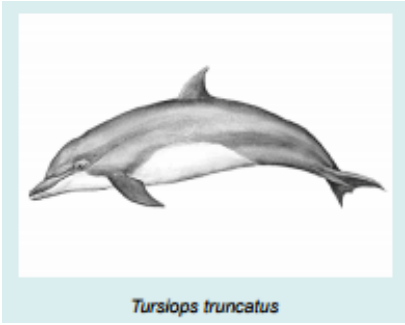

Tursiops truncatus


Portofino lighthouse

Statistical evaluation of the background signal in acoustic data from ARION project

Alessi J [2], Bianchi C.N. [2], Bozzini G. [1], Brunoldi M. [1], Cappanera V. [3], Casale A. [1], Cavalleri O. [1], Corvisiero P. [1], Fanciulli G. [3], Grosso D. [1], Magnoli N. [1], Mandich H [2] ,Melchiorre C. [4] , Morri C. [2], Pesce A. [1], Povero P. [2], Stasi N. [5], Taiuti M. [1], Viano G. [4], Wurtz M. [2]

1. **University of Genoa - DIFI** (Italy)
2. **University of Genoa - DISTAV** (Italy)
3. **Portofino MPA**, Genoa (Italy)
4. **Softeco Sismat**, Genoa (Italy)
5. **Capitaneria di porto** (Italy)

Introduction

ARION project aim is:
to protect dolphins and boats, while preserving human activities, mainly preventing collisions

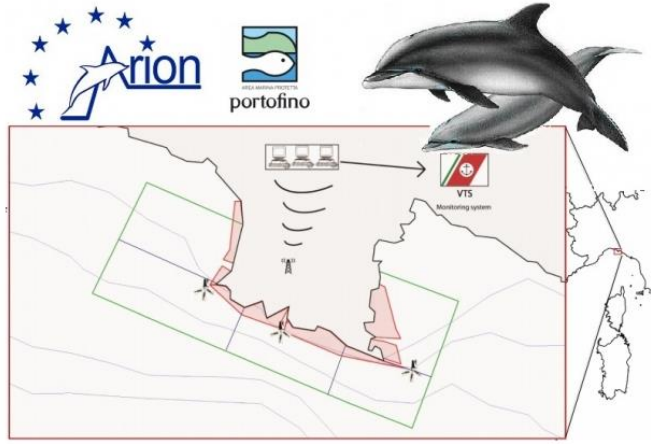
To achieve this goal it is necessary to track both and to signal the presence of the dolphins to possibly any subject operating in the protected area.

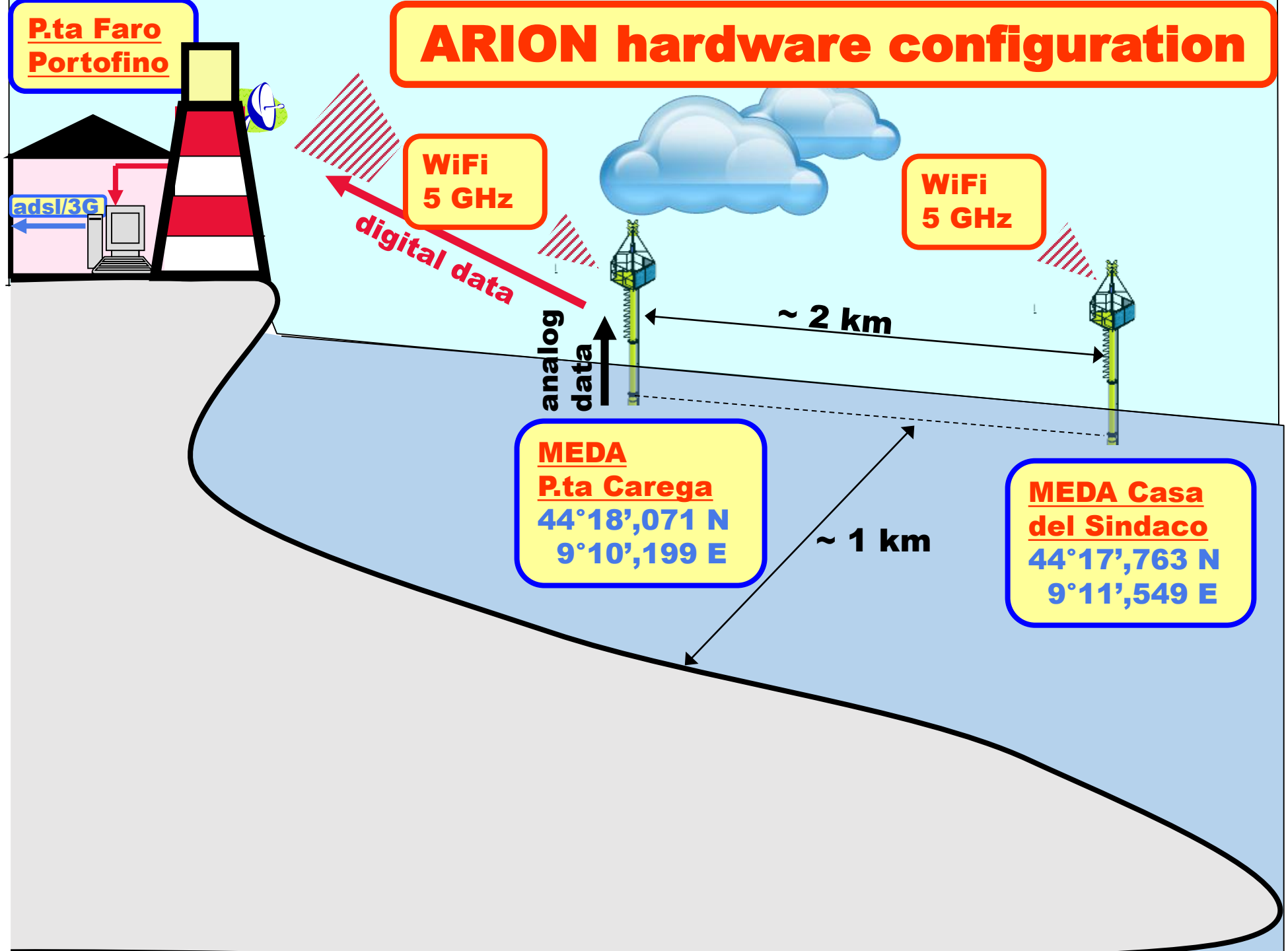
Two buoys with four hydrophones each, installed in Santa Margherita-Portofino marine protected area, collect data transmitted to a ground station

