Glider Experiment in the Ligurian Sea as part of MREA08 (La Spezia, 30 September – 23 October 2008)

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Summary

1. Introduction

The MREA08 experiment took place in the Ligurian Sea in the period spanning from the 30th of September to the 23rd of October 2008. It involved several institutes which cooperated and conducted related experiments with the aim of collecting oceanographic data to calibrate and validate the MREA (Marine Rapid Environmental Assessment) model system and to study the mesoscale processes in the Ligurian Sea and demonstrate their importance on surface contaminant dispersal. In particular, thanks to the collaboration with the Italian Navy, it was possible to carry out three oceanographic cruises of about 4 days. During these campaigns, CTD casts were performed, XBTs were launched and 12 drifters (CNR, INGV and OGS) were deployed nearby the ODAS oceanographic buoy. At the same time, the University of Bologna and the INGV ran the MREA model system. The OGS glider was operated during the first and the third cruises but, due to several technical problems, it collected data only for about one day.

This report describes the glider operation conducted as part of MREA08. The glider preparation, tests and missions are depicted. Additionally, the technical problems that occurred during the missions are illustrated together with the explanation of how the OGS Glider Team managed to solve them. Finally, the preliminary results of the glider sampling are presented.

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 a prescribed routes. It is equipped with several oceanographic sensors for the measure of temperature, salinity, oxygen, turbidity and chlorophyll (see specification in Gerin et al., 2007 and in Operations Manual v1.6, 2005).

3. Oceanographic cruises

Initially, the oceanographic campaigns of the R/V Ammiralio Magnaghi were organized in 3 legs of about 5 days each (see MREA08 cruise plan v6.0, 2008):

1. from the 30th of September to the 4th of October;
2. from the 13rd to the 17th of October;
3. from the 20th to the 24th of October.

Unfortunately, during the first cruise some technical problems occurred to the ship engines and consequently the first leg was shortened to 2 days (30 Sep-1 Oct). The second leg was shifted by one week and the scientific operations were concluded successfully in 3 days (9-11 Oct). The last leg was shortened to 4 days due to bad weather conditions (20-23 Oct).

4. Glider mission planning

The glider missions were planned in collaboration with Alberto Alvarez optimizing a 5-day zig-zag trajectory (Fig. 1) so as to cover a specific area of interest and to cross the temperature fronts as perpendicularly as possible (optimizing the sampling on a regular grid of 10 km using the covariance obtained by 10 years of averaged SST). The glider should have operated continuously from the beginning of the first leg to the end of the campaigns with two interruptions for the downloading of the data. In particular, on Tuesday 30 September, the glider should have been deployed nearby the CTD1 point (43°52.584'N - 9°42'E) and, on Friday 3 October, should have been recovered the first time after 4 days, nearby the WPT5 point (43°50.095'N – 8°44.316'E) and, during the same day, it should have been redeployed again in the CTD1 point (transfer by ship). The second glider mission should have been recovered after 10 days, on Monday 13 October, close to the CTD1 point after a back and forth pattern and should have been redeployed in the same position (after downloading the data) duplicating the previous path. The glider experiment should have terminated on Friday 24 October.

Unfortunately, due to several technical problems, the glider operated only during the first and the third legs and it collected data only for about one day during the third leg.

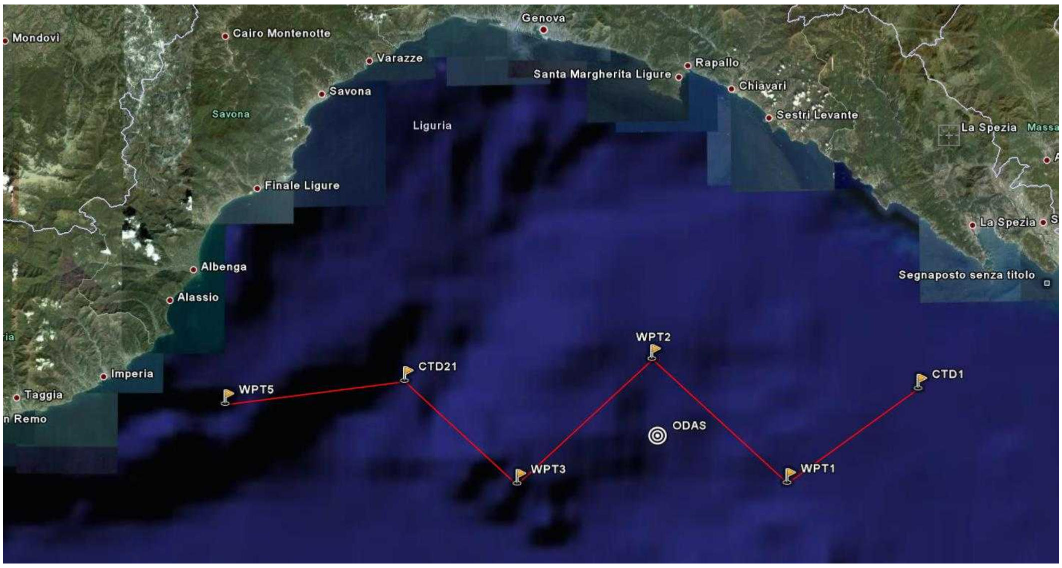

Fig. 1: The zig-zag path of the glider as optimized by OGS and Alberto Alvarez.

5. Glider preparation

5.1. Battery substitution and weights redistribution

The glider preparation began in July 2008. Due to the intense glider use planned for the MREA08 missions, we decided to replace the battery (the autonomy guaranteed by the old battery was about 10-15 days). We took the advantage of this change, and the consequent redistribution of weights (see Fig. 2 and Table 1 for the details), to fix the hook (provided by the manufatcurer Webb) on top of the mid hull section of the glider. The hook (Fig. 3) is very useful when the glider is handled or in case of recovery.

