The Research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 262584, JERICO

TNA PROJECT REPORT

1st Call of Proposals
12 January – 3 April, 2012

A) General Information

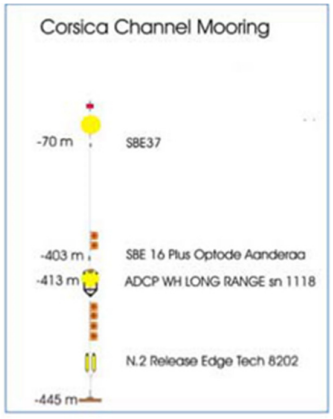
Proposal reference number	CALL_1_9
Project Acronym (ID)	OXY-COR
Title of the project	Integration of dissolved oxygen concentration measurements in the long term time series data in the Corsica Channel
Host Research Infrastructure	CNR MPLC
Starting date - End date	20/11/2012 - 25/11/2014
Name of Principal Investigator **Home Laboratory** **E-mail address** **Telephone**	Laurent Coppola Observatoire Oceanographique de Villefranche/Mer UMS829 Chemin du Lazaret Batiment Jean Maetz 06238 Villefranche-sur-Mer, France coppola@obs-vlfr.fr +33493763988
Additional users	Dominique Lefevre, Mediterranean Institute of Oceanography, Marseille, France

B) Project objectives (max. 250 words)

The Levantine Intermediate Water (LIW) is the warmest and saltiest water resulting from the dense water formation processes that occur in several zones of the Mediterranean Sea. This water mass is formed in the Levantine basin and circulates from the Eastern basin to the Western basin through the Sicilian Strait. In the Northwestern basin, the Corsica Channel is a strategic site where a branch of the LIW is passing through before reaching the DYFAMED site (cyclonic circulation).
From previous time series data, a time lag has been observed in term of T-S change in the LIW level. To solve this issue, regular and long term oxygen measurements might provide a good opportunity to understand and to estimate accurately this time lag. This also gives us the possibility to quantify the variability versus anomalies of the LIW property due to the climate change already observed in the Mediterranean Sea.
In summer 2012, the DYFAMED mooring located in the Ligurian Sea between Nice and Calvi has been equipped with two DO sensors (optode 4330F) at 400 m and 2000 m depth (MOOSE-GE cruise). The objective of the access is to complete the oxygen observation in the Ligurian Sea by implementing a DO sensor on the CC mooring (located at the east of the DYFAMED mooring) at the core of the LIW water mass (400 m depth). The collected data will provide information to track the water mass variability, the impact of the water mass change on the oxygen content and to estimate the time lag between the eastern (Corsica Channel) and the western (Dyfamed) part of the Ligurian Sea.

C) Main achievements and difficulties encountered (max. 250 words)

An optical dissolved oxygen sensor (OPTODE 3975 Aanderaa) was installed on November 20, 2012 in the underwater station at 400 m depth during a maintenance cruise (EUROFLEETS12) on board the research vessel URANIA of CNR. The sensor remained in the location until October 22, 2013, when it was replaced with a second sensor (OPTODE 4330 Aanderaa). The latter remained on the mooring until November 25, 2014, when it was finally recovered. Both the sensors used were connected to a SBE16plus probe which logged the data. The main difficulty of the experiment was a malfunctioning of the communication between the SBE16plus probe and the Optode 4330 which prevented to get useful data in the second measuring period.



A sketch of the mooring in the Corsica Channel.

D) Dissemination of the results

It is planned to disseminate the results in scientific conferences and, if suitable, to a peer-reviewed scientific journal.

E) Use of the Infrastructure/Installation

	In situ	By remote
Nr. of Users involved		2
Access units (days/months/etc)	Day	months
In situ stay day / Remote Access duration		24

F) User project scientific field

Main field	Earth Sciences & Environment
Scientific description	Marine Science/Oceanography

H) Technical and Scientific preliminary Outcomes (max. 2 pages)

The purpose of the research is integrating the dissolved oxygen concentration measurement in the long term time series data in the Ligurian basin to track the water mass variability, the impact of the water mass change on the oxygen content and to estimate the time lag between the eastern and the western part of the Ligurian Sea. The Levantine Intermediate Water (LIW) is the warmest and saltiest water resulting from the dense water formation processes occurring in the Mediterranean Sea. This water mass is formed in the Levantine basin and circulates from the Eastern basin to the Western basin through the Sicilian Strait. In the Northwestern basin, the Corsica Channel is a strategic site where a branch of the LIW is passing through before reaching the DYFAMED site (cyclonic circulation) and the area of dense water formation (Fig. 1).