At an early stage of the project, knowing there were few data available, we decide to monitor even “background” noise
(from boat, sea, other natural sources…)

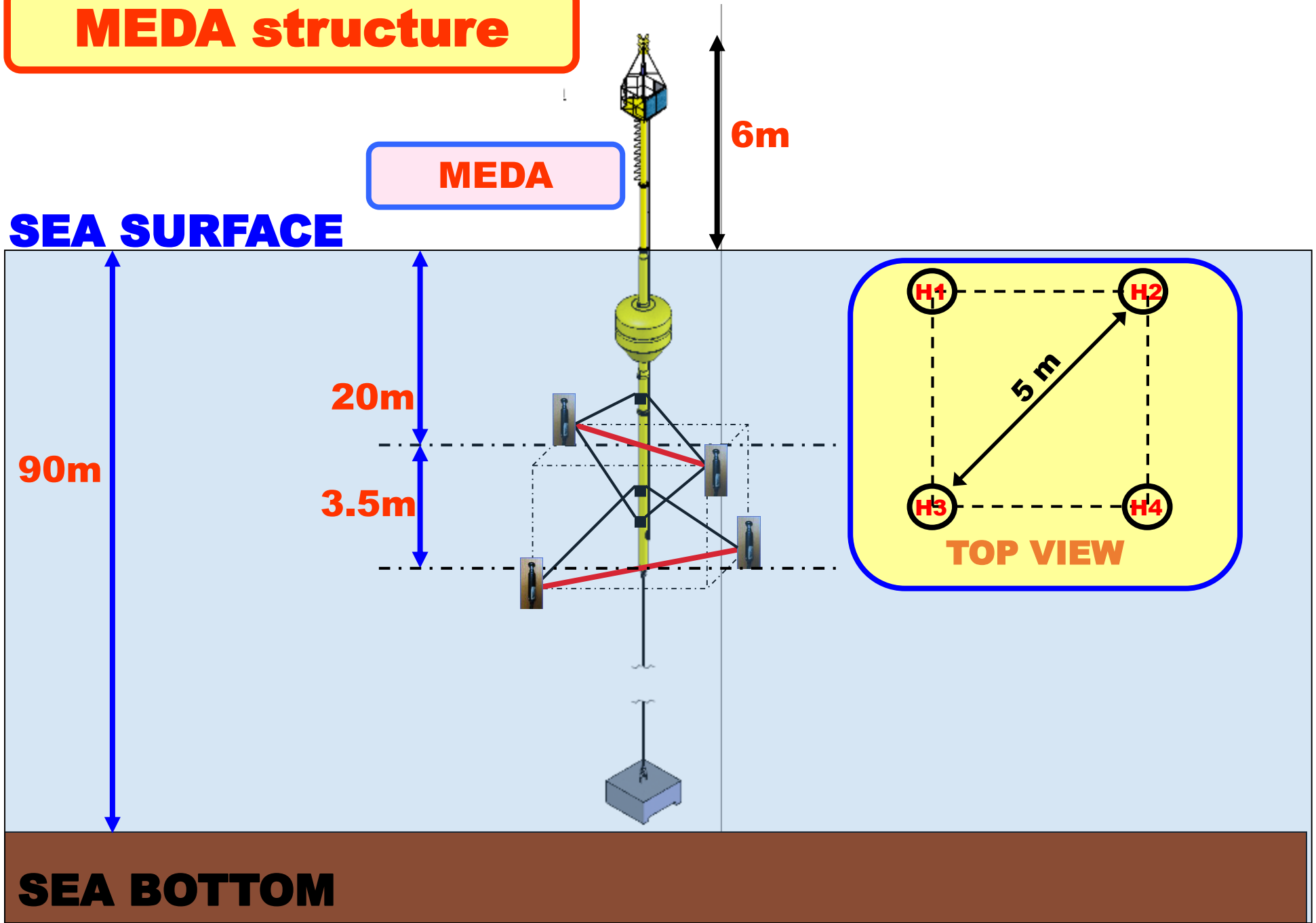
The average power of noise background is at the same time a parameter affecting resolution and an indicator of “noise pollution”

