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E1 AND S1 METEO-OCEANOGRAPHIC BUOYS
(NORTH ADRIATIC SEA)

Technical details, data, open problems and "Best practices"

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Best Practices Workshop
4 Oct 2012 Heraklion, Crete

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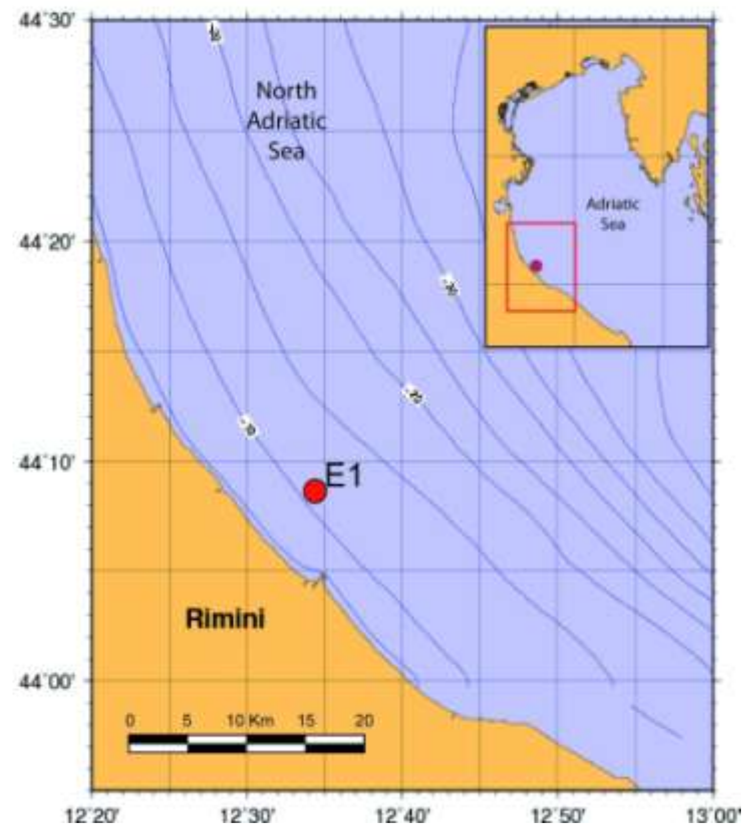
S1 and E1 METEO-OCEANOGRAPHIC BUOY

COORDINATED BY CNR-ISMAR DI BOLOGNA

LOCATION: North Adriatic
(south of the Po River Delta)
Operative since April 2004
Max Depth: **22.5 m**
Distance from the coast: 6 km

LOCATION: North Adriatic
(North of Rimini coast)
Operative since August 2006
Max Depth: **9.5 m**
Distance from the coast: 6 km



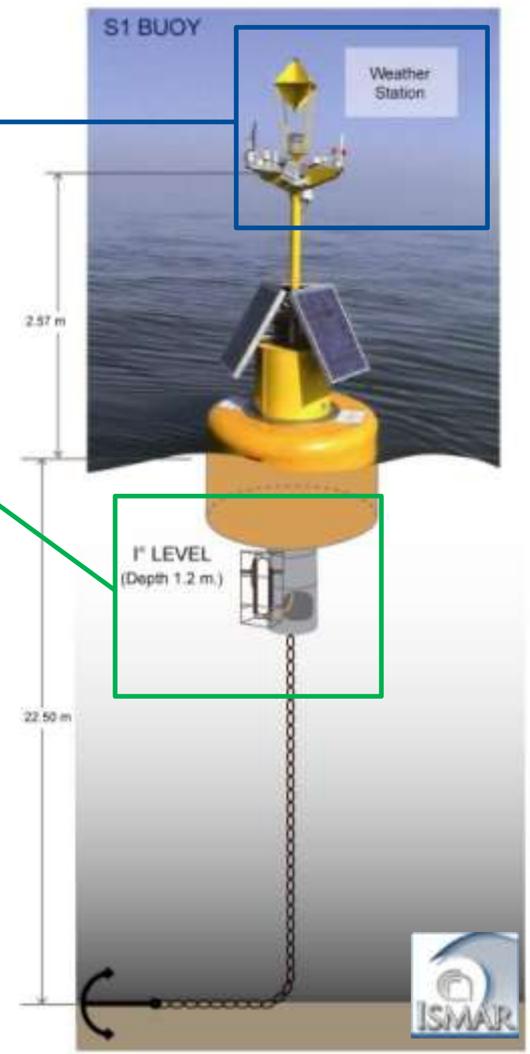
S1 BUOY SENSORS: TECHNICAL DETAILS

Meteorological sensors and measured parameters :

- Aanderaa 2740 Wind Speed and Gust — Wind Speed & Gust
- Aanderaa 3590 Wind Direction — Wind Direction
- Aanderaa 3455 Air Temperature — Air Temperature
- Aanderaa 2810 Atmospheric Pressure — Air Pressure
- Aanderaa 3445 Relative Humidity — Relative Humidity
- Aanderaa 2770 Solar Radiation — Net Solar Radiation

I° LEVEL Sensors and measured parameters (1.2 m. below the sea level):

- CTD SBE 37 — Water temperature and Salinity
- SBE 43 — Dissolved Oxygen
- Aanderaa DCS 3900 — Current speed and direction



Between March 2004 and August 2012 the following data were also acquired:

Sensor	Parameter	Depth of measurements (m)	Sampling frequency	Operation start	Operation end
CTD SBE 37	Sea Temperature	21.5	1h	July 2006	October 2008
CTD SBE 37	Sea Water Salinity	21.5	1h	July 2006	October 2008
SBE 27	Sea Water pH	1.2, 21.5	1h	March 2004	December 2009
SBE 43	Dissolved Oxigen	21.5	1h	March 2006	October 2008
D&A OBS-3+	Sea Water Turbidity	1.2	1h	March 2004	November 2007
Turner Designs SCUFA II	Sea Water Fluorescence	1.2	1h	March 2004	May 2008
ADCP RDI (Monitor)	Wave period	21.5	1h	May 2007	July 2008
ADCP RDI (Monitor)	Period wave peak	21.5	1h	May 2007	July 2008
ADCP RDI (Monitor)	Peak direction	21.5	1h	May 2007	July 2008
ADCP RDI (Monitor)	Wave maximum high	21.5	1h	May 2007	July 2008

E1 BUOY SENSORS: TECHNICAL DETAILS

Surface meteorological Sensors and measured Parameters :

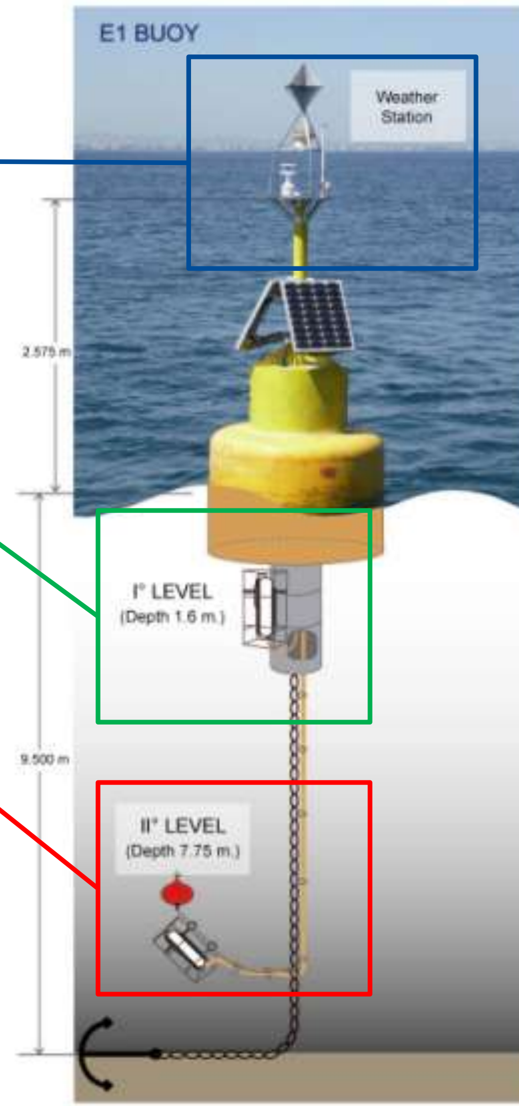
➢WS MetPak Pro, Gill	Wind speed and direction; Air temperature; relative humidity; barometric pressure and dew point
➢LP02, Hukseflux	Solar radiation

I° LEVEL Sensors and measured Parameters (1.3 m. below s.l.):

➢CTD SBE 37	Water temperature and Salinity
➢SBE 43	Dissolved Oxygen
➢SBE 63	Dissolved Oxygen
➢OBS 3+	Turbidity
➢WetLabs Triplet	Chlorophyll, CDOM, Scattering (Proambiente Probe)
➢Aanderaa DCS 4100	Current speed and direction

II° LEVEL Sensors and measured Parameters (7.75 m. below s.l.):

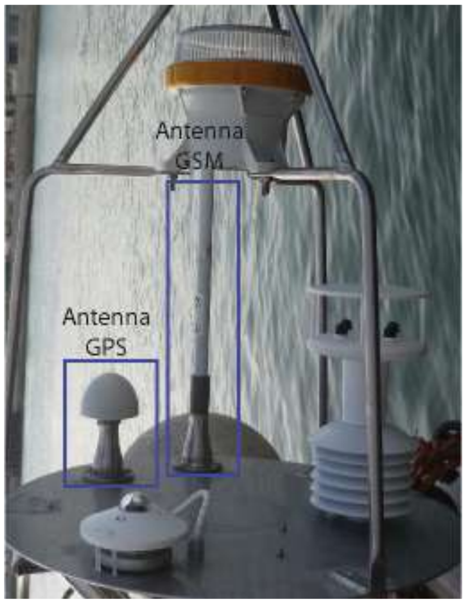
➢CTD SBE 37	Water Temperature and Salinity
➢SBE 43	Dissolved Oxygen



Between 2007and 2008 were also acquired the following parameters:

Sensor	Parameter	Depth of measurements (m)	Sampling frequency	Operation start	Operation end
Aanderaa 3900 DCS	Current Speed & Direction	8.8	1h	May 2007	July 2008

