# Upgrade of the marine station PALOMA (North Adriatic Sea) in order to better determine air-sea $CO_2$ regional fluxes in a coastal area.

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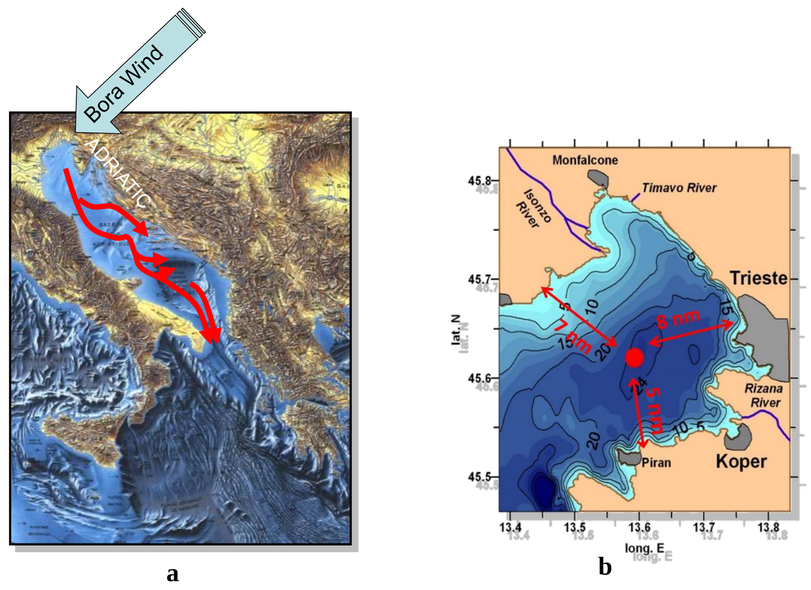
While confidence in estimating air–sea $CO_2$ fluxes in open sea environments is increasing, large uncertainty remains in defining the role played by coastal ecosystems as $CO_2$ sinks or sources. This is due either to their highly variable oceanographic and climatic characteristics and to the effect of continental inputs.

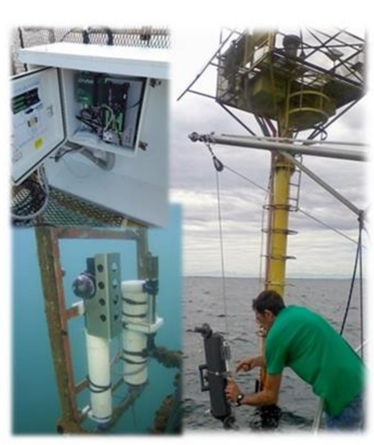
The PALOMA station (Northern Adriatic Sea) has been collecting sea surface $pH_T$ and TA data since 2008 (as time series, fig 2) and $pCO_2$ in continuous since 2012 (fig 3). The elastic beacon belongs to the ICOS-OTC and ICOS Italy network, and is labelled as FOS class 1 station since 2019.

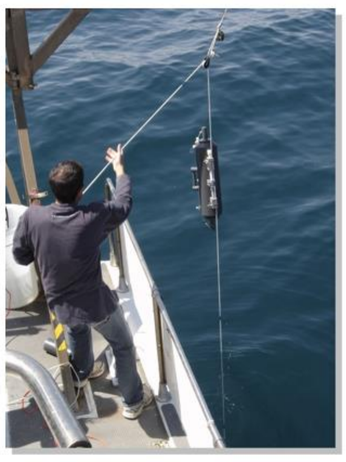
Due to its central position in the Gulf of Trieste (fig.1) (45° 37.097' N, 13° 33.913'E; 25m deep), the PALOMA site (fig. 2) provides an ideal location where observing, by remote, the in situ properties and air-sea exchanges and calculate $CO_2$ fluxes over a Mediterranean shelf region (N. Adriatic) open to intense land-sea interactions and air-sea interactions and site of dense water formation during winter.




a b

**Fig. 1** The North Adriatic site: (a) the pattern of deep water circulation in the Adriatic basin (b) the postion of the elastic beacon in the Gulf of Trieste.