The equivalent sea state noise is calculated from this parameter and compared against Wentz curves




ARION hardware configuration
P.ta Faro
Portofino
adsl/3G
WiFi
5 GHz
digital data
WiFi
5 GHz
~ 2 km
analog
data
MEDA
P.ta Carega
44°18',071 N
9°10',199 E
~ 1 km
MEDA Casa
del Sindaco
44°17',763 N
9°11',549 E

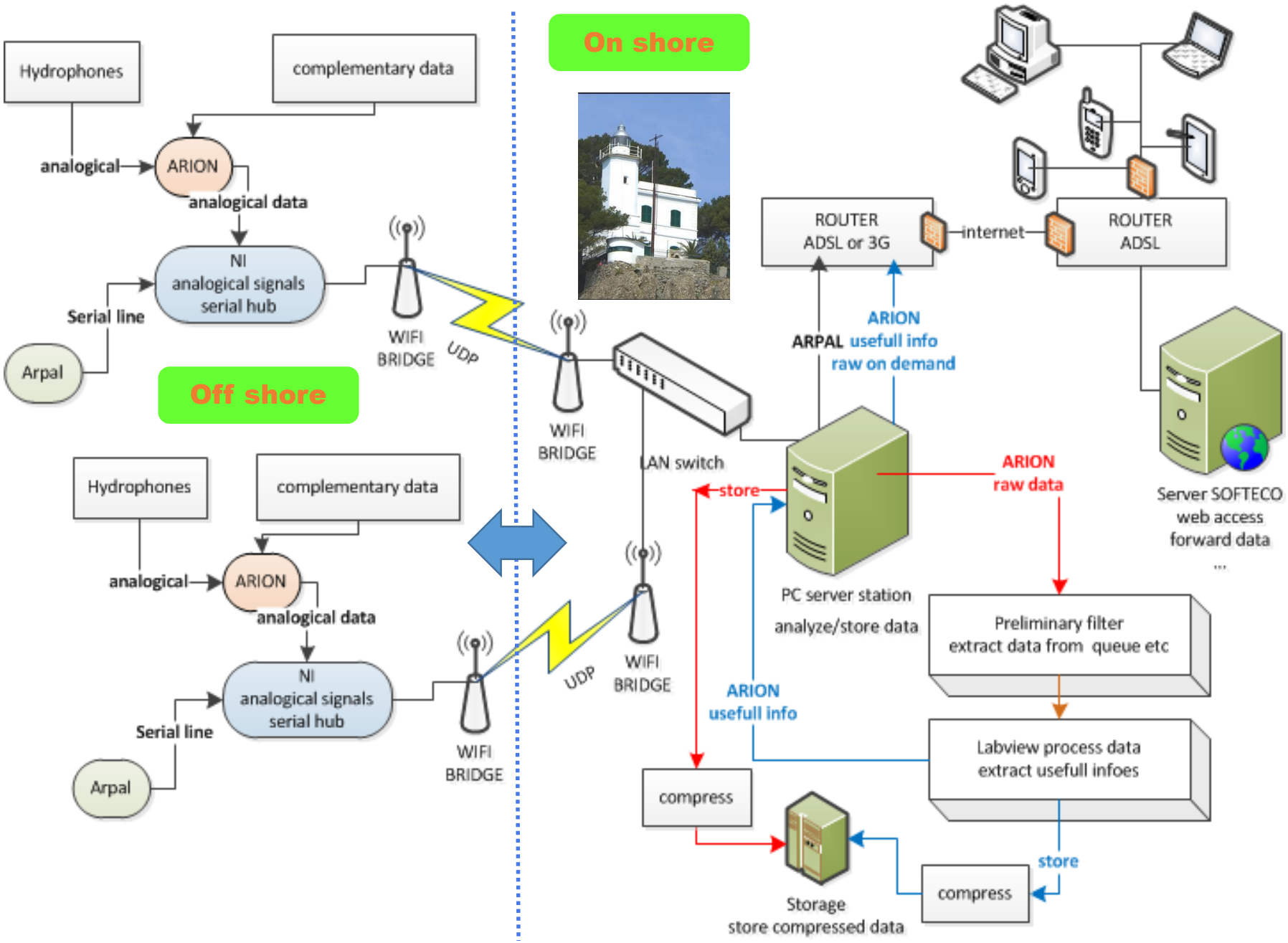
MEDA structure



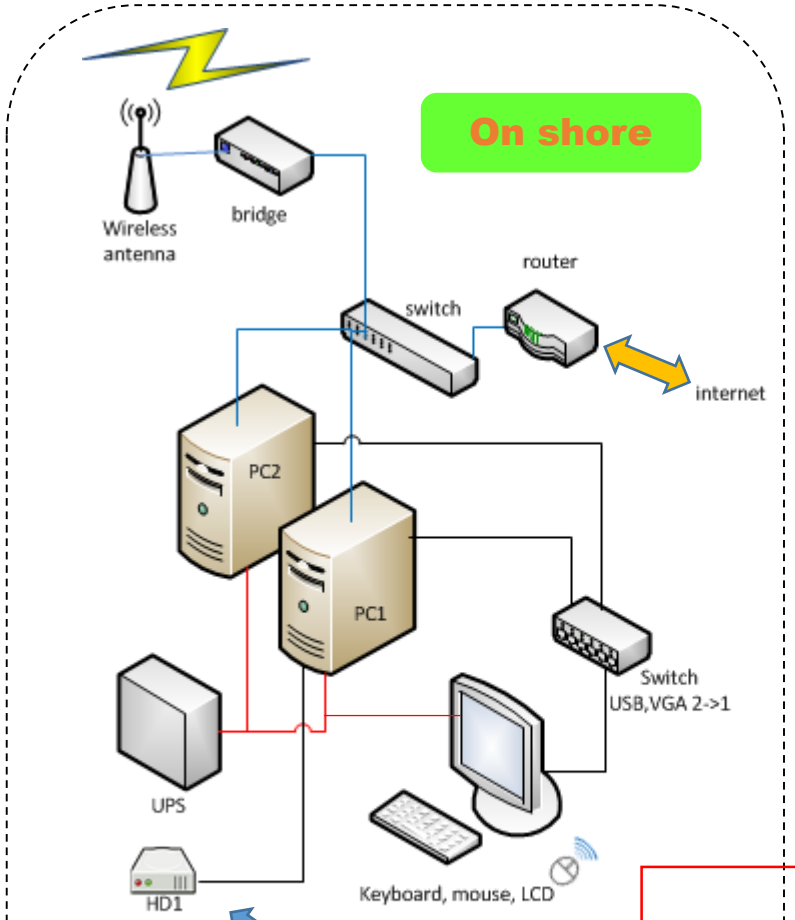
Following data flow: how it works