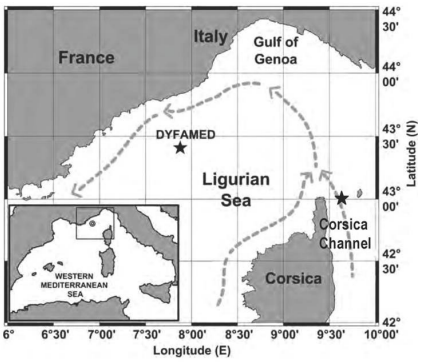


Fig. 1 - Location of the mooring in the Corsica Channel and the DYFAMED station in the Ligurian Sea (from Millot and Taupier-Letage 2005).

From previous time series data, a time lag has been observed in terms of T-S change in the LIW level. To solve this issue, regular and long term oxygen measurements might give a good opportunity to understand and to estimate accurately this time lag. This also gives the possibility to quantify the variability versus anomalies of the LIW property due to the climate change already observed in the Mediterranean Sea. The DYFAMED site (DYF, 2350 m depth), in the western part, and the CORSICA Channel (CC, 445 m depth), in the eastern part, are permanently monitored since 1988 and 1985 respectively to observe the water masses evolution and more specifically the shift of the LIW properties due to the climate change.

These observations are done through fixed moorings regularly maintained to record temperature, salinity and currents data. Since 2005 and 2009, the CC and DYF moorings are equipped with precise Seabird sensors (0.001°C). Both moorings are maintained every year through annual/semiannual scientific cruises in order to collect T-S data, to clean and to calibrate the sensors and to repair the mooring line.

The oxygen optode (optical sensor) is designed to measure the dissolved oxygen concentration by quenching method. The optode sensor fits to the long term monitoring, as the data drift is very low and the data accuracy higher than other classical membrane type sensor. An optical dissolved oxygen sensor (OPTODE 3975 Aanderaa) was installed on November 20, 2012, in the underwater station at 400 m depth during a maintenance cruise (EUROFLEETS12) on board the research vessel URANIA of CNR. The sensor remained in the location until October 22, 2013, when it was replaced with a second sensor (OPTODE 4330 Aanderaa). The latter remained on the mooring until November 25, 2014, when it was finally recovered. Both the sensors used were connected to a SBE16plus probe equipped with alkaline battery logging dissolved oxygen concentration every 30 min. The main difficulty of the experiment was a malfunctioning of the communication between the SBE16plus probe and the Optode 4330 which prevented to get useful data in the second measuring period.

During the CC maintenance cruises, additional measurements were carried out with instrumentation on board the R/V Urania along a transect crossing the channel, including CTD profiles, vessel mounted ADCP, lowered ADCP profiles, and chemical sampling at discrete depths (dissolved oxygen, dissolved inorganic nutrients). Fig. 2 shows sections of SBE43 Dissolved Oxygen concentration (ml/l) and Salinity measured on 19-20 November 2012 during the maintenance cruise EUROFLEET12 with the SBE9plus multiparametric probe on board the R/V Urania and the θ/S diagrams in the pressure range 150-440 m from measurements in the CC site during three maintenance cruises in the deployment period.