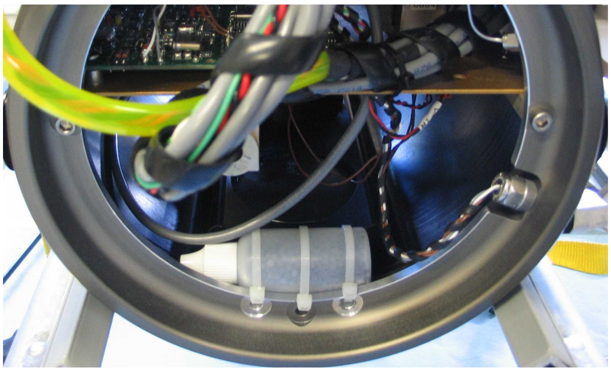

Fig. 2: Redistribution of the internal weights of the glider: bottle filled by plumb bobs (left) and load rail (right).

Fig. 3: The hook mounted on top of the mid hull section of the glider.

difference of battery weight (old - new)	-13 g
hook weight (in air)	118 g
mid hull bottle weight	200 g
difference of weight on the load rail (before - after)	-142 g
difference of weight in the rear hull	-100 g

Table 1: Weight distribution.

After these operations, the conductivity and temperature sensors of the Trieste-1 glider were intensively monitored in the CTO laboratory at OGS with the purpose of activating a procedure for checking the accuracy and to evaluate the drifter of these sensors (see Medeot et al., 2008).

5.2. Ballasting and testing in the Gulf of Trieste

The glider was ballasted for the water of the Gulf of Trieste (36.7 psu and 23 °C) and the H-moment was calculated in mid August. After the weight redistribution, the weight fitted inside the nose dome, necessary for a precise neutral buoyancy, was about 15 g instead of the previous 89 g. The H-moment calculation revealed an evident improvement (from 4.8 mm measured in June 2007 to 5.5 mm).

On the 9th of September 2008, the glider was tested in the Gulf of Trieste. In particular, some of the standard tests, recommended by Webb, were executed (see Table 2 for the details).

mission name	beginning time (GMT)	beginning latitude (N)	beginning longitude (E)
status.mi (air)	8:28	45°42.446' N	13°42.829' E
status.mi (water)	10:03	45°42.446' N	13°41.520' E
overtime.mi	10:12	45°42.300' N	13°41.896' E
ovrdepth.mi	10:20	45°42.332' N	13°41.957' E

Table 2: Details of the tests carried out in the Gulf of Trieste.

All the tests and the mission were completed successfully with no errors. After the operations, the range of the “Freewave” radiolink was checked up to 1.5 nm.

5.3. Ballasting for the Ligurian Sea

On September 2008, the glider was ballasted for the Ligurian Sea considering a mean water salinity of 38 psu and a mean water temperature of 21°C (the data were taken from the INGV forecasting model and from CTD data provided by the Italian Navy). To obtain the correct ballasting, we added other 35 g inside the nose dome (for a total of 50 g).

6. Glider missions in the Ligurian Sea

6.1. First leg

Starting from the 30th of September, we participated in the first leg of the R/V Ammiraglio Magnaghi cruise. As planned, the glider was deployed nearby the CTD1 point (at about 12:00 GMT). Unfortunately, during the testing operations, the security rope (see Medeot e Gerin, 2007) slid into the space between the fixed and the mobile part of the rudder cutting two of its rubber hinges (Fig. 4). Considering the total duration of the other two glider missions, we decided to come back to OGS and to repair the rudder there.

Fig. 4: The damage occurred on the rudder during the first leg.

6.2. Rudder and air bladder repair

The rudder was repaired by attaching a plastic hinge (of model aircrafts) using polyester resin. During the laboratory tests, we discovered that the air bladder did not inflate. Upon opening the glider, few drops of salty waters were found inside the tygon tube joining the air pump system to the bladder (Fig. 5). Additionally, dry salty water was found directly below the electrovalve which drives the inflation of the air bladder. After a careful inspection, we discovered that the electrovalve was blocked in the "always open" position. The electrovalve was replaced by another one taken from an Apex float.

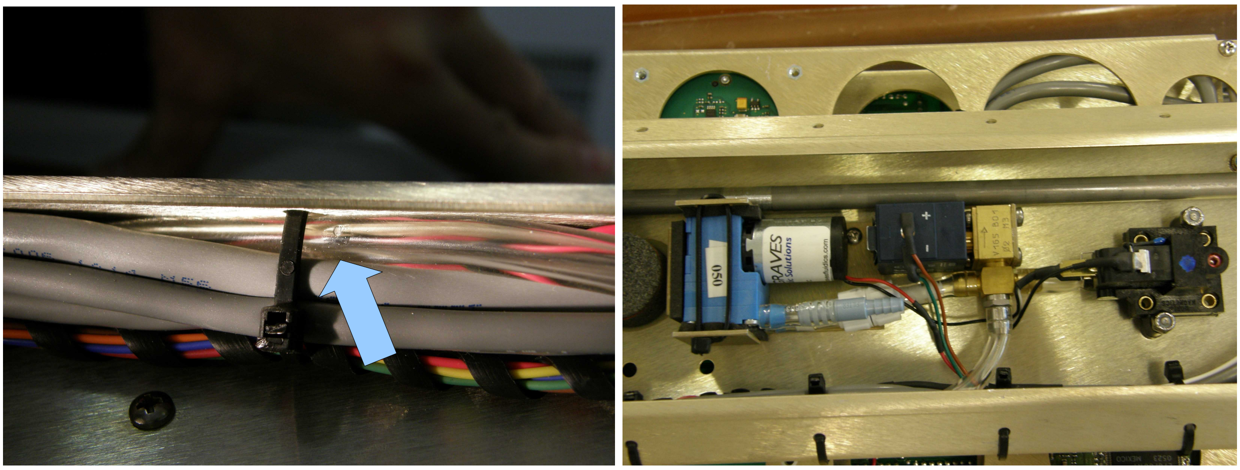

Fig. 5: The tygon tube joining the air pump system to the air bladder with salty water inside (left) and the air pump system (right).