Off shore

On shore



hardware installed on shore (at the lighthouse)



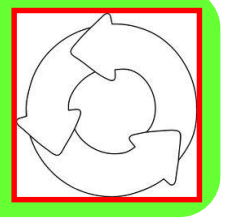
High Data Availability:
- **PC1 collects and store data** (normal mode)
- **PC2 is PC1 mirror in *watchdog mode***

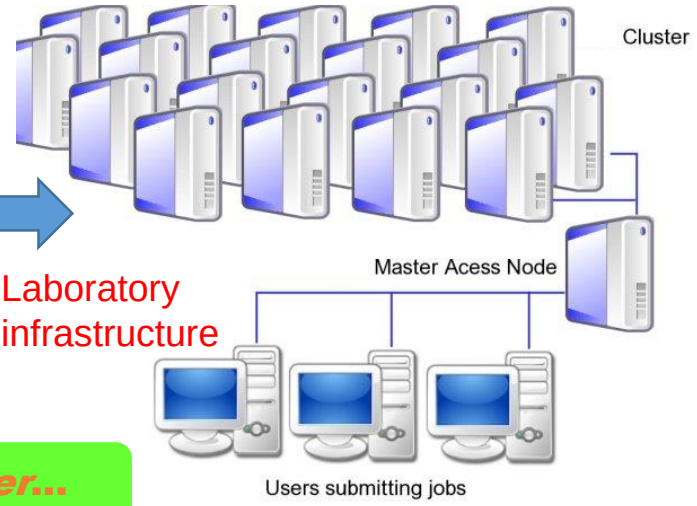
if PC1 is unreachable =>
PC2 restart in normal mode

2 PC with:
- 8Gb RAM
- 100Gb SSD HD buffer
- HD sata 2Tb

hub usb, router switch 1Gb etch. LCD, keyboard, mouse, ADSL...