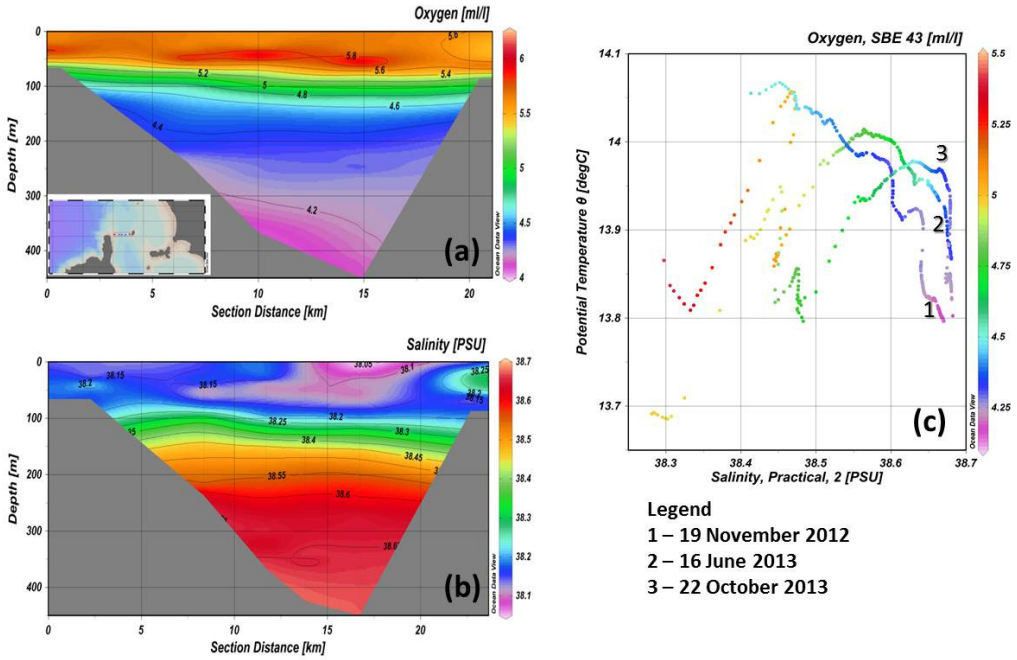


Fig. 2 - Sections of (a) Dissolved Oxygen concentration (ml/l) and (b) Salinity measured on 19-20 November 2012 during the maintenance cruise EUROFLEET12, using a SBE9plus multiparametric probe; (c) θ/S diagrams in the pressure range 150-440 m from measurements in the CC site during three maintenance cruises in the Optode 3975 deployment period. The color bars on the left of the plots are Dissolved Oxygen in ml/l (a) and (c), Salinity in Practical Salinity scale (b)

LIW is found to fill the layer below 250 m to the bottom, and its core placed close to the bottom is identified by a maximum in Salinity (38.67-38.69) and a minimum in Dissolved Oxygen concentration (4.11-4.30). The LIW core characteristics vary with the season, being then saltier and rich in dissolved oxygen in June 2013.

The optode 3975 Aanderaa has been calibrated during the cruise with Winkler titration and also compared in profiling mode with two calibrated SBE43 sensors also installed on the SBE16plus probe. The results of comparison are shown in Fig. 3.

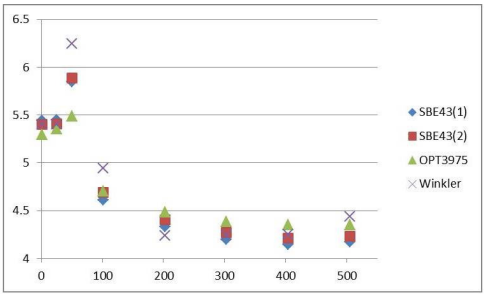


Fig. 3 - Comparison of contemporary vertical profile of DO measured by two SBE43 and the optode 3975 Aanderaa with Winkler data (38.917N -13.299E November 9th, 2012).

Period	Deployment date	Recovery date	Mooring CTD	Mooring Optode	Mooring depth (m)	CTD file	Winkler (ml/l)	Others data	Comments
November 2012 - June 2013	20/11/2012	16/06/2013	SBE16 sn6134	3975 sn1035	412	d108_16062013.cnv d108_19112012.cnv	4.04-4.06 / 4.18-4.20	Turbidity and ADCP data	
June 2013 - October 2013	16/06/2013	21/10/2013	SBE19 sn4183	3975 sn1035	402	d108_22102013.cnv	n.d.		
October 2013 - April 2014	22/10/2013	4/4/14	SBE19 sn4183	4330 sn1031	392	dcors01_04042014.cnv	3.87-4.07	RCM9 sn127	problem with optode
April 2014 - November 2014	4/4/14	25/11/2014	SBE19 sn4183	4330 sn1031	401	d108_04112014.cnv	4.27		problem with optode

Table 1. Sensors deployment on CC mooring from Nov 2012 to Nov 2014

The first observation of the CC mooring data during the last 2 years time series shows, above all, few variability of temperature, salinity and oxygen content near the bottom except in March 2013 (Fig.4). At this period, an effect of water mixing affected the temperature, salinity and oxygen contents. This event was not observed during the following winters in the Corsica Channel site. This forcing induced

a brutal decrease of salinity and temperature while the oxygen content was increasing (around 1 ml/l or 45 µmol/kg). This suggests a mixing of colder and less dense water recently ventilated with oxygen. A second, but less strong, identical event was also observed in May 2013 but with less impact on oxygen content. One reason explaining the first rapid mixing in winter 2013 might be associated to a WIW lense (Western Intermediate Water) passing through the Corsica Channel. In this case, the WIW lense has been probably formed during the previous winter in the center of the NW Mediterranean region and travelled undisturbed into the Tyrrhenian Sea.