After other tests on the electrovalve and on the air bladder, we realized that there was a leak at the air bladder seam (Fig. 6).

Fig. 6: The leak in the air bladder.

The Webb company was contacted immediately and they rapidly provided us with all the needed spare parts. The air bladder and the entire air pump system were replaced with the new elements and the vacuum inside the glider was monitored for one day to make sure that there was no leakage.

6.3. Third leg

On the 20th of October we embarked again on the R/V Ammiraglio Magnaghi for the 3rd leg. The planned point of deployment was forbidden because of Italian Navy submarine activity, hence we decided to move the initial point of the glider path southward, deploying the glider in free waters (43°44.020'N - 9°41.890'E). Additionally, due to the limited ship time, we shortened the glider path (compare Fig. 1 and Fig. 7)

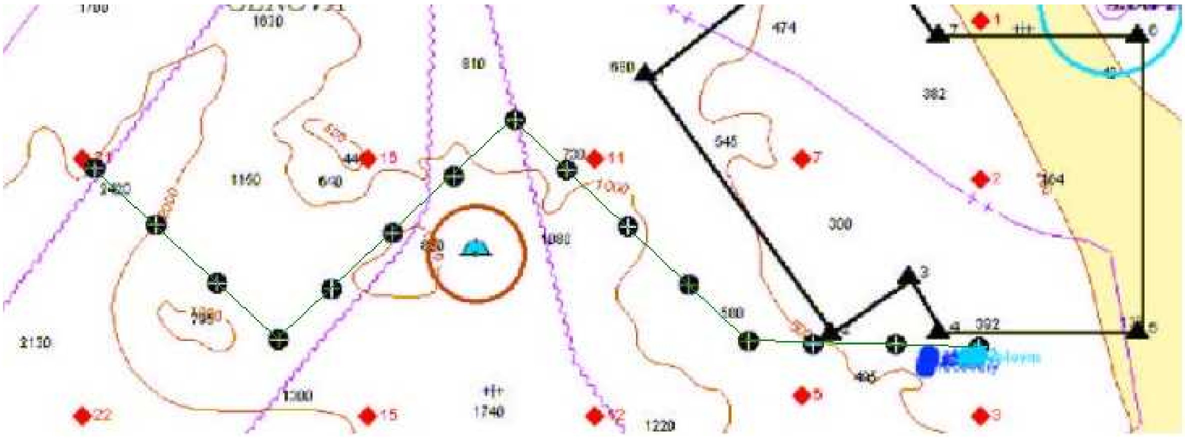

Fig. 7: The path of the glider as planned during the 3rd leg. Planned zig-zag path (green line); surfacing points (every 6 hours; black dots with white plus); forbidden area (black line bounded by the black triangle); CTD stations (numbered red rhombus); real glider course (regularly at surface: light blue dots; during abort: dark blue dots).

The glider was deployed nearby the new planned point of deployment. The standard tests were executed and the mission was launched at about 11:30 (see Table 3).

After about 6 hours, the glider aborted the mission because of leakage (17:17 – 43°43.6735' N – 9°38.4027' E). The R/V Ammiraglio Magnaghi stopped the CTD activity and headed toward the glider. The recovery occurred during the night with calm sea and the operations were completed at 19:56 - 43°43.076' N – 9°38.035' E.

mission name	beginning time (GMT)	beginning latitude (N)	beginning longitude (E)
status.mi (air)	10:17	43°43.913' N	9°41.2953' E
status.mi (water)	10:35	43°43.909' N	9°41.2818' E
ovrdepth.mi	10:40	43°43.8905' N	9°41.2473' E
overtime.mi	10:46	43°43.8435' N	9°41.221' E
ini1.mi	10:50	43°43.8124' N	9°41.1968' E
status.mi (water)	11:16	43°43.614' N	9°41.0316' E
tstest08.mi	11:27	43°43.5484' N	9°40.8883' E

Table 3: Details of the glider tests and mission carried out during the 3rd leg.

6.4. Leakage repair and final mission

The glider was immediately opened to avoid any damage due to salty water. Only a few drops of water were found over the leak detector in the rear section of the glider (Fig. 8). After an accurate inspection, we realized that the leakage was due to a corrosion damage of the swagelok connector (Fig. 9). The problem was fixed onboard using a self-fusing 3M scotch (Fig. 10).

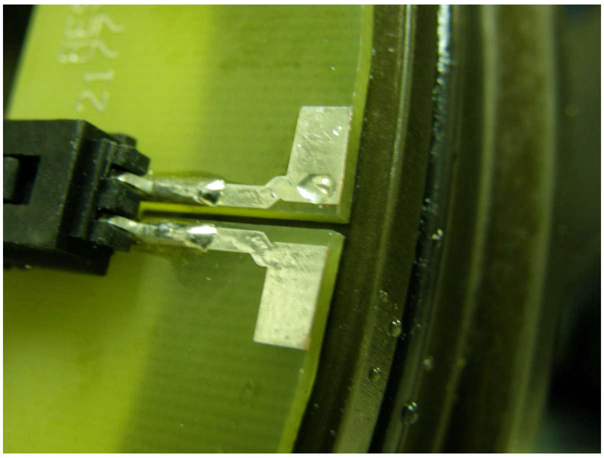

Fig. 8: The leak detector with few drops of water over.