3 USB3 portable HD:
1. at the lighthouse
2. on the road (lighthouse-laboratory)
3. Laboratory (to storage unit)



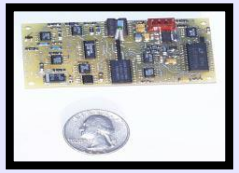


4 units 15Tb storage, raid 5 + *a cluster*...

water-tight instrum box

Data acq
Serial com
GPS sync

filter-
amplif
board



tilt-
heading

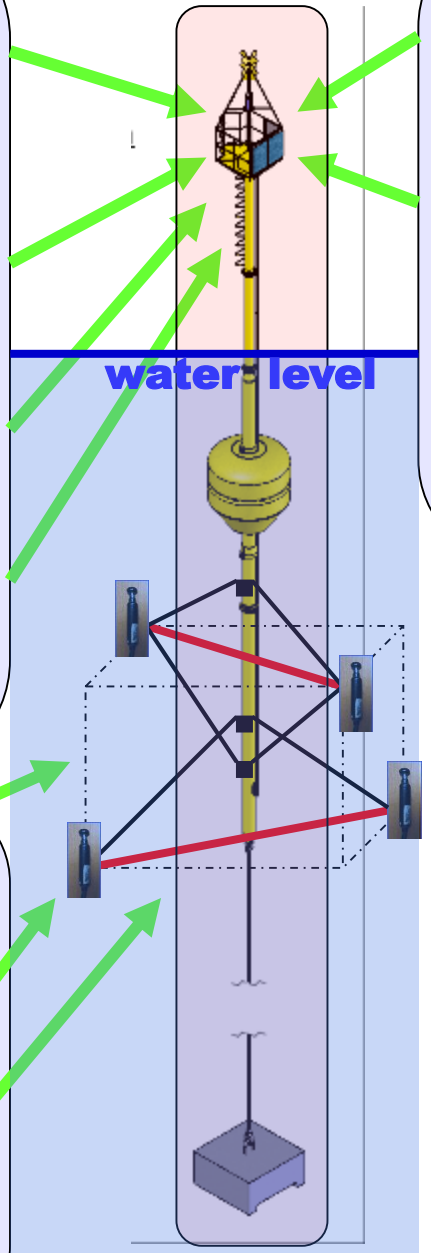
batteries
& ch reg

underwater instrum

current-
wave
meter

idrofoni

CTD sensor



WiFi
radio
transmis
sion

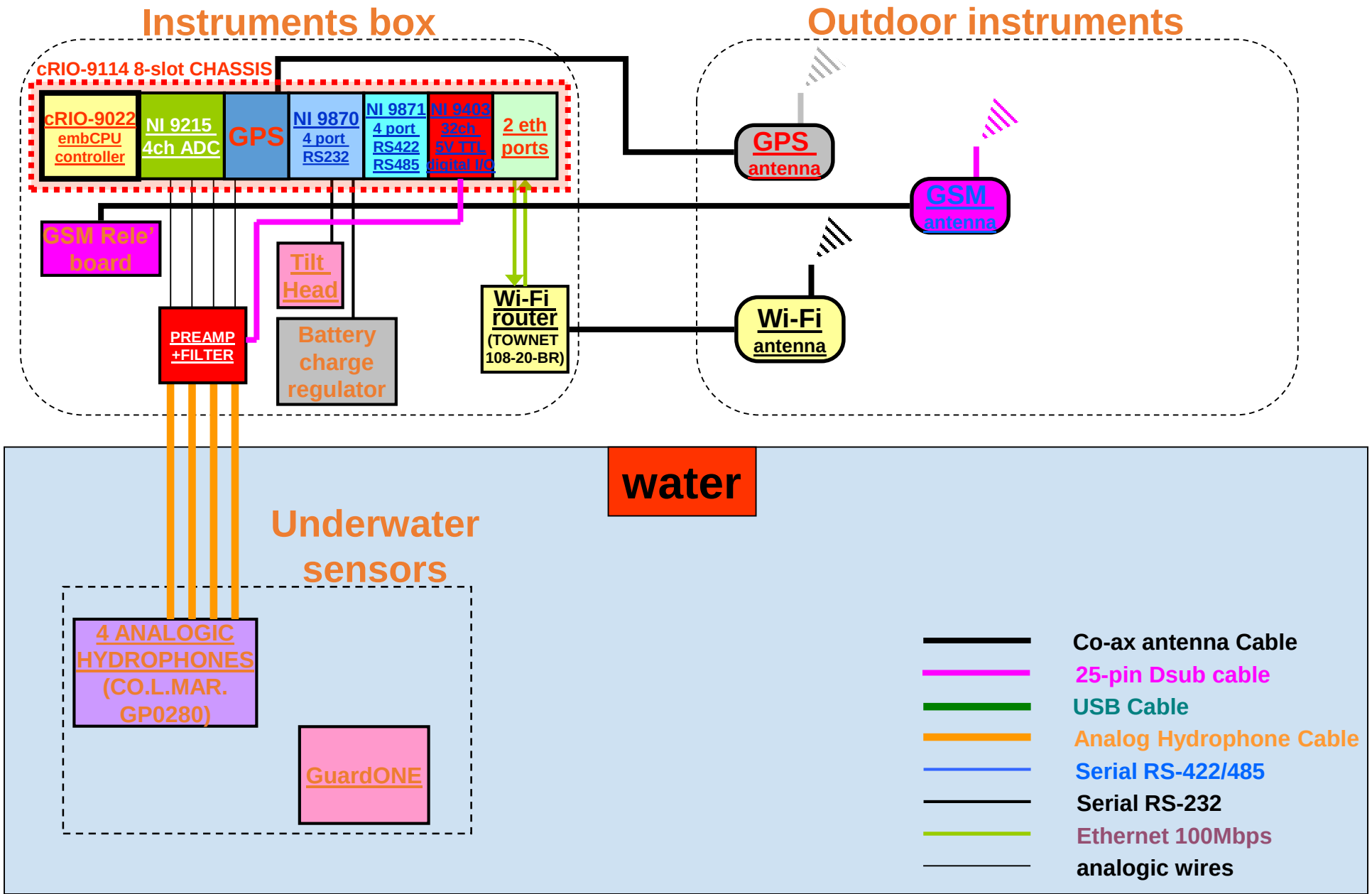
Photov
panel
~40 W

meteo station
air pressure,T,hum
wind speed and dir

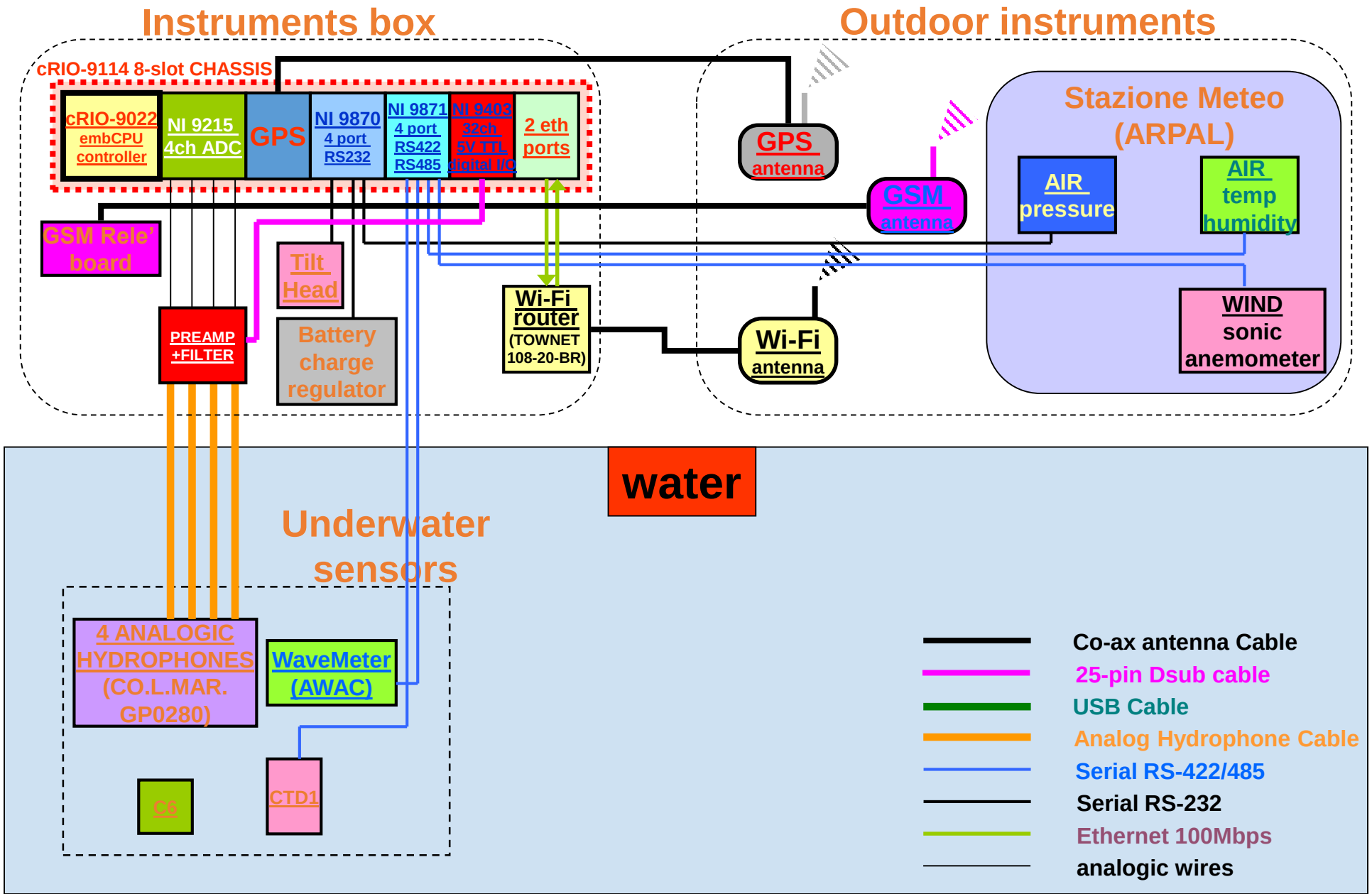
outdoor instrum

MEDA hardware

MEDA-Carega

