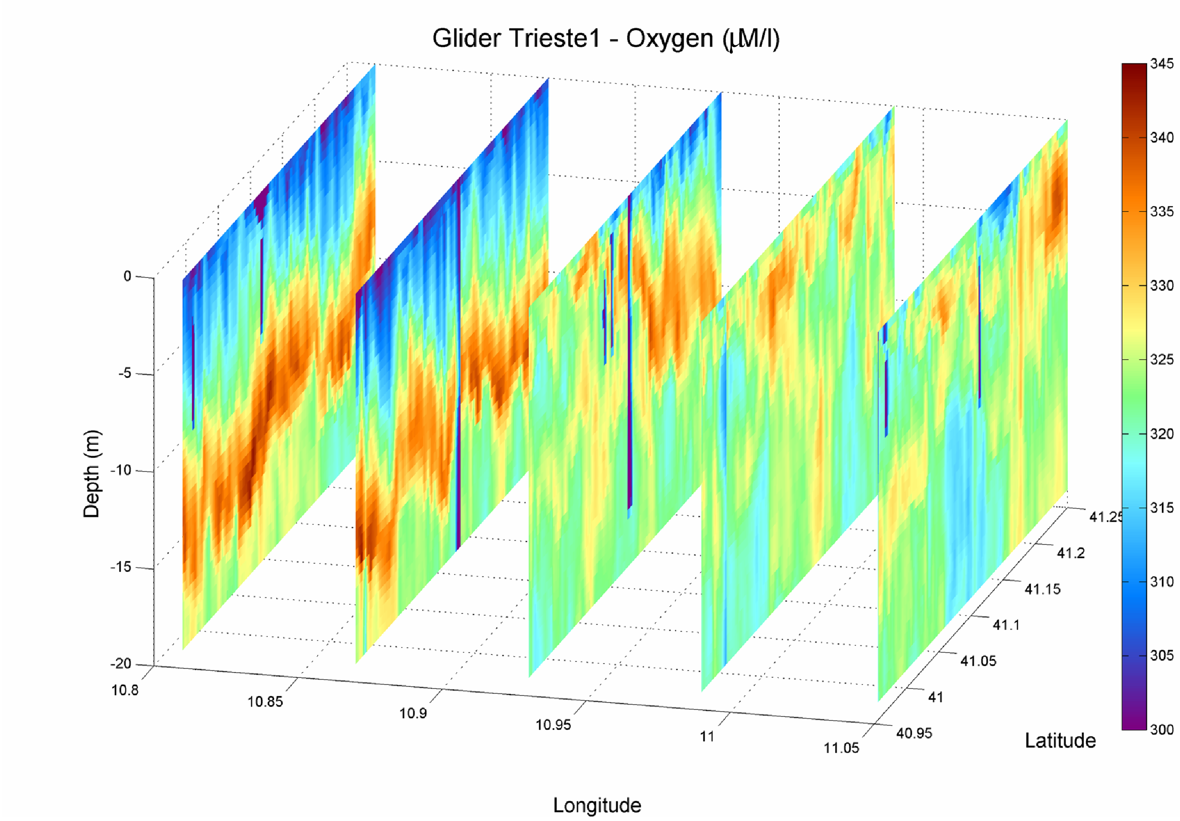
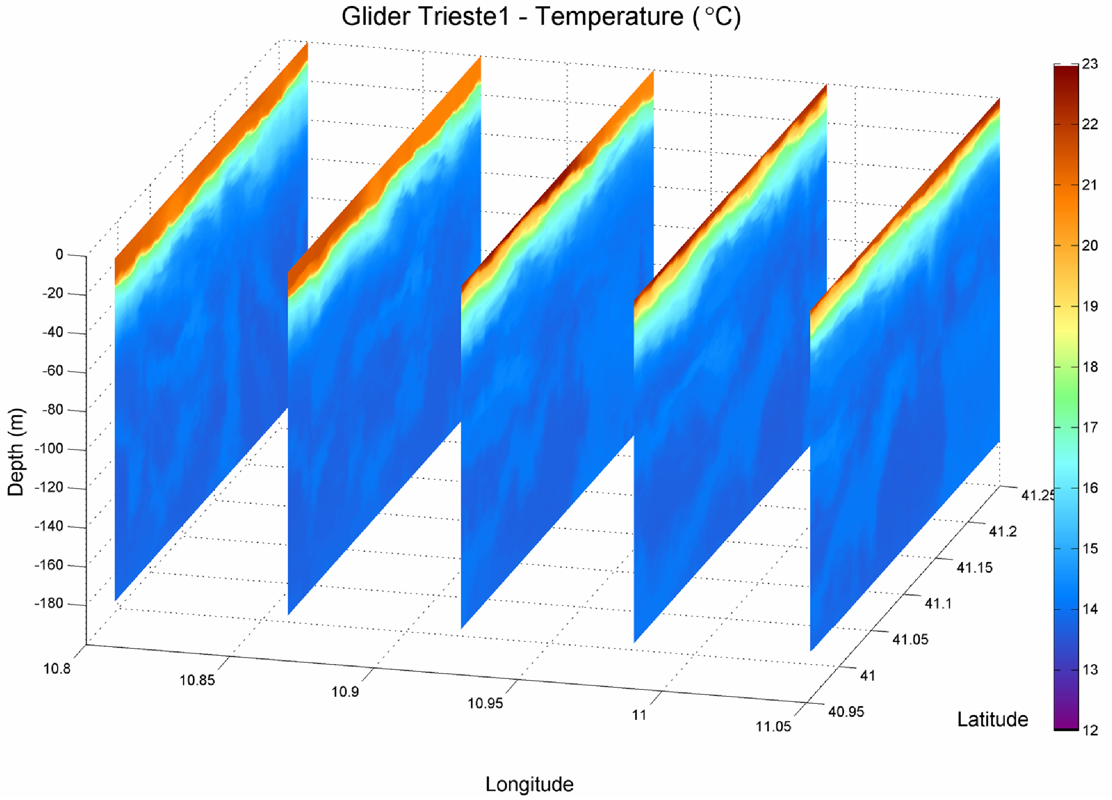