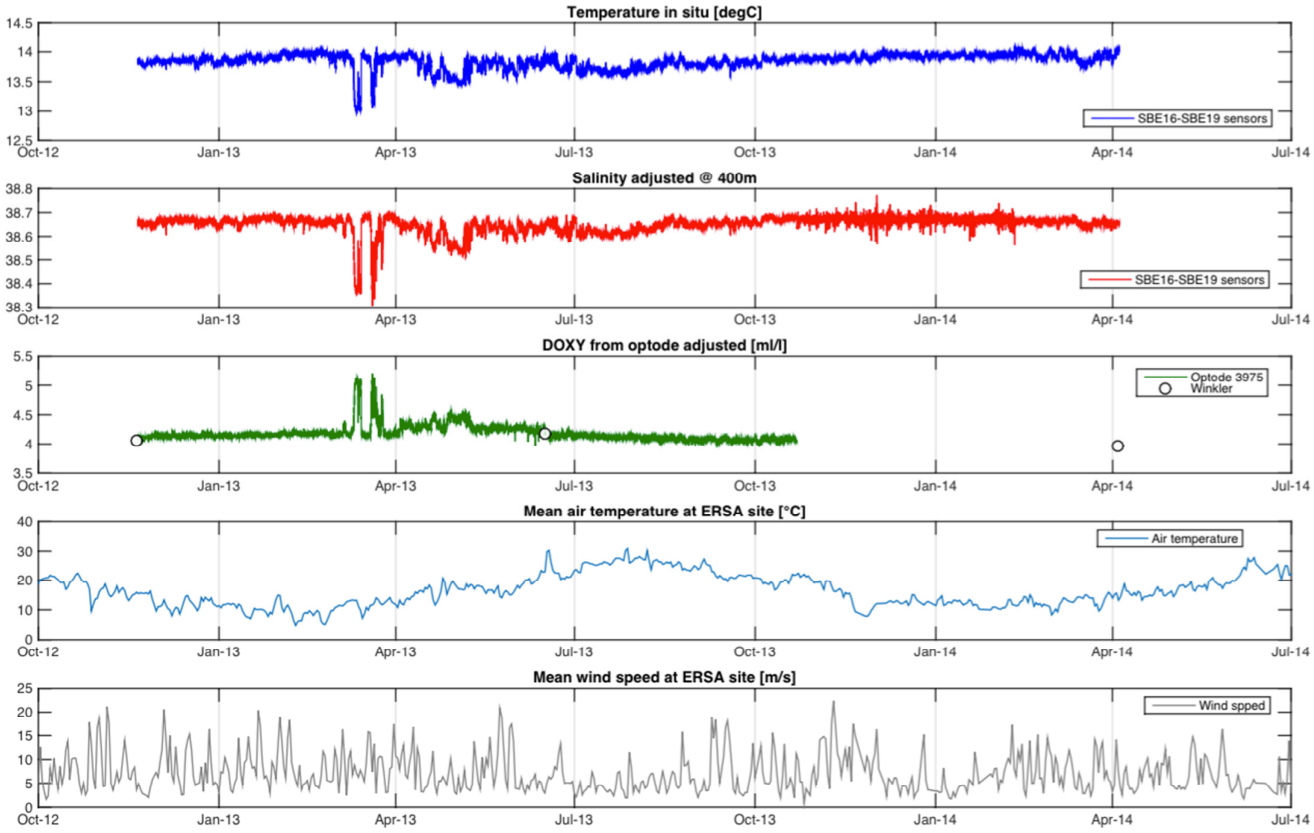


Fig. 4 - Time series of temperature, salinity and dissolved oxygen recorded on CC mooring. Meteorological data (air temperature and wind speed) from ERSA site (Corsica) are reported. In the oxygen panel, the open dots represent the Winkler measurements collected during the maintenance of the mooring. Salinity and oxygen data have been adjusted from in situ measurements.

Finally, the impact of the mixing event in the Corsica Channel seems to affect the LIW signal in the DYFAMED site, located 150 km north-west of the CC mooring. Theta-S diagrams at DYFAMED from March to May 2013 (from data monthly cruises) showed a clear apparition of warmer and saltier water, richer in oxygen around 400 m depth (Fig. 5A). The oxygen content in April-May 2013 was higher than usual (up to 4.5 ml/l) and decreased over the time to reach its classical level at the DYFAMED site (3.5-4 ml/l). This oxygen enrichment at DYFAMED is rapid and might be the signature of the WIW lense observed at the Corsica Channel site two months ago (Fig 5B).