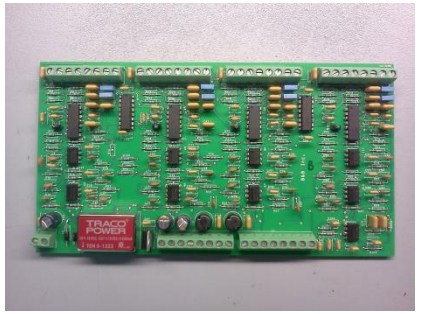

Instruments box
Outdoor instruments
cRIO-9114 8-slot CHASSIS
cRIO-9022
embCPU
controller
NI 9215
4ch ADC
GPS
NI 9870
4 port
RS232
NI 9871
4 port
RS422
RS485
NI 9403
32ch
5V TTL
digital I/O
2 eth
ports
GPS
antenna
GSM
antenna
GSM Rele' board
Tilt Head
Wi-Fi
router
(TOWNET
108-20-BR)
Wi-Fi
antenna
PREAMP
+FILTER
Battery
charge
regulator
water
Underwater
sensors
4 ANALOGIC
HYDROPHONES
(CO.L.MAR.
GP0280)
GuardONE
Co-ax antenna Cable
25-pin Dsub cable
USB Cable
Analog Hydrophone Cable
Serial RS-422/485
Serial RS-232
Ethernet 100Mbps
analogic wires

MEDA-Sindaco



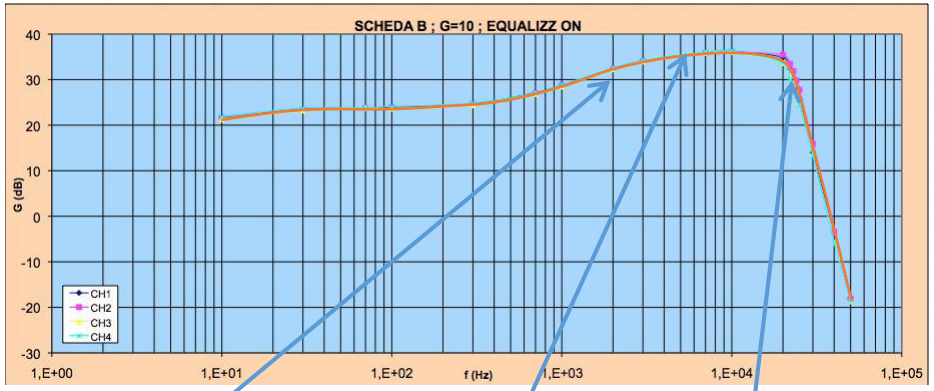
hydrophones

home-made filter/amplifier PCB