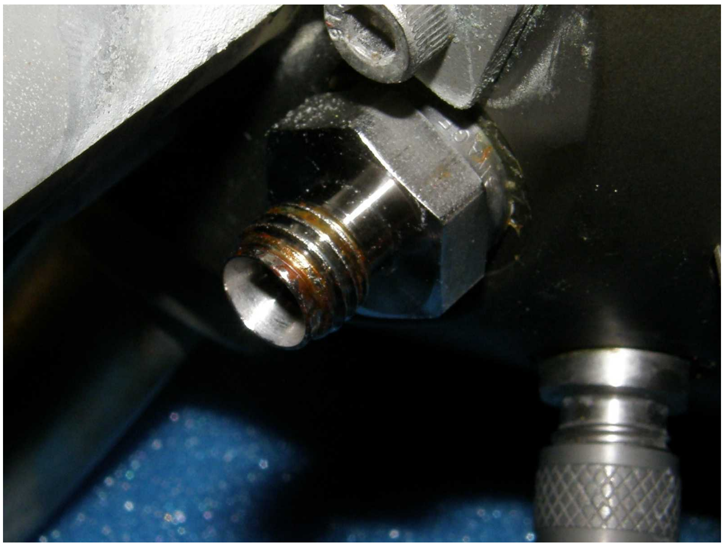

Fig. 9: The swagelog connector corroded.

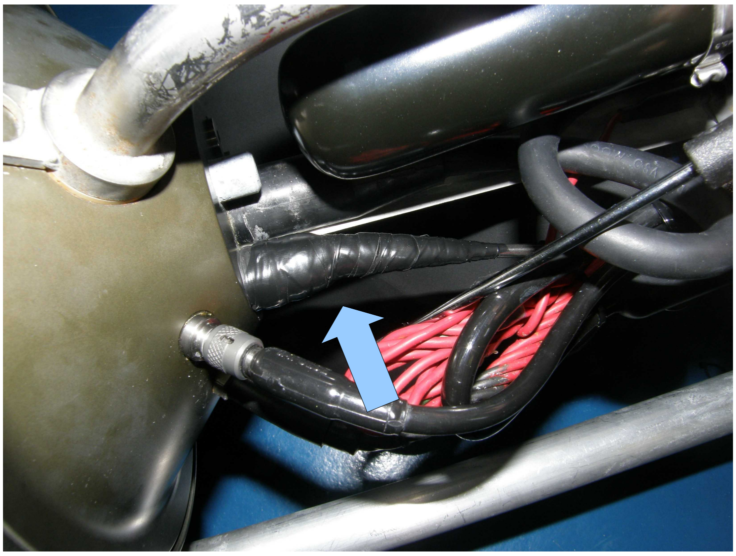

Fig. 10: The swagelog connector wrapped with the self-fusing 3M scotch.

The glider mission was reprogrammed taking into account the ship course and the meteorological conditions (less than one day of good weather). On the 21st of October, the glider mission was launched (after the status.mi and ovrdepth.mi tests) nearby the CTD20 point (44°06.724' N – 8°38.5742' E) at about 13:00. The glider operated correctly (Fig. 11) surfacing every 3 hours instead of the usual 6 hours (for security reasons) and was recovered after about 19 hours (8:38 - 44°11.694' N - 8°49.147' E).