Fig. 13 Color-coded contours of density and oxygen (μM/l) along the drifter track between 4 and 20 m.



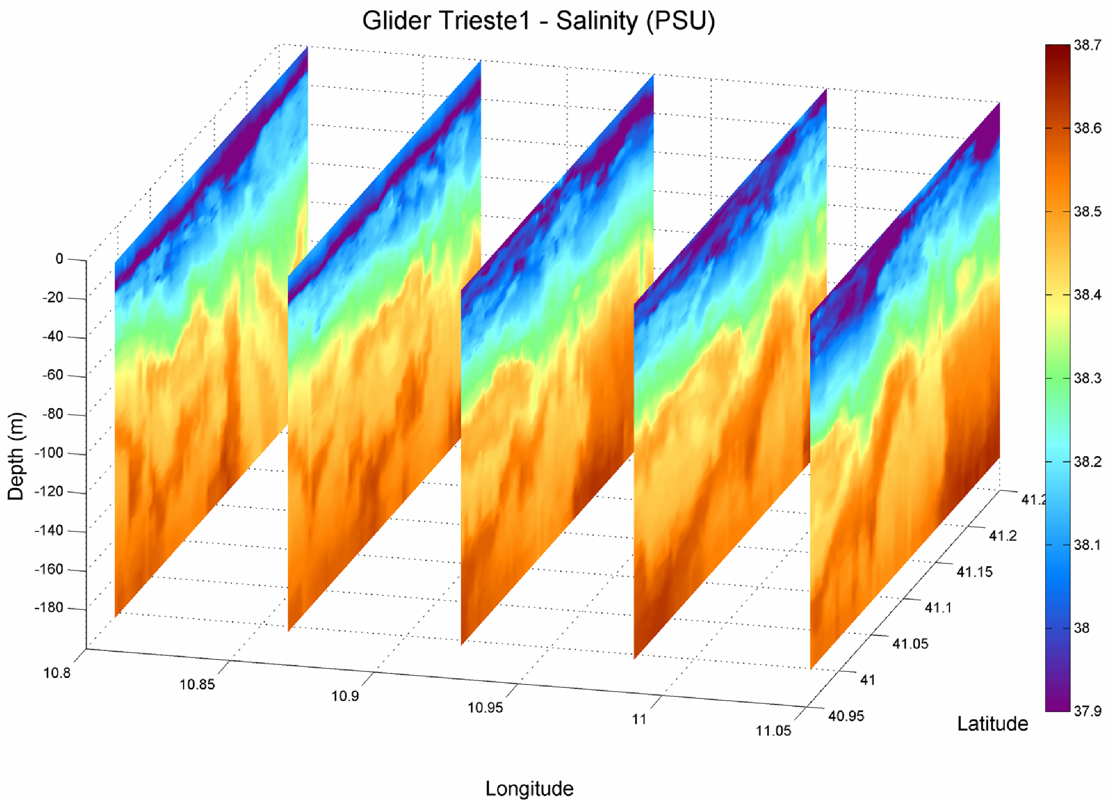


Fig. 14 Color-coded contours of temperature (°C) and salinity along the drifter track between 4 and 180 m.