onboard PC with ADC

- hydrophone sensitivity: -199 dB re 1V/uPa @10kHz
- hydrophone pre-amp gain: 36 dB @5kHz



ADC: 4-channel, single clock, 16 bit, +-10V range, up to 100 kS/s

sea-noise equalizing high-pass filter (-3dB @3kHz)

Antialiasing 8-poles Sallen-Key low-pass filter (-3dB @23kHz)

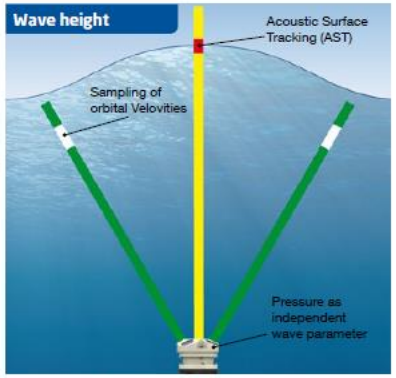
Band-pass zone gain: 36,28 dB

NORTEK Acoustic Wave And Current Profiler (AWAC)

The Nortek Acoustic Wave and Current profiler (AWAC) performs «triple duty»:
It measures wave height, wave direction and the full current profile.
The system can resolve waves from 1 to 100s, a capability that is unique to the Nortek AWAC.