**PALOMA time series, since 2008. Monthly sampling at 4 depths:**
- Physical parameters profiles (T, S, fluorescence, DO )
- Biogeochemical (DO, $NO_3$, $NH_4$, $NO_2$, $PO_4$, $SiO_2$, TOC)
- biological parameters (chlorophyll_a, phyto e zooplankton )
- high quality carbon chemistry ($pH_T$, TA)

**Fig. 2** Discrete measurements: sampling different parameters of the monthly time series since 2008.
Results have shown an increasing trend of dissolved $pCO_2$ over the time span 2009-2020.
For further insights listen to the oral presentation "The complexity of coastal environments: unravelling the long term drivers combining data from two ICOS stations" by Cantoni et al., in the parallel session 25.

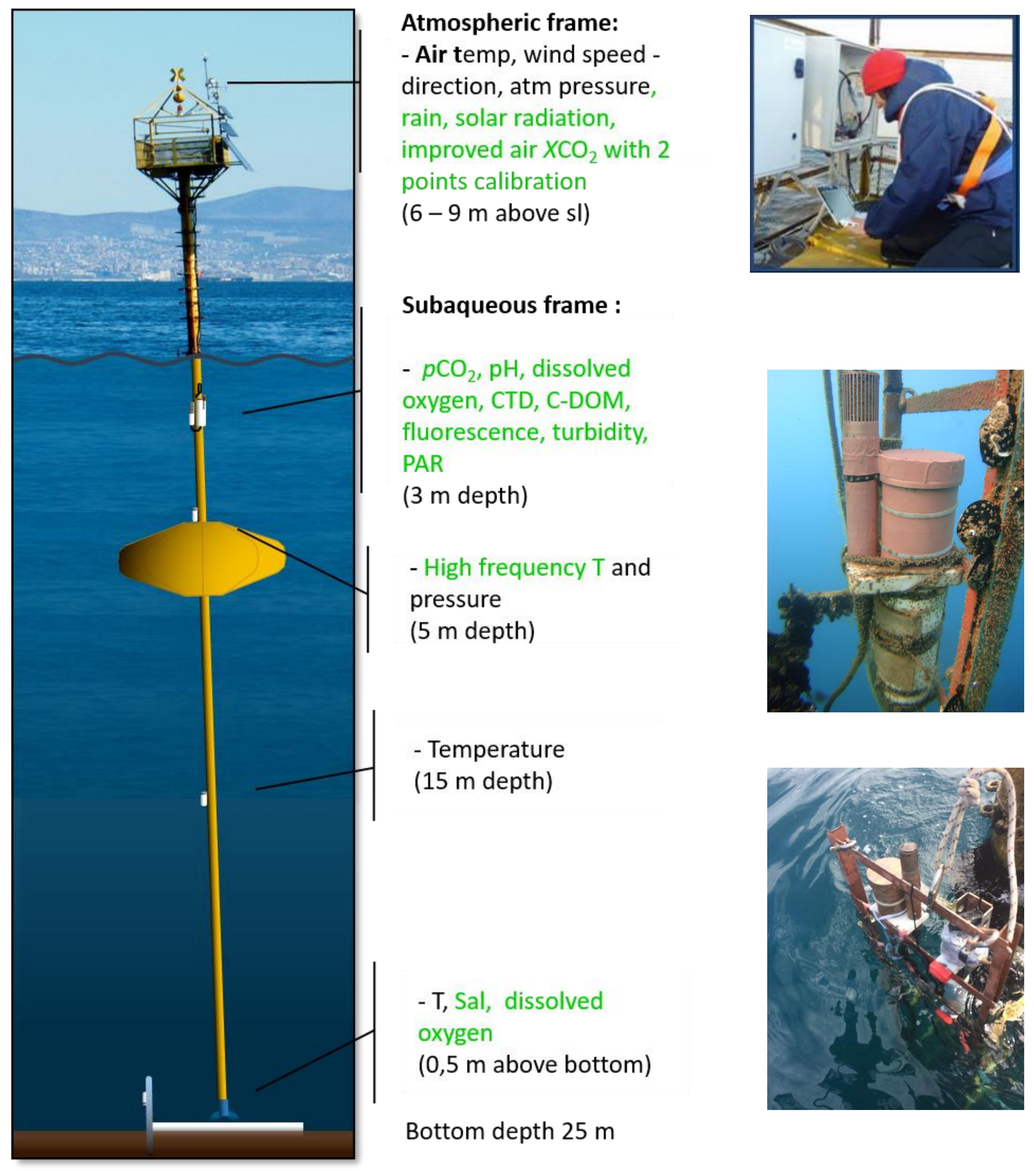



**Fig. 3** Station scheme with sensors. In black instruments recording data since 2012, in green the implemetation with new sensors acquired by means of the PON Pro_ICOS-Med project.