E1 AND S1 BUOY: COMMUNICATION SYSTEM

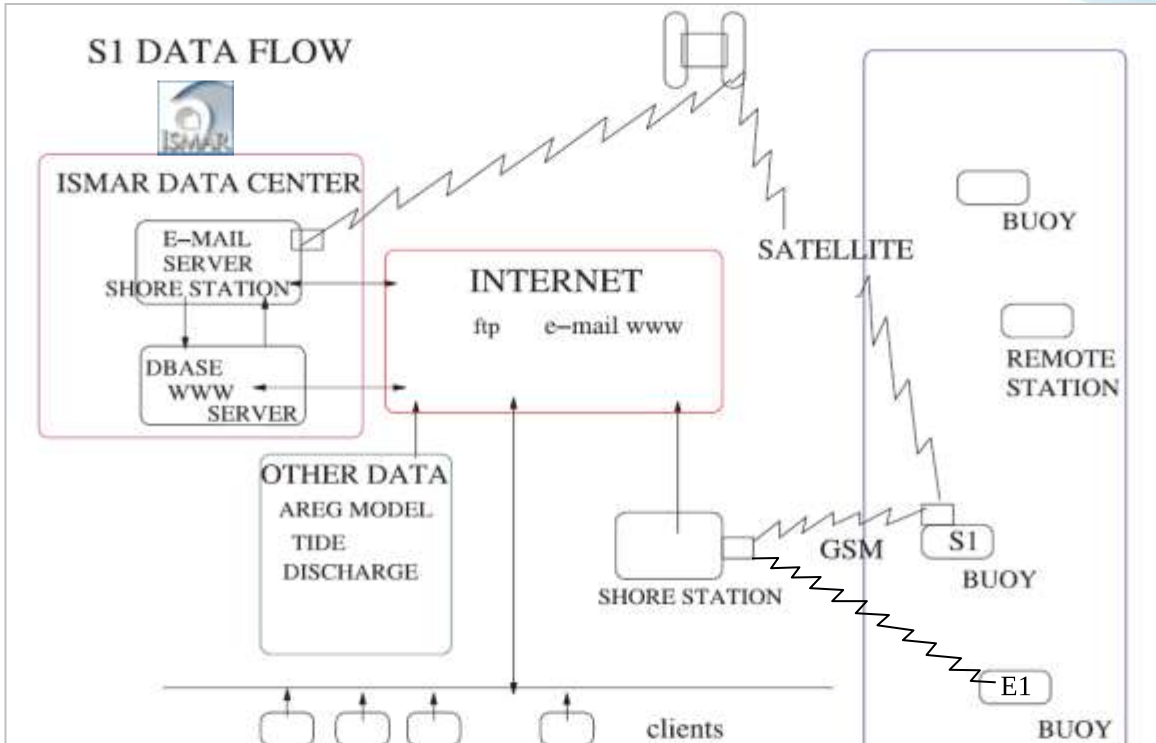


Particular GSM and GPS antennas, buoy E1

Distance from the coast: 6 km

Communication data: Bi-directional communication system via GSM, G2 or G3 (this depends on the available coverage network)

Frequency of transmission: every hour (occasionally every two hours)



Data flow and handing

The **data acquired by sensors are stored on the internal buoy data logger and are transmitted ashore** at programmable rates (10 min to 2-3 hours, depending on battery status and available data links). **At shore station a terminal encode the data in an e-mail message**, that is sent to authorized addresses (mail box S1 and E1)

DATA STORAGE AND DATA CONTROL

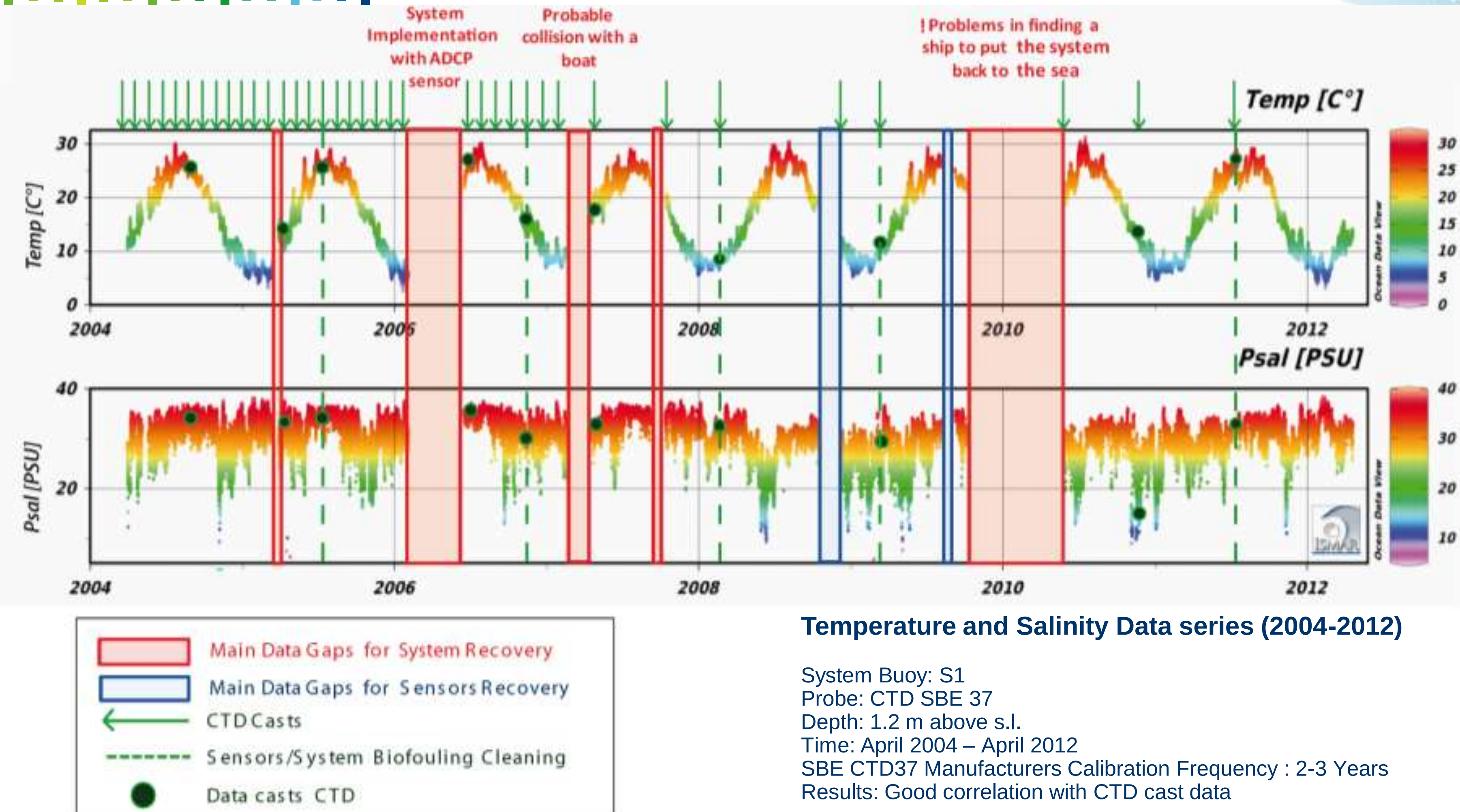
When the data arrive in the authorized mail box, an automatic procedure (implemented using Shell and Perl scripts) filters the data and inserts them in a relational database (MYSQL) on the ISMAR server. Once in the database, data may be retrieved, processed and plotted.