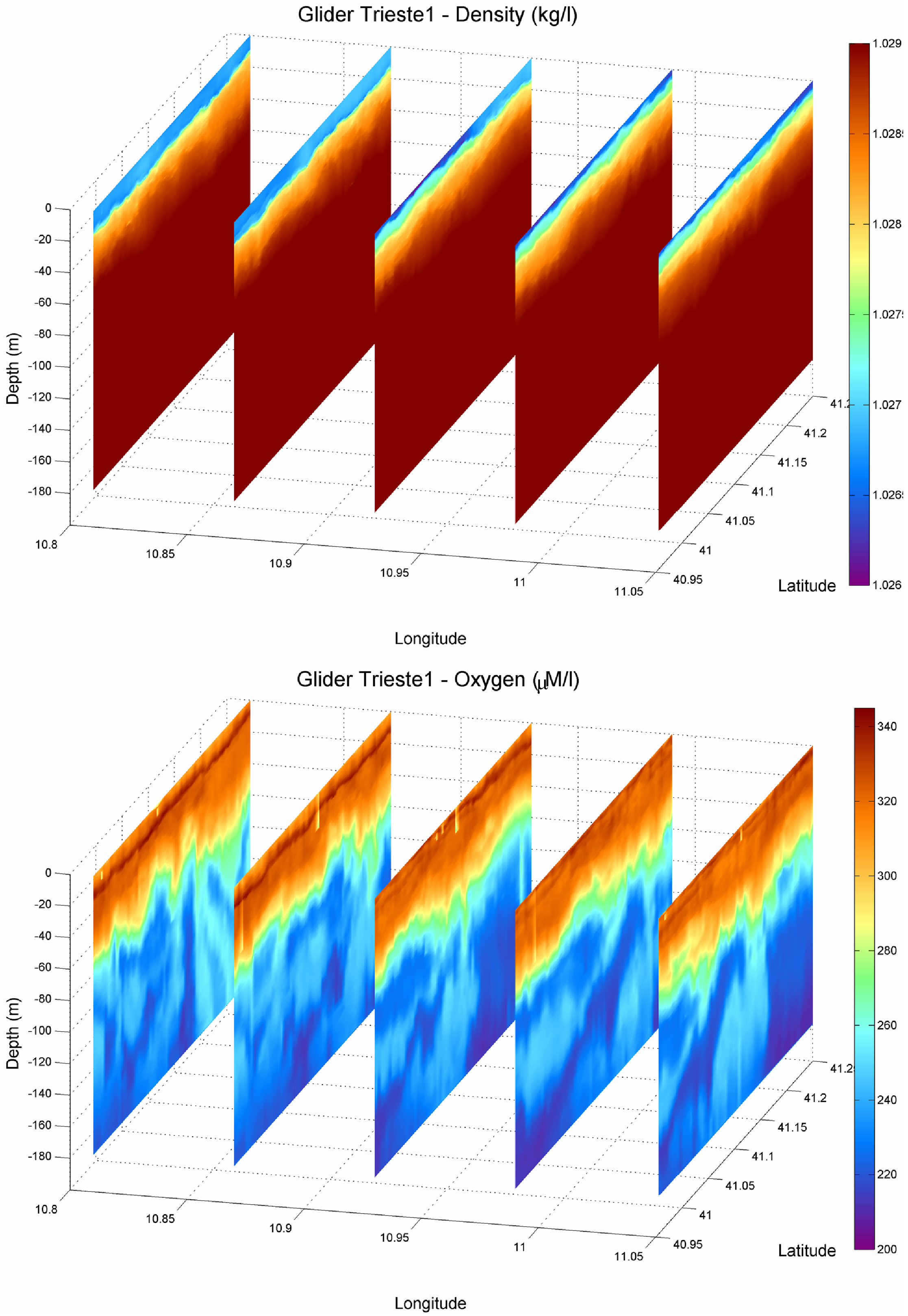


Fig. 15 Color-coded contours of density and oxygen (μM/l) along the drifter track between 4 and 180 m.

