1. Hydrological characterization of the Ridge Station of Santa Croce

Research unit
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The scientific programme on the hydrological characterization of the Ridge of Santa Croce foresaw the monitoring of the main chemical/physical parameters, as well as the study of the marine-optical properties regarding the site under examination.

Material and methods

The physical – chemical and optical samplings were carried out by means of different tools:

• Multiparametric CTD Idronaut Probe – Ocean Seven 316 Probe capable to measuring pressure, temperature, conductivity (salinity), dissolved oxygen, pH, torbidity, chlorophyll a (Figs. 1.1; 1.2);

• WetLAbs Spectometer – AC9 to measure the attenuation coefficient along the column of water (Figs. 1.3; 1.4);

Selective radiometers Satlantic OCI-200, OCR-200 to measure the descending irradiance and the ascending radiance (Fig. 1.5);

• PAR LiCor Radiometer – Li-192SA to measure the spherical irradiance (Figs. 1.6; 1.7).

All the instrumentation was equipped with a depth sensor except the Li-Cor radiometers for which the profiles were recorded with the help of a metric rope.

The data was collected monthly, from December 2004, and carried out always during the second ten days of the month (except January 2006 due to hostile marine-weather conditions). All the samplings were conducted between 10.40 a.m. and 1.40 p.m.

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The sampling was carried out according to an articulate protocol according to the following:
- wiring harness, air calibration (if necessary) and immersion of instruments for the acclimatization to the temperature;
- first profile with Satlantic radiometers and Li-Cor sensors for the spherical PAR irradiance;
- contemporaneous collection of data with the use of Satlantic radiometers and Li-Cor sensors for 10 minutes each at the following depths: 0.5m (below superficial), 7m, 9.5m and 12m;
- first collection of data by means of a multiparamentric CTD probe and an AC9 spectrophotometric profile (absorption and attenuation on 9 wavelengths);
- at the end of the first series of optical data collecting at fixed sea levels, the contemporaneous profiles were repeated by means of Satlantic and Li-Cor radiometers;
- second series of collection at fixed depths (0.5m, 7m, 9.5m, 12m) each lasting 2 minutes;
- third series of collection at fixed depths (0.5m, 7m, 9.5m, 12m) each lasting 10 minutes;
- second profile both with AC9 and CTD multiparametric probe;
- the sampling was concluded with a contemporaneous profile with radiometers and with the Li-Cor sensor.

During every immersion, the following data was recorded:
2 profiles with an CTD probe;
2 profiles with AC9;
3 profiles with Li-Cor sensors;
3 profiles Satlantic radiometers;
2 10.5 minute sets of Li-Cor data at predefined depths (0.5m, 7m, 9.5m, 12m);
1 2-minute set of Li-Cor data at definite depths (0.5m, 7m, 9.5m, 12m);
2 10.5 minute sets of Satlantic radiometers data at definite depths (0.5m, 7m, 9.5m, 12m);
1 2-minute set of Satlantic radiometers data at definite depths (0.5m, 7m, 9.5m, 12m).

The data recorded (Fig. 1.8) was then converted using the appropriate software in txt format and cleaned by spikes (suspected data). The data collected bathymetrically was averaged by metres, those taken by the time, every 5 seconds; they were then archived and added in Excel tables.

Discussions on physical/chemical findings

On the basis of the temperature values recorded along the water column the averages by metre was calculated, except the superficial layer which represent the average of the first half metre.

The temperature trends were then considered, according to the depth, between January 2005 and March 2006.

The analysis of the data shows a trend typical of the Gulf of Trieste (Fig. 1.10) with the presence of isothermy along the column of water in the winter months and values near 6-7°C (absolute minimum of 6.31°C recorded on 11/03/2005 at 1 metre deep). During the spring warming a progressive increase of values was noticed, which was constant along the whole column at least until June, when a thermocline started to form, which characterises the hottest months (July and August). At the same time this thermocline influenced also the distribution of the fish species present around the submerged structures (see R.U. Orel).