Steps of the automatic procedure in ISMAR server :
1) checks the presence of coded data on the remote mailbox
2) decodes data if coded (header and data) messages are found
3) copies and renames messages and data on both servers (first stage backup)
4) processes buoy data, inserting them in the RDBMS with unique buoy ID's
5) updates user downloadable data files and 'custom' data for authorized access by www, ftp, e-mail or other Internet services
6) updates the daily, weekly and monthly maps and publishes them on the INTERNET
7) logs and sends messages to system administrators and to the project responsible.

When there is data requests from external users, we can be provided three formats:

- **Raw data**: therefore unfiltered;
- **Filtered data**: where we apply (manually or automatic) low pass filter and add *SeaDataNet* flags
- **Calibrated and filtered data**, where we apply a data correction comparing the records with contemporary CTD casts acquired near the system

S1 BUOY: TIME-SERIES, MAIN GAPS, CALIBRATIONS



Temperature and Salinity Data series (2004-2012)

System Buoy: S1
Probe: CTD SBE 37
Depth: 1.2 m above s.l.
Time: April 2004 – April 2012
SBE CTD37 Manufacturers Calibration Frequency : 2-3 Years
Results: Good correlation with CTD cast data

E1 AND S1 BUOY: Sensor and Data Quality

DATA	Sensor	Data validation	Data quality reached	Next step	Technical solutions
Meteo	Aanderaa sensors	Every 6 months with vessel meteo sensors	Good	-	New Metereological Station Gill MetPack Pro with sonic anemometer sensor
Sea water Temperature	CTD SBE 37	Every 6 months with CTD casts	Good	-	CTD intubated with TBTO pill
Sea water Salinity	CTD SBE 37	Every 6 mounths with CTD casts	Good	-	CTD intubated with TBTO pill
Dissolved Oxygen	SBE 43	Every 6 months with calibrated DOX sensor	Good for the first two months following the sensor cleaning by biofouling	• Calibration with Winkler analysis • Greater cleaning frequency by biofouling (2 months)	New optical oxygen sensor (SBE63) intubated with TBTO pill
Sea Water Fluorescence	Scufa II	Every 6 months with calibrate Fluorescence sensor	Good for the first two months following the sensor cleaning by biofouling	• Calibration with Winkler analysis • Greater cleaning frequency by biofouling (2 months)	New fluorescence optical sensor with Bio-wiper system and copper face plate
Sea Water Turbidity	OBS3+	Every 6 months with calibrate Fluorescence sensor	Good for the first two months following the sensor cleaning by biofouling	Greater cleaning frequency by biofouling (2 months)	New turbidity optical sensor with Bio-wiper system and copper face plate
Current Speed & Direction	ADCP RDI DCS Aanderaa 3900	Every 6 mounths with vessel ADCP	Good for the 2-3 mouths after the sensor cleaning by biofouling	Greater cleaning frequency by biofouling (2 months)	-
Sea Water pH	SBE 27	Every 6 months with calibrated Ph sensor	Problematic	Sensor removed	-

OPEN PROBLEM: Biofouling

Both buoys are located in high productivity areas, and biofouling causes many problems to the stations:

- ➢Alter the buoyancy of the system;
- ➢Alter the quality of the acquired data;
- ➢Creates problems for connectors and cables.

S1 Buoy after one year at sea

Particular Water suction pipe of E1 CTD SBE 37 after one year at sea

E1 Buoy I° Level after one year at sea

S1 Buoy: ADCP Sensor after one year on the sea bottom

Technical solutions adopted against the biofouling

- Using a mix of Duct tape and stretchable food-grade plastic films wrapped all around instrumentation and connectors (Figure 1).
  Good solution to protect sensors body and connectors from biofouling deposits.

- Sensors intubation in a single closed hydraulic circuit, served by the same pump, with a TBTO pill in the entrance tube (Figure 2).
  Good solution in the short and medium term.

- Bio-wiper system (mechanical brush) and copper face plate (commercial system, Figure 3).
  New system. After 45 days of its application the device seems to work properly

But so far, the most effective anti-biofouling system is a periodical (each 2-3 months) manual cleaning of the sensors and an annual cleaning of the system (Figure 4).