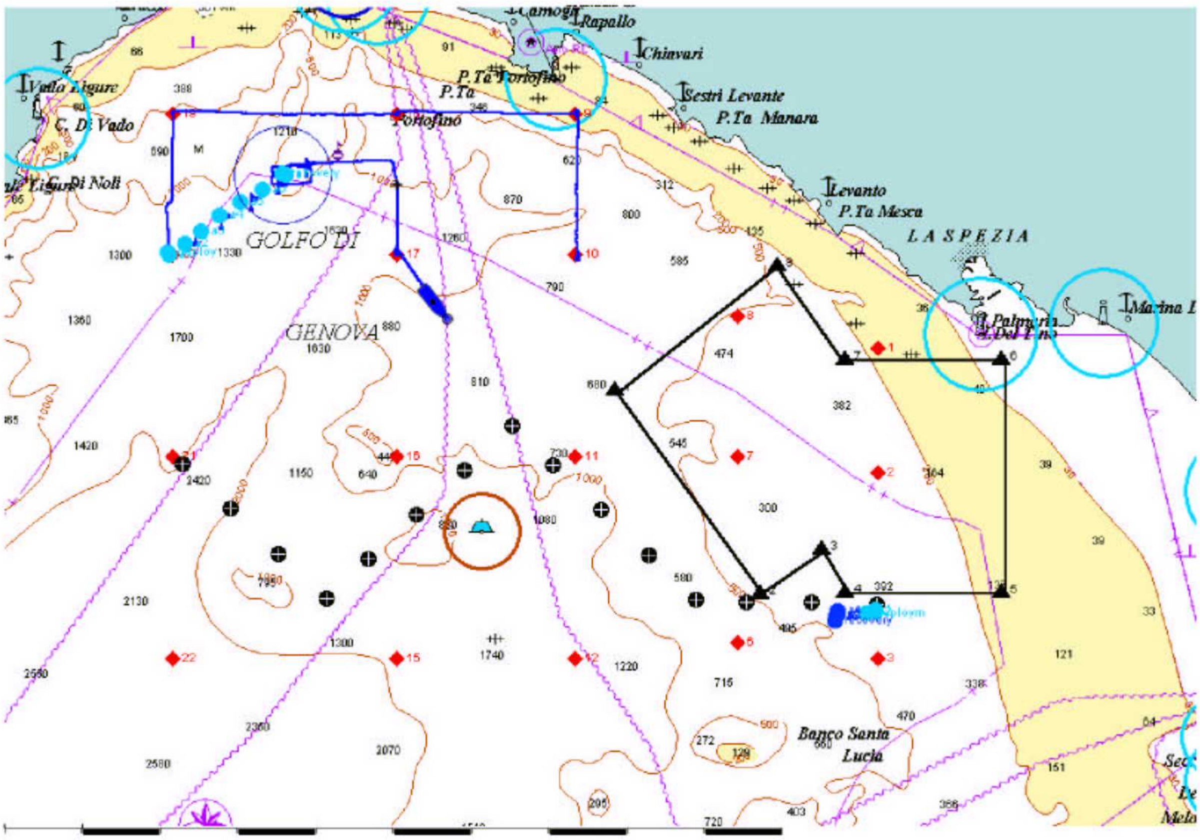

Fig. 11: Overview of the 3rd leg missions. The surfacing locations of the mission (21st of October) are represented by the light blue dots (near upper left corner).

7. Results

During the last mission, the glider covered 9 nm and performed 31 complete yos down to 180 m. The following figures (from Fig. 12 to Fig. 18) report the profiles as recorded by the glider (one dots every two, color coded by parameter). The thermocline is recognizable at 40 m and it became deeper (down to 50 m) close to the coast (right hand side of the plots). The salinity graph (Fig. 13) display a core of fresh water in correspondence to the thermocline. The oxygen and the saturated oxygen plots (Figs.15 and 16) show a maximum in correlation to the thermocline, while the chlorophyll maximum (Fig. 17) is below the thermocline. Finally the turbidity plot (Fig. 18) is very scattered.

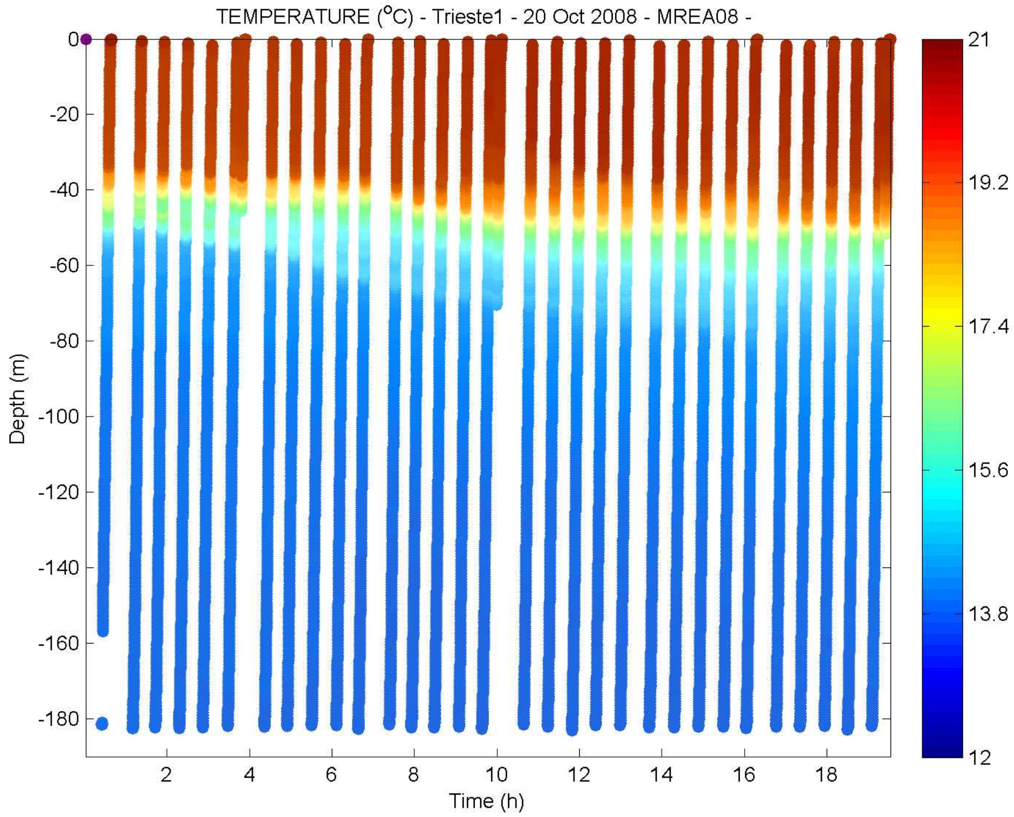

Fig. 12: Temperature profiles. The thermocline is at about 40 meters and become deeper close to the coast.