The warming, which appeared constant along the column of water during the spring months, is due to the interpolation obtained with one monthly data only, which did not enable therefore to appreciate the spreading of the thermal wave from the most superficial layers to the bottom.

The thermal maximum values were recorded on 21/7/2005 with 27.11°C at 0.25 metres deep, while 23.78°C were recorded on the sea bottom.

The maximum warming phase was then followed by a progressive cooling which led, along the whole column, to values such as 18.5°C in October. The cooling continued until December when temperatures of 10.5°C were reached.

The chemical measurements regarding the salinity recorded during the sampling period enabled to highlight a rather irregular annual trend which reflected anyway the peculiar characteristics of the area (Fig. 1.11).

The maximum salinity values were observed in the winter months (February-March 2005 and January-February 2006 resulting in 38.2 psu), while the minimum values were reached in May 2005 (average value of the first 50cm: 31.29 psu) and February 2006 (average value of the first 50 cm: 33.73 psu) (Tab. 1.1).

The salinity values in the period between February 2005-March 2005 exhibited uniform resulted along the whole column of water. A similar period of isohalinity was recorded between October 2005 and January 2006; during this phase though the salinity increased in time, passing from the value of 37.4 psu in October to 38.2 psu in January 2006.

In the period between April 2005 and August 2005 (Fig. 1.11) a weak stratification was noticeable due to supplies of superficial fresh water which lay by the bottom water masses at higher salinity (37.9 in August 2005).

This data confirmed the general characteristics of the Gulf of Trieste which has an average salinity of about 37 psu which usually increases during winter, whereas the supply of coastal fresh water tends to decrease in the surface during spring and autumn.

Optical [see "Bio-optical"]

The main optical parameters monitored and recorded according to the methodology and the protocol previously shown, were respectively the irradiance, the selected 7-wavelength radiance and the PAR irradiance.

Please note that by the terms:

- *irradiance* (*Ed*) we intend the radiant flux as energy occurring on one surface unit measured in W m^{-2};
- *radiance* (*Lu*) is considered not only the surface unit but also the solid angle unit and is measured as W m^{-2} sr^{-1};
- *irradiance PAR* (Photosynthetically active radiation) is the photosynthetically active radiation and obtainable through the photosynthetic process, measured in µmol $s^{-1}m^{-2}$. The PAR is generally considered 50% of the total incident solar radiation. It concentrates in the blue and red bands, peaking 430 and 680 nm wavelength.

To measure the optical parameters some selective radiometers were used; they analyse the luminous flux in a very narrow band of the visible spectrum. Particularly they are centred on seven wavelengths, expressed in nanometres (412, 443, 490, 510, 555, 665, 683) with a limited width band of 10nm.

Following the methodology described by Gerin (2004), all the profiles recorded were then controlled, cleansed off by suspected data and averaged.

Particularly:

the depth was checked manually, anomalous values (even different from –999) and values corresponding to the probe impact hitting the bottom or stopping during a profile were eliminated;

those values recorded on the surface were checked manually and also in this case the anomalous values (even different from –999) were discarded;

all the negative values as well as those exceeding the recordable maximum values were eliminated (data supplied by the manufacturing firm);

layer extrapolation (20cm and 1m) using the natural energies logarithm in order to have a linearity. A statistic was performed and the values exceeding 3 sigmas were eliminated. The statistic was calculated once again, eventually.

Files containing data extrapolated by metre plus the value at 20cm and the last value obtained in the elaboration with a 20cm-step were created. The PAR values were subsequently obtained for integration.

The data recorded continuously at a certain depth were cleansed by spikes and averaged analogously to what described above (elimination exceeding data 3 sigma).