Fig. 1

Fig. 3


Fig. 2

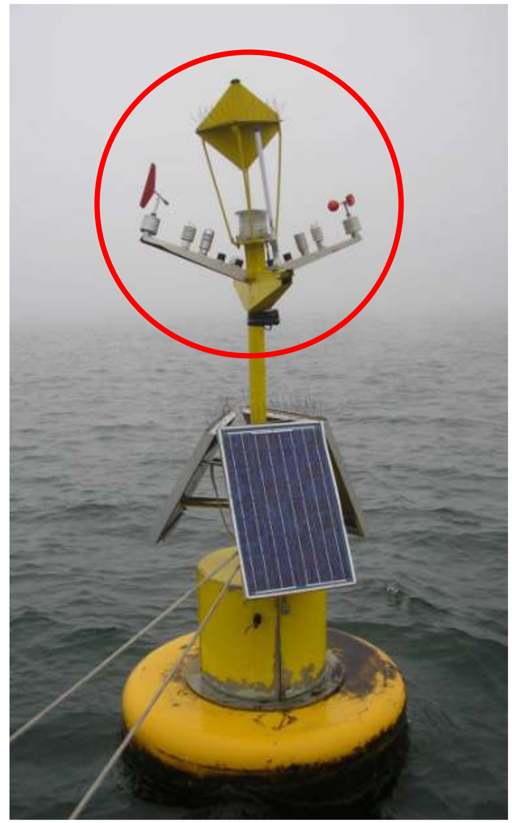

Fig. 4

OPEN PROBLEM: System vulnerability

Buoys are placed in areas subjected to intense fishing and anthropic activities.
The traffic of boats near the stations, may occasionally produce collisions with the structures causing multiple damages such as:

- Loss of the anchor;
- Breaking of connecting cables of sensors near the bottom;
- Damages of the structure (e.g. solar panels, Meteorological mast, body buoy, etc.);
- Damages of the sensors.

S1 Buoy: Damage to the meteorological mast



E1 Buoy: Damage to the meteorological mast

E1 Buoy: Problems to solar pannels (breakage or theft)

Further problems are caused by private boats, which anchor near the buoys or hook up directly to the buoy. The buoys are not protected by guardian buoys, however they are moored in prohibited area controlled by Coast Guard and their presence is marked on nautical charts.

POSSIBLE SOLUTION: Transition to Elastic Beacon

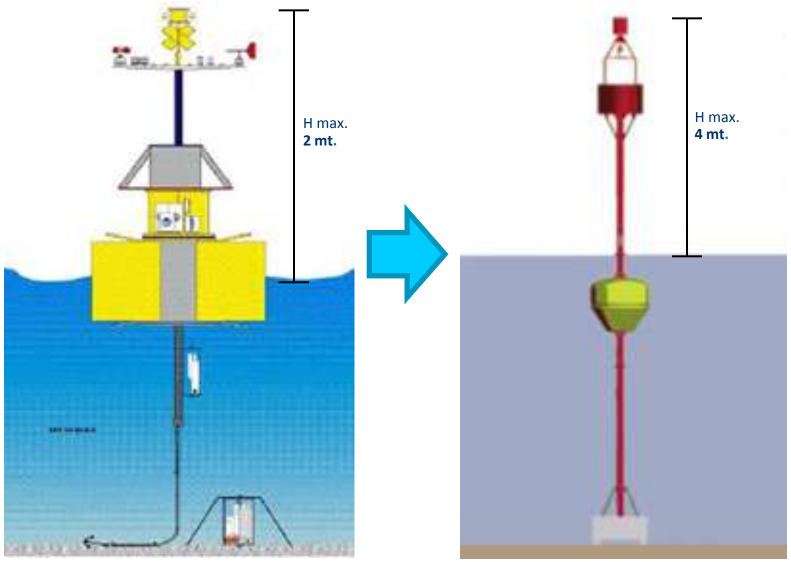
The system transition from buoy to floating elastic beacon could solve many of the problems occurred at stations E1 and S1 between 2004 and 2012

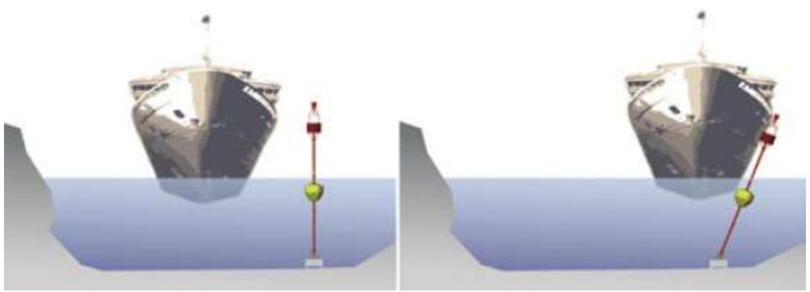
Elastic beacon installation advantages:

- More protection and stability on bottom level instrumentation;
- Reduced vulnerability of the anchorage and greater protection of submerged data transmission cables;
- Less vulnerability to collisions with boats;
- Greater stability of the installation -> Facilitation in the sensors maintenance procedures;
- Increased visibility of the installation (H max on s.l. 4 mt.)
- Reduced vulnerability of weather sensors ;
- Limited possibility of sensors and instrumentation flooding

The transition to the elastic beacon will impose alternative solutions for the surface oceanographic sensors: sensors basket under wave motion level (3-4 m.) and tides level (1.5 m.).