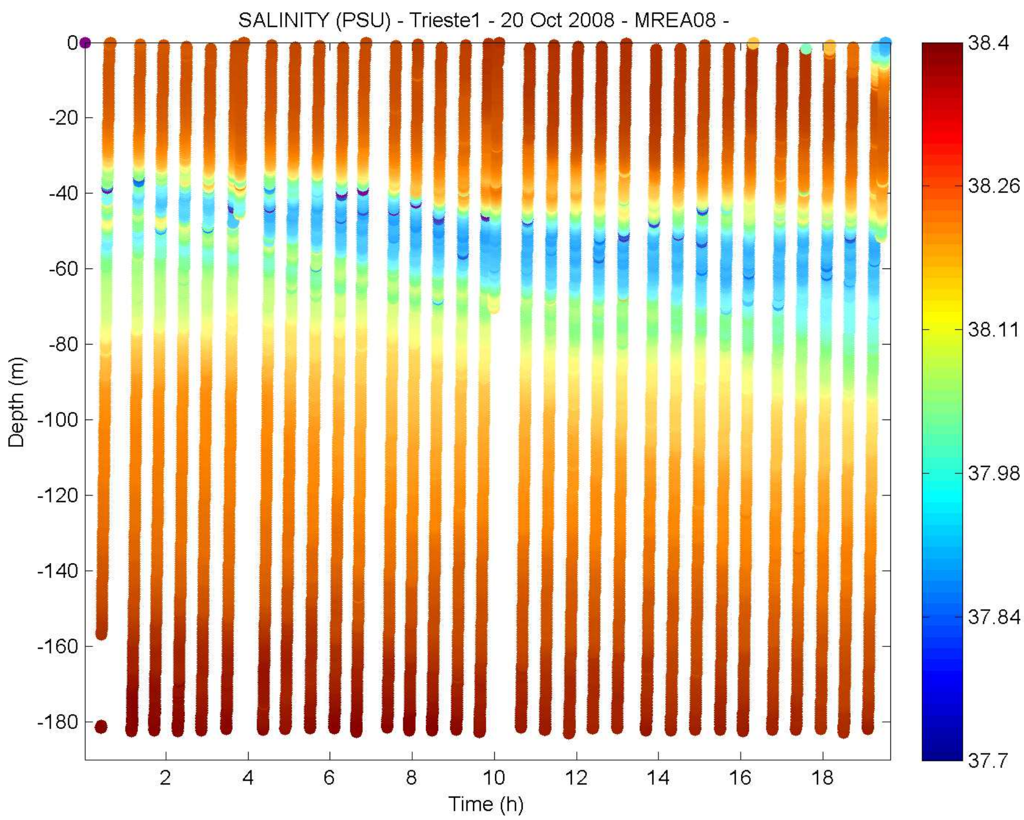

Fig. 13: Salinity profiles. A core of fresh water is visible in correspondence to the thermocline.

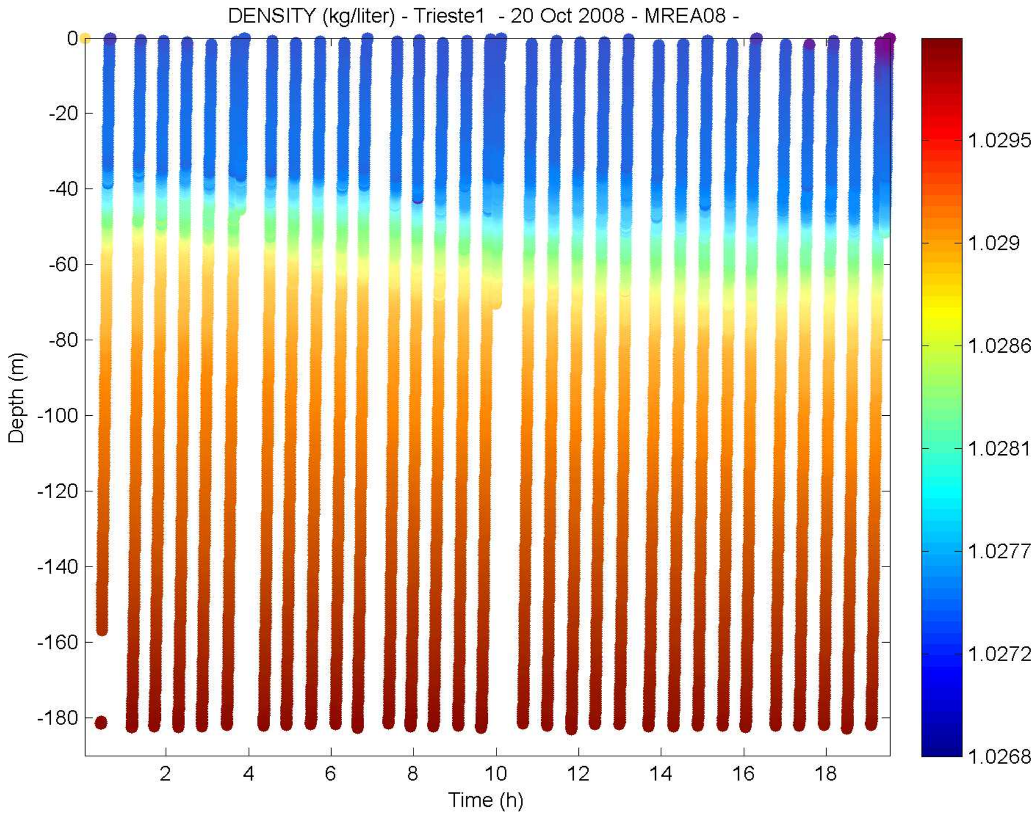

Fig. 14: Density profile.