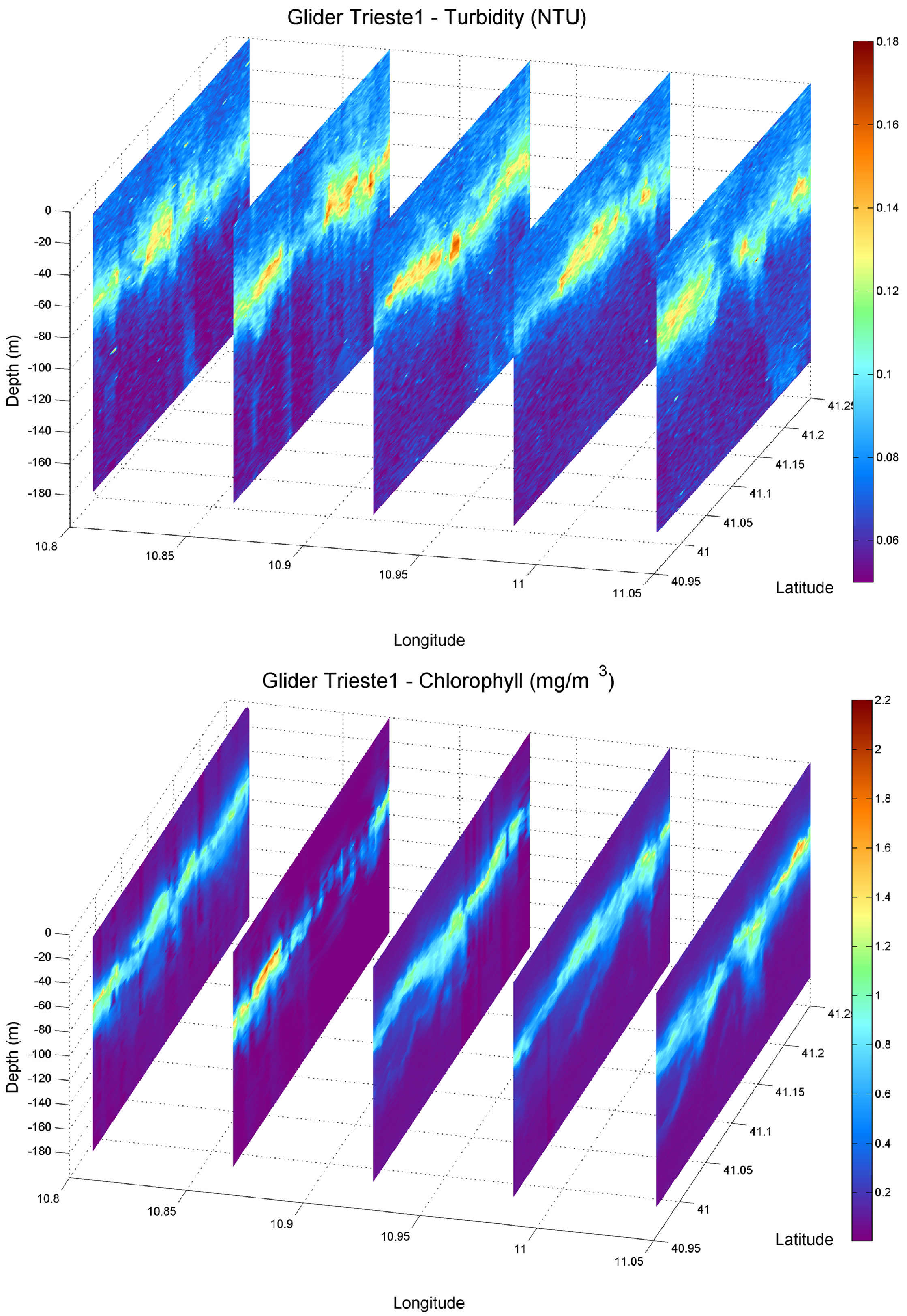


Fig. 16 Color-coded contours of Turbidity (NTU) and Chlorophyll (mg/m^3) along the drifter track between 4 and 180 m.