Current installation | Transition to Elastic beacon



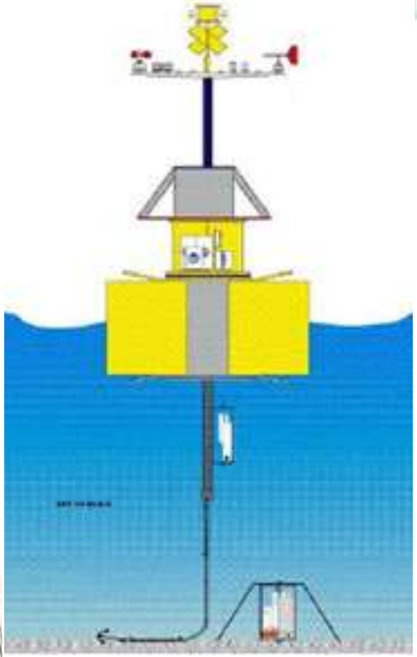


CNR buoys in the North Adriatic Sea

OPEN PROBLEM: Bottom Sensors Vulnerability

In the years we've been trying some technical solutions in order to install a sensors basket on (or near) the sea bottom of buoy E1 and buoy S1 (e.g. Tripod near the anchor, Sensors on the chain, etc.).
These attempts produced, however, various problems over the years, including:

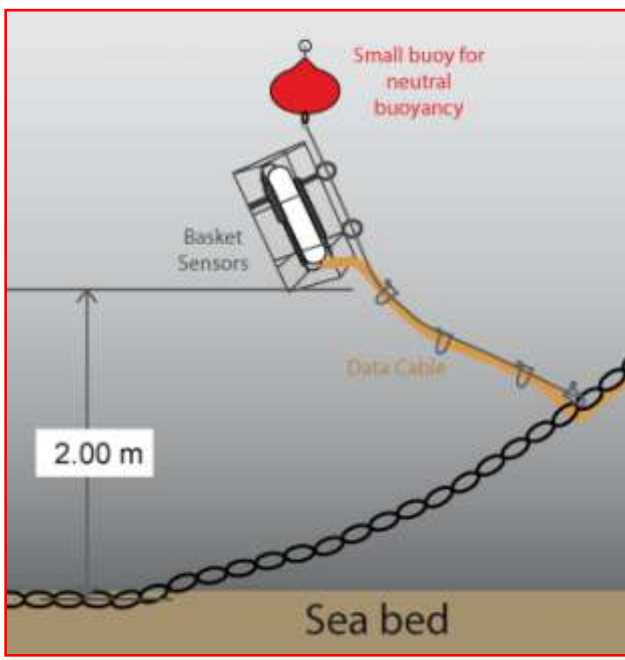
- Partial burial of the sensors placed on the tripod anchor;
- Breaking of the cables communicating with the surface;
- Difficulty in recovering the buoy bottom sensors (which requires fully equipped vessels and sub team);
- Bottom sensors collision with the buoy anchoring chain.

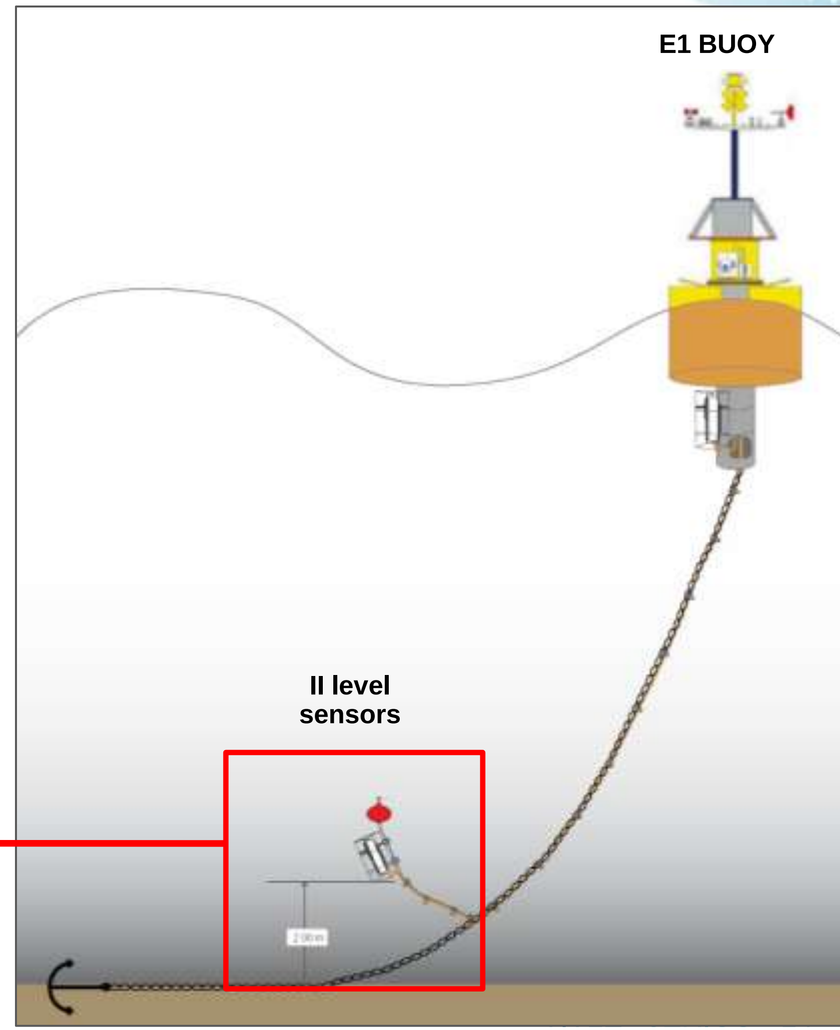


S1 Buoy: ADCP Tripod installation

SOLUTION *(in progress):* Floating basket sensors

To date, we adopted an alternative technical solution: a floating sensors basket, placed at about two meters far from the seabed; the basket is attached through a steel cable to the anchor chain (with a little buoy at the end). This whole system, is able to brake the basket sensors in case of sudden movements of the chain.