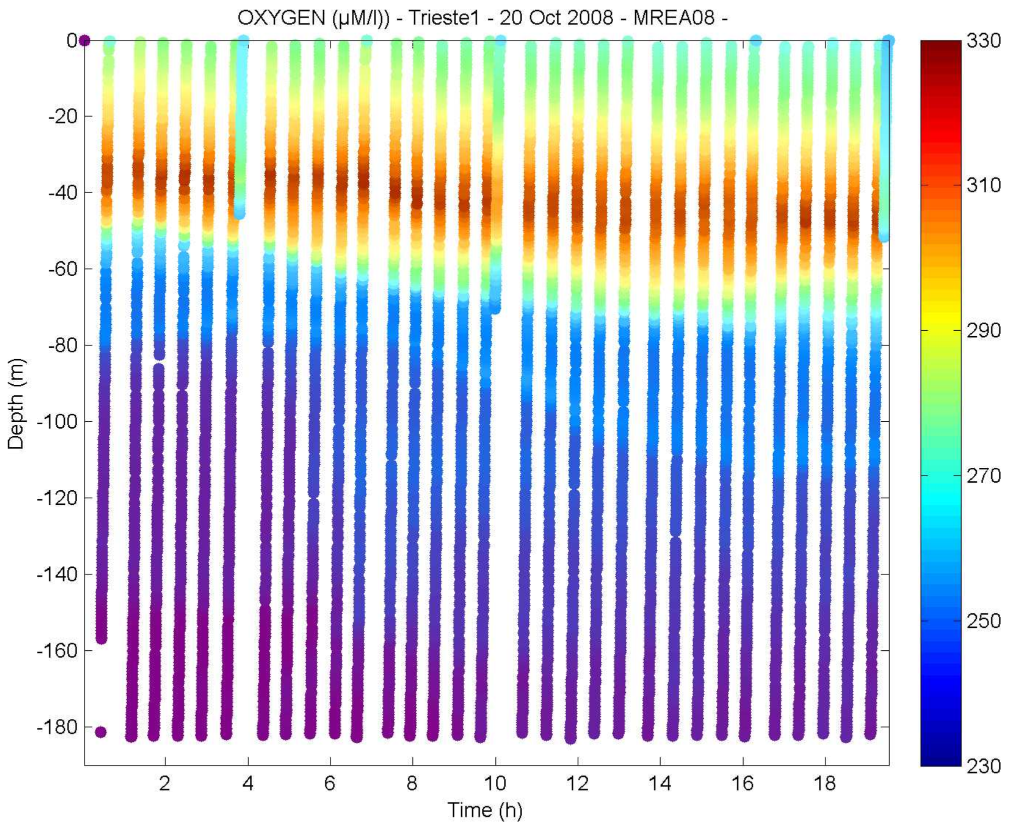

Fig. 15: Oxygen profiles. The maximum is observable in correspondence to the thermocline.

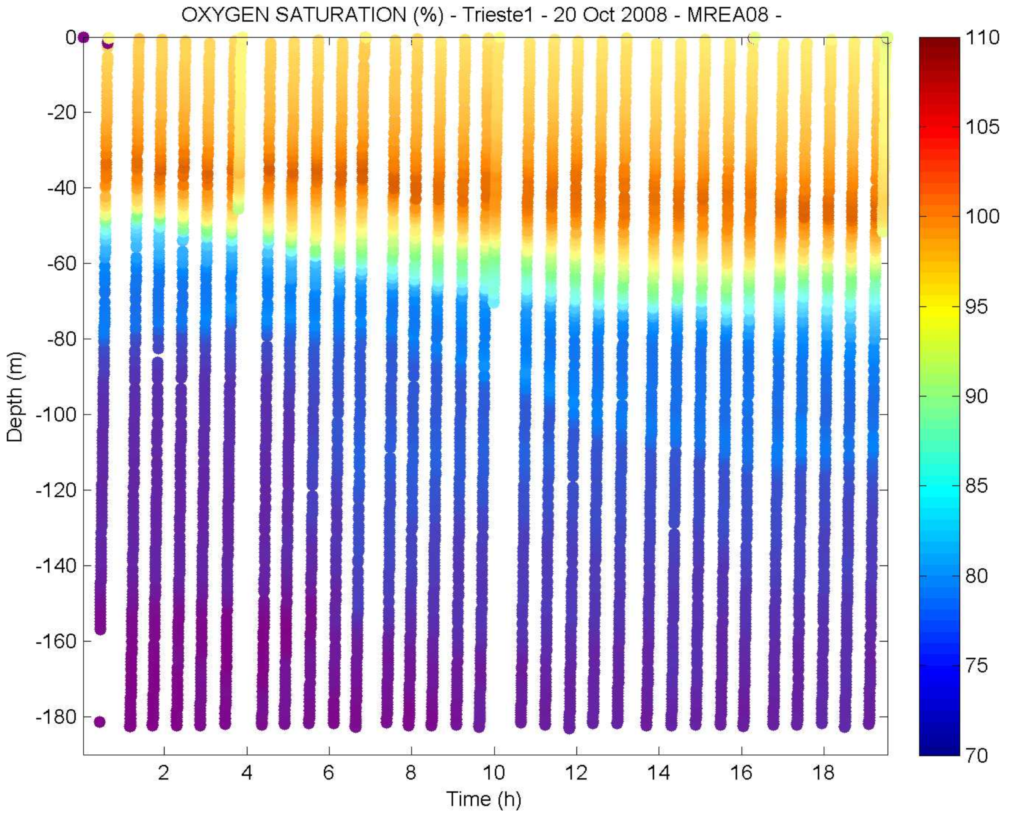

Fig. 16: Saturated oxygen profiles. The maximum is observable in correspondence to the thermocline.