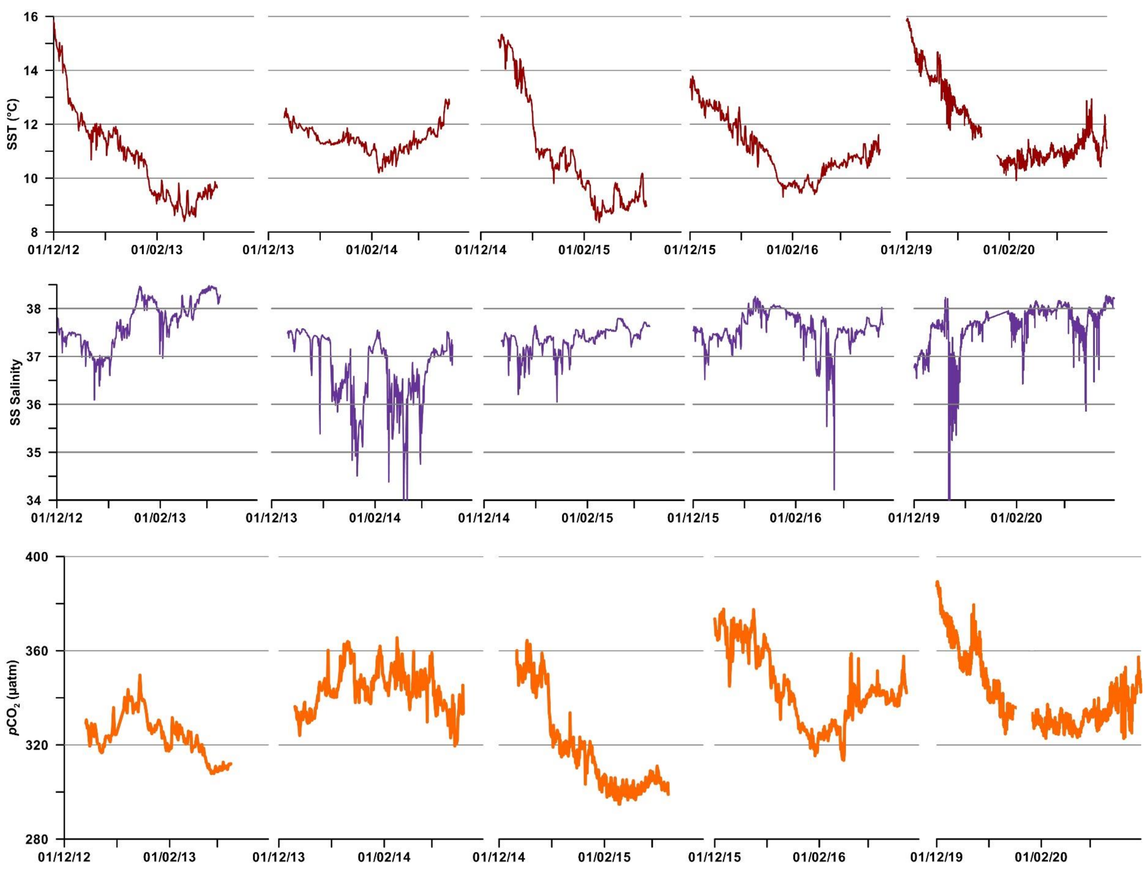
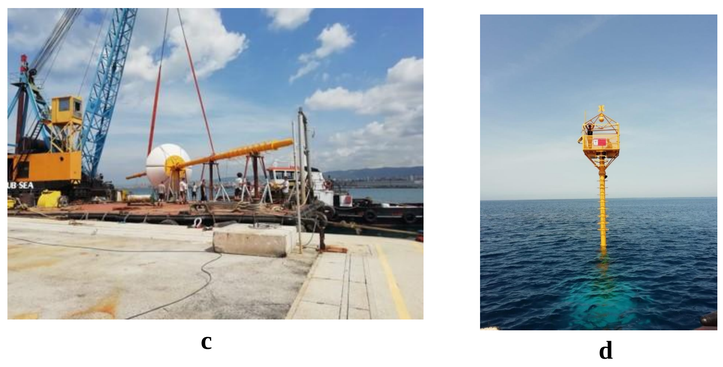