S1 BUOY: SHORT TERM SYSTEM DEVELOPMENTS

In the next two months, the station S1 will be recovered and brought back to the laboratories of the ISMAR-CNR (Bologna) for the routine sensors calibration, the system reset and the implementation of the sensor package.

By the end of **November**, the installation S1 will be equipped with the new sensors (see below) in addition to those already in use.

New Ultrasonic Anemometers will replace the two old wind sensors:

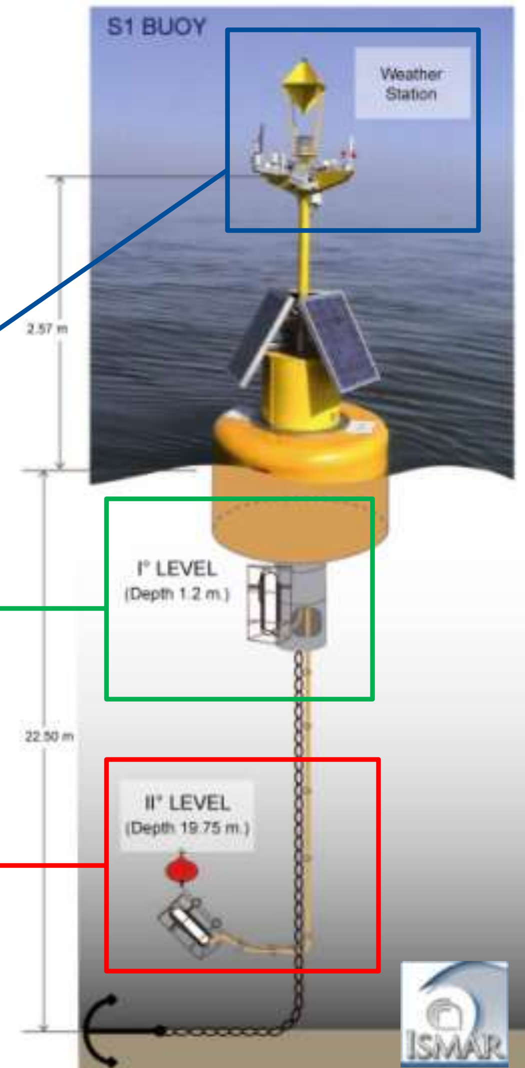
- Wind sonic 2-axis, Gill — Wind Speed and Direction

I° LEVEL implementation (1.2 m. below the sea level):

- SBE 63 (D.O. Optical) — Dissolved Oxygen
- WetLabs Eco-Triplet — Chlorophyll, CDOM and Scattering

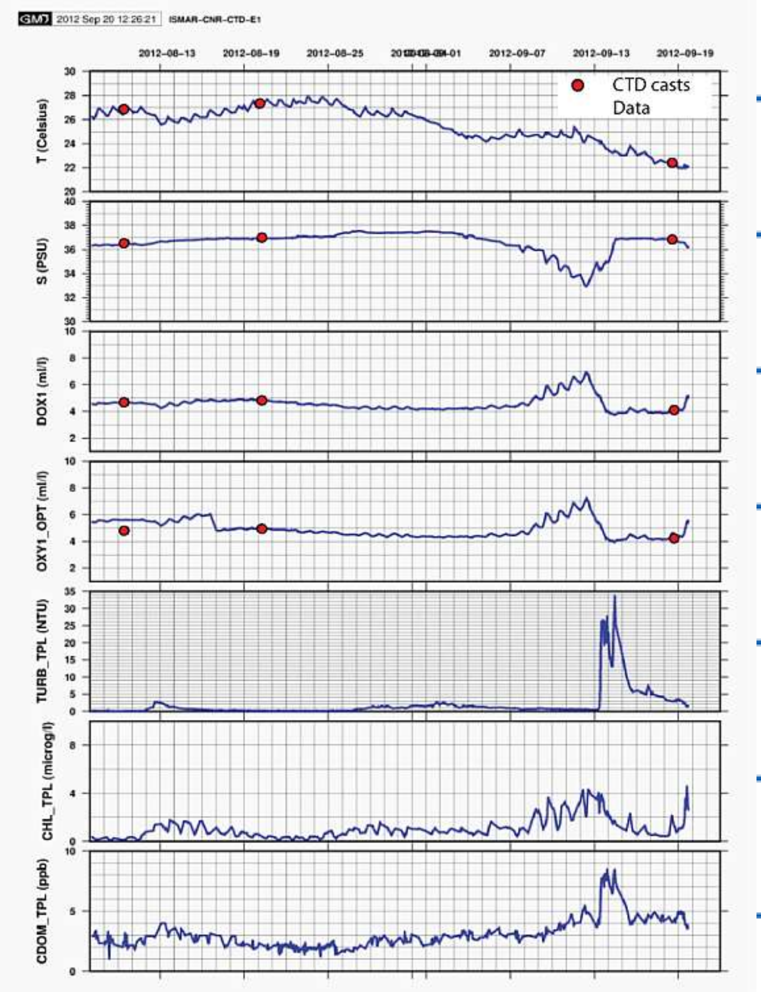
NEW II° LEVEL Basket Sensors (19.75 m. below the sea level):

- CTD SBE 37 — Water Temperature and Salinity
- SBE 43 — Dissolved Oxygen



E1 BUOY: EXAMPLE OF DATA ACQUIRED

Recent data acquired after implementing the new system



Data between 08/08/2012 and 20/09/2012

Temperature 1.3 m below sea level (Probe CTD SBE 37)

Salinity 1.3 m below sea level (Probe CTD SBE 37)

Dissoved oxygen 1.3 m below sea level (SBE 43, Membrane sensor)