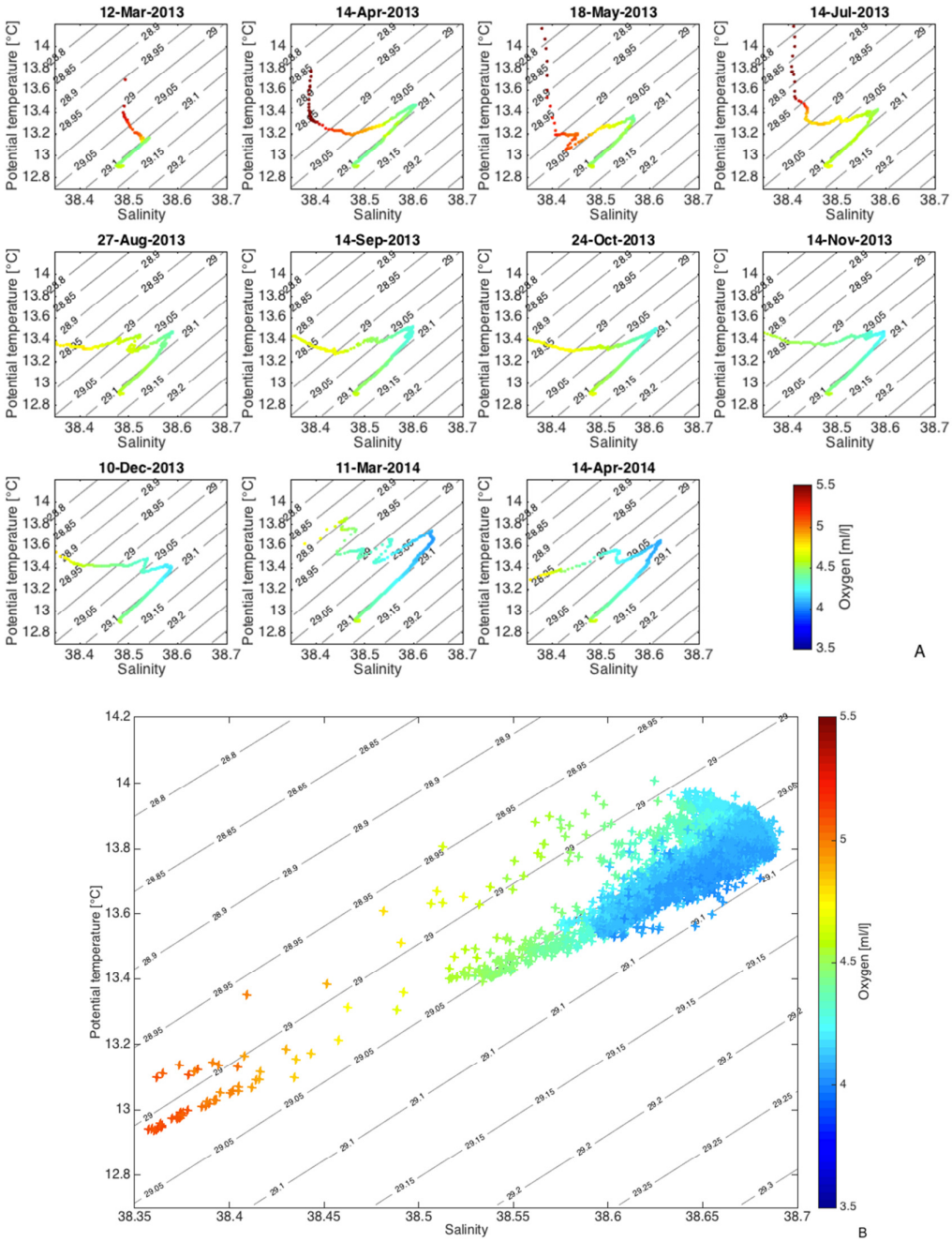


Fig. 5 - (A) Diagrams Theta-S for DYFAMED data from March 2013 to April 2014. (B) Diagram Theta-S for CC mooring data at the same period. The colorbar represent the oxygen concentrations. The x-y axes are identical for both graphs.

References

Millot, C. and Taupier-Letage, I., 2005. Circulation in the Mediterranean Sea. The Handbook of Environmental Chemistry, K, 29 - 66, doi:10.1007/b107143

CC: http://www.jerico-fp7.eu/images/tna/fixed-platforms/fixed_platforms_mplc_cnr.pdf
http://www.ismar.cnr.it/infrastructures/observational-sites/catene-correntometriche/il-canale-di-corsica

DYF: http://www.eurosites.info/dyfamed.php
http://www.obs-vlfr.fr/sodyf/