**Fig. 4** Continuous acquisition of $pCO_2$, SST and SSS by PALOMA in the time spanning 2012-2020. They refer to winter seasons (from December 1 to March 31): the influence of riverine inputs can be seen. Mild and rainy winters (2013-2014, 2015-2016 and 2019-2020) correspond to high pCO2 (oversaturation) whereas cold dry winters correspond to much lower pCO2 (undersaturation). The calculated air-sea $FCO_2$ clearly indicate a significant decrease (down to about 60%) during mild and rainy winter, thus suggesting that meteorological condition almost halve the $CO_2$ uptake by the North Adriatic sea (Cantoni et al., 3rd ICOS Scientific Conference, 2018).
Data are available on the carbon portal of ICOS (https://data.icos-cp.eu)

During 2021 the elatisc beacon has been recoverd on land (fig. 5a) to undergo a full maintenance (fig 5b). In the end of May 2022 it was successfully repositioned at sea (fig 5c-d).
Now, thank to the national project PON Ricerca e Innovazione 2014-2020 - Pro_ICOS-Med (Potenziamento della Rete di Osservazione ICOS-Italia nel Mediterraneo) funded by the Italian Ministry of Education, Universities and Research (MIUR), the FOS is under implementation and upgrading with new sensors to measure core and desirable ICOS parameters (fulfilling the high standard quality requirements of the OTC).
Expansion include: new SBE16 plus probe equipped with sensors for chlorophyll_a, pH, CDOM, turbidity and PAR at 3 m (fig 6). Spare sensors for seawater and atmospheric $pCO_2$, dissolved oxygen, temperature and salinity in order to garantee the continuity of the time series. New meteorological sensors (wind speed and direction, air temperature necessary to determine the CO2 fluxes) together with humidity, precipitation and PAR.
In addition, in order to have a well-equipped and efficient marine carbon laboratory: new DIC multi-sample analyzer (fig. 7) will be purchased to provide the third (of four) carbon parameter to better dertermine the uncertainty for $fCO_2$, and two fellowships (one graduate and one PhD) have been activated.

a b



c d

**Fig. 5** Recovery of the platform (a), maintenance (b), repositioning at sea (c-d).

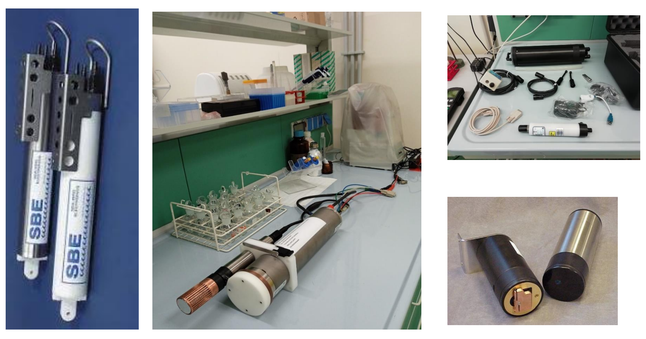



**Fig. 6** The new probe SBE16plusV2 supporting numerous auxiliary sensors (CONTROS Hydro C-CO2, CO2 ProCV; ECOtriplet, PAR, ECO-FLNT)

**Fig. 7** DIC multisample analyzer

**Aknowledgments**
The long monthly time series of discrete samples and the station maintenance were possible thanks to the support of ARPA FVG (on board of their vessel) and several national (RITMARE, JRU-ICOS, MSFD Italy, PNRR) and european (JERICO, JERICO Next, RINGO, JERICO – S3, DANUBIUS) projects.