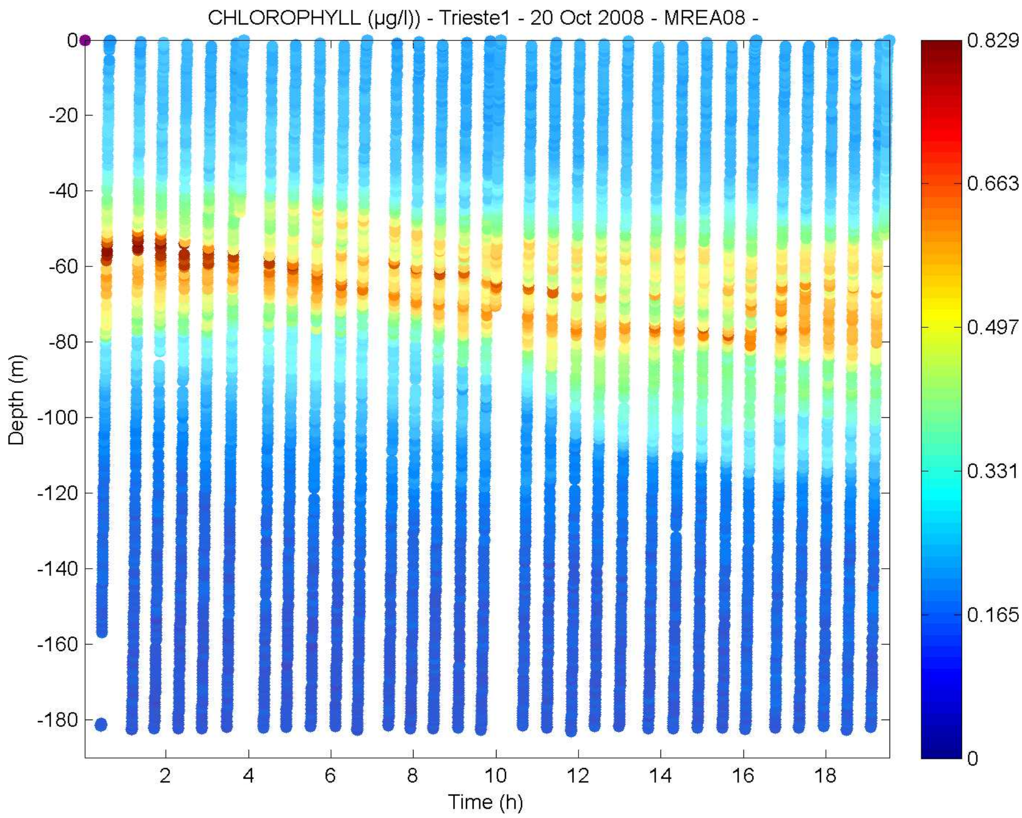

Fig. 17: Chlorophyll profiles. It displays the maximum below the thermocline.

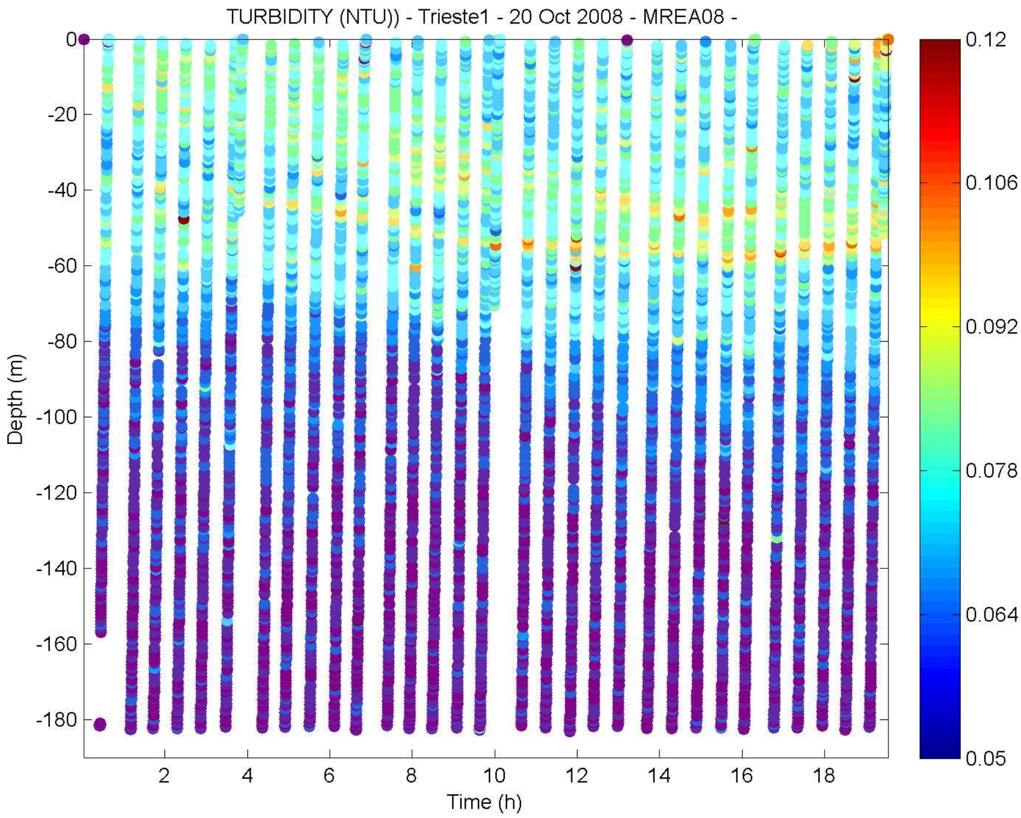

Fig. 18: Turbidity profiles. The plot of this parameter is very scattered.

8. Acknowledgments

The author wishes to thank all the people who were involved in the MREA08 glider experiments. In particular, he would like to acknowledge the Italian Navy for the collaboration and professional support, the R/V Ammiraglio Magnaghi crew for their enthusiastic help, Alvarez A. (NURC) for the inputs of the glider mission planning and the OGS colleagues Brunetti F., Mauri E., Medeot N., Nair R. and Poulain P.-M. who were directly involved in the glider operations and in the mission planning.

9. References

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