Since it was highlighted (Gerin, 2004), the possibility of grouping the luminous energies in three main classes (blue, green, red) the analysis of the data obtained took into consideration the wavelength of 443nm, 510nm and 665nm.
The red irradiance (*Ed*) (665nm) showed to be lower compared to the other two classes, while the trend of the radiance (*Lu*) highlighted a strong variability along the profile. A decrease of incident energetic flux sometimes corresponds to a shifting of the radiance or irradiance curve, which however did not always display symmetrical results compared with that concerning the profile of the previous samplings. From this first analysis it is possible to notice that the optical characteristics of the water studied are variable along the column.
The data analysis of the irradiance took into examination the trends regarding the period January 2005-March 2006, both the luminous energy (Fig. 1.12), and its percentage (Fig. 1.13), both considered according to the depth. The superficial irradiance data were likewise evaluated (before and after the profile) for the same period (Fig. 1.14).
The elaboration of the PAR data, recorded through Li-Cor photometer, was carried out taking into consideration the average value measured at every depth; subsequently the percentage of luminous energy along the column of water was calculated, compared to the energy measured in the air, considering for the latter the average value recorded in surface before and after the profile.
The trends obtained gave rather irregular results (Fig. 1.12) with foreseeable minimum irradiation values during the winter seasons and with maximum during the summer months; therefore the highest irradiation present in the summer months, with the sun being higher, is very much evident. This irregularity in the trends was observable in relation to the PAR values recorded in surface (air) before and after each profile (Fig. 1.14).
The non continuous sampling carried out did not enable us to draw conclusions regarding their seasonability, yet it enabled us to highlight the great variability, in terms of luminous energy, which characterises the site under examination. In order to highlight thoroughly this variability four ‘type’ cases were taken into examination: two winter days and two summer days, with samplings performed at very short time distance from one another and that showed different conditions of irradiation.
Particularly the data recorded in the following days of sampling were analysed:
(See Tab. 1.1)

For every day graphs of all the vertical profiles regarding the data of Temperature (°C), Salinity, PAR (µmol s-1 m-2) and PAR(%) were executed. A table was then created where all the averages and the standard deviations of the values recorded at different depths were reported, keeping the instrument at fixed depths (0.5m; 7m; 9.5m; 12m), together with a table reporting all the data of the average irradiances in surface.

As far as the hydrology of the two summer days is concerned no particular differences were noteworthy of reporting, but a higher salinity in the deepest half of the column on 11/08/2005.

The comparison amongst the summer samplings underlined the high variability of luminous energy even at few days distance. The irradiation values along the column, recorded on 11/8/2005, were very low and even similar to those recorded on a sunny February day (1/02/2006) (Figs. 1.15; 1.17). That day was particular even for the great variability recorded during the three hour sampling (Fig. 1.17); as a matter of fact the third profile diverged considerably from the two previous ones and gave very low values, even lower than those recorded on the sunny February day.

From the comparison of the values of the different samplings recorded in air, surprisingly the maximum values were recorded in February (1/02/2006) (Fig. 1.15); on the other hand the irradiance measurements in the water gave higher values on 17/08/2005 (Fig. 1.18).

The analysis of the data regarding 21/02/2006 revealed the presence of a superficial halocline (Fig. 1.16) well marked (phenomenon rather frequent as the mouths of the Isonzo are nearby) and the values of luminous energy resulted particularly low already in the first metres of depth.

Conclusions

The optical variability observed is strictly high and seems to be influenced predominantly by the external irradiation conditions more than by other factors. The presence of cloudy bodies and the incidence angle of the light on the sea surface are, indeed, the main factors conditioning the availability of energy.

It is important to emphasise how the Ridge of Santa Croce, where the average depth is 12m, the extinction of the light according to the depth is not sufficient to distinguish completely the irradiance as a matter of fact nearby the sea bottom a relatively high energy may be found, which remains available for to be used by the vegetals.

Generally, the study conducted has enabled us to draw some interesting information on the characterization of the site under examination, albeit in order to evaluate accurately the availability of the light in the sea it would be most suitable to use a continuous protocol of samplings.