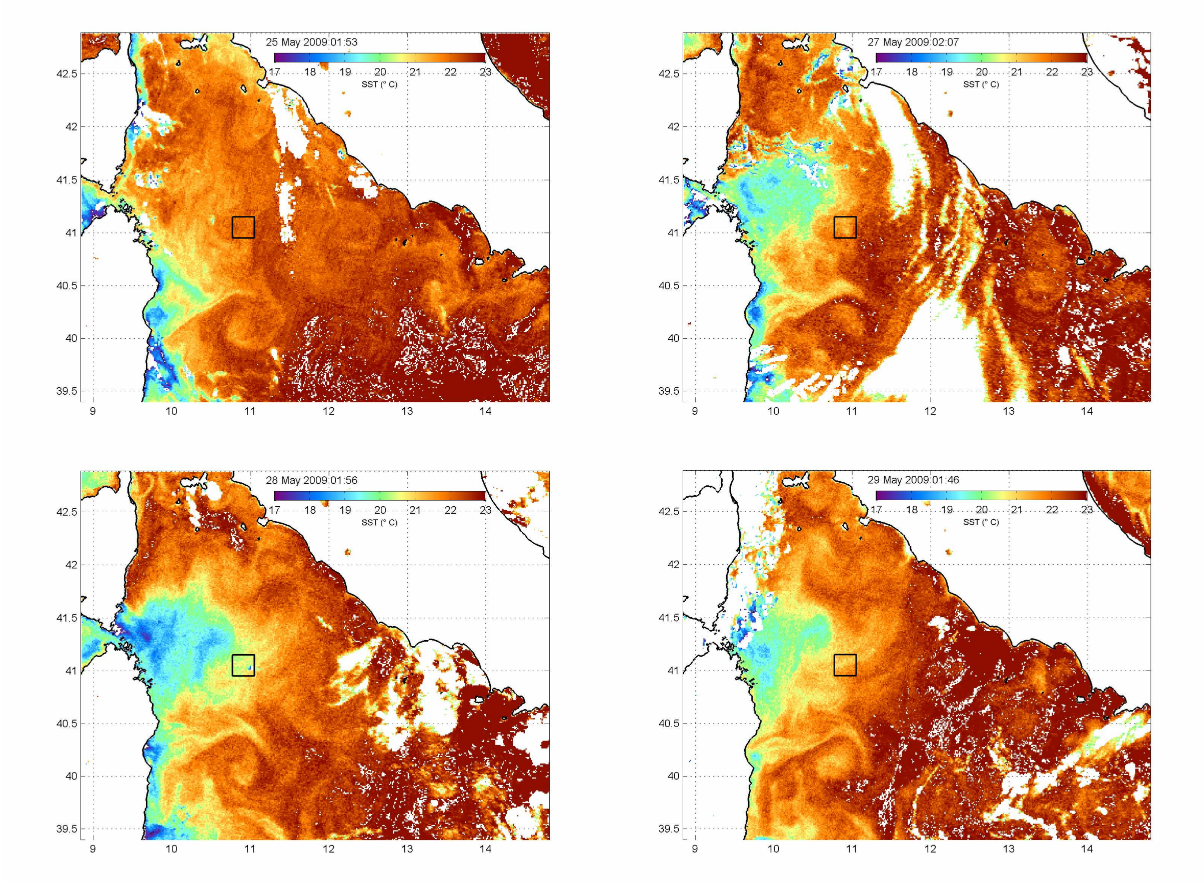


Fig. 17 Color-coded SST (Sea Surface Temperature) images from 26 to 29 May 2009. The square indicates the area surveyed by the glider.

7. Acknowledgements

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8. References

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