Dissoved oxygen 1.3 m below sea level (SBE 63, Optical sensor)

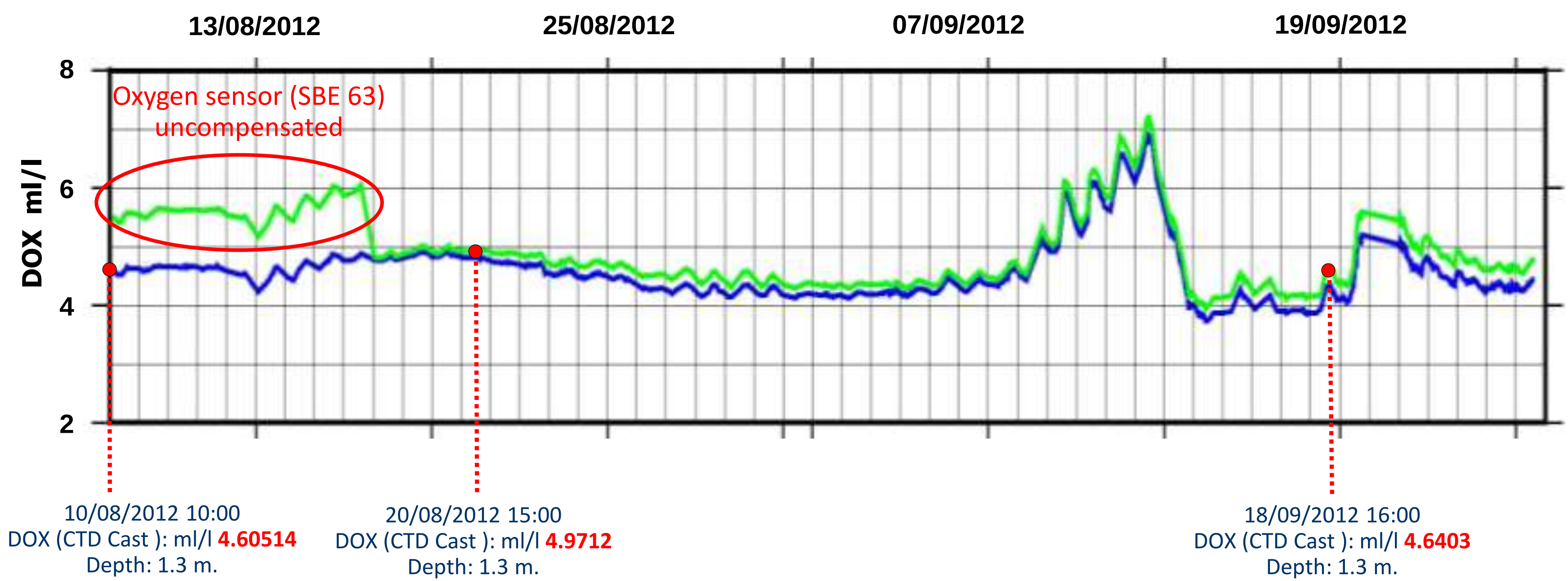
Turbidity 1.3 m below the sea level (ECO-Triplet Optical sensor, *Tecnopolo-Proambiente ,ISAC*)

Chlorophyll 1.3 m below the sea level (ECO-Triplet Optical sensor, *Tecnopolo-Proambiente,ISAC)*

CDOM 1.3 m below the sea level (ECO-Triplet Optical sensor, *Tecnopolo-Proambiente, ISAC*)

E1 BUOY: OPTICAL VS MEMBRANE OXYGEN SENSOR

Comparison data between **Membrane oxygen SBE 43**, **Optical oxygen sensor SBE 63** (Depth 1.3 above sl) and **Membrane oxygen SBE 43 on CTD casts**



After 40 days:
- the data acquired by the SBE 43 Oxygen sensor display a shift of -0.3 ml/l when compared to the CTD data
-the data acquired by the SBE 63 Oxygen sensor are in agreement with the CTD data

E1 AND S1 BUOY: Sensors and System Maintenance

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Sensors regular maintenance:

Sensors/Probes	Buoy	Real Frequency	Optimal Frequency	Activity	Facilities Required
Meteo Sensors	S1	12 months	12 months	Oil wind sensors and data test	Motor boat
	S1	12 months	12 months		
CTD SBE 37	E1	8/12 months	6/8 months	Sensors cleaning to biofouling, change TBTO pill and data test	Vessel or scuba team
	S1	6/12 months	6 months		
Optical Sensors (OBS3+, Scufa II)	E1	8/12 months	2/3 months	Sensors cleaning to biofouling, and data test	Vessel or scuba team
	S1	6/12 months	2 months		
Chemical sensor (SBE43)	E1	8/12 months	1-2 months	Sensors cleaning to biofouling and data test	Vessel or scuba team
	S1	6/12 months	1-2 months		
Current meters (ADCP and DCS)	E1	8/12 months	2-3 months	Sensors cleaning to biofouling and data test	Vessel or scuba team
	S1	6/12 months	2-3 months		

Usually the biofouling cleaning operation are performed lifting the buoy on CNR vessel (R/V Urania or R/V Dallaporta). This process usually takes 1-2 days of work, during this period other research activities are done.

System recovery:

Buoy	Real Frequency	Optimal Frequency	Activity	Facilities Required
E1	2-3 years	1-2 years	Sensors substitution or calibration; system update and check	Vessel
S1	2 years	1-2 years	sensors substitution/calibration; system update and check	Vessel

The need for fully equipped ships and the lack of funding are the main problems, especially in case of un expected events (e.g. system damages). Organizing a recovery without a CNR ship might be very expensive.