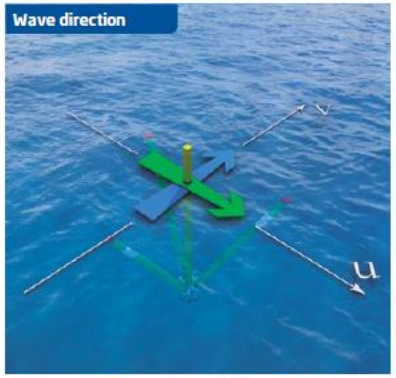
AWAC
Acoustic Wave And Current Profiler

Wave height



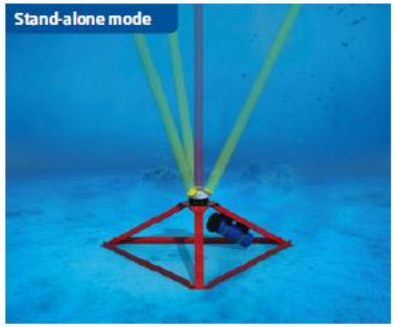
The AWAC measures wave height and period using the unique acoustic surface tracking (AST) feature. A short acoustic pulse is transmitted vertically toward the water surface, and the time lag between the transmitted ping and its reflection is used to generate a time series of the surface elevation.

Wave direction



Wave direction is calculated by combining AST with orbital velocity measurements in an array near the surface. The four point array data can be processesed with the maximum likelihood method to generate accurate directional wave spectra. For AWACs mounted on subsurface buoys, the patented SUV processing can be used to generate similar results from deep ocean moorings.

Stand-alone mode



In stand-alone mode, the AWAC is deployed with an external battery canister that supplies power. Raw data recorded to internal memory can be downloaded to a PC once the instrument is recovered. The maximum duration of the deployment depends on the size of the internal recorder and the number and the type of batteries that are used.

Online data

The AWAC can transmit raw or processed data to shore if the instrument is connected via cable or a suitable data modem. Data can be displayed using the SeaState software and made publicly available through custom WEB solutions.

CURRENT AND WAVE MEASUREMENTS IN THE OCEAN, LAKE AND LABORATORY

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1351 Rud, Norway
Tel: +47 6717 4500
Fax: +47 6713 6770
E-mail: inquiry@nortek.no

www.nortek-as.com
True innovation makes a difference

AWAC a small revolution in ocean wave measurements

With the Nortek AWAC, you get a current profiler and a wave directional system in one unit. You can measure the current speed and direction in 1-meter thick layers from the bottom to the surface. Waves of all varieties are measureable; this includes long waves, storm waves, short wind waves, or transient waves generated by local ship traffic.

The AWAC is designed as a coastal monitoring system. It is small, rugged, and suitable for multi-year operation in tough environments. The mechanical design is all plastic and titanium to avoid corrosion. The AWAC is available in three transmit frequencies (1 MHz / 600 kHz /400 kHz) which allow for different deployment depths.

The sensor is usually mounted in a frame on the bottom, where it is protected from complications at the surface such as harsh weather, vandalism, and ship traffic. While safely located at the bottom, it is operated in online or in stand-alone mode.

In stand-alone mode, the raw data are stored to the internal data logger and power comes from an external battery pack. A variety of options are available with maximum deployment lengths of 12 months with hourly wave data when using lithium batteries.

Online systems have a variety of possible communication configurations. The most common are long, offshore cables (max. 5 km) or acoustic modems. Online systems can be delivered with backup batteries, protected cables, shore side interface units, and online software.

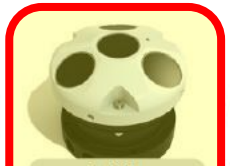
AST breakthrough
The AWACs extraordinary wave performance has largely to do with the Acoustic Surface Tracking (AST). The AST is based on echo-ranging to the surface with the vertically oriented transducer. The beauty of this method of measuring waves is that it circumvents the depth limitations imposed by bottom mounted pressure and velocity measurements. Long waves (swell) and storm waves are rarely difficult to measure, however waves generated by local winds are challenging without AST. Moreover, the AST also gives you the ability to derive wave parameters based on times series analyses. This means that the AWAC can directly measure wave parameters such as Hmax, H1/10, Tmean, etc. which other bottom mounted systems simply cannot.

Tidal elevation with improved pressure sensor
From the spring of 2011, an improved pressure sensor with an absolute accuracy of 0.1% of full scale is available for the AWAC. For a deployment depth of 20 m (and a 50m full scale sensor), this means the absolute accuracy of the sensor is 5 cm, which is within the requirements for many operational harbor systems

Software
The AWAC software is used to configure the instrument for deployment, retrieve the data, and convert all raw data files to ASCII. In order to calculate the wave parameters, you have the choice between the non-graphical QuickWave software and the graphical Storm software. For online systems which require data management and generating content for internet use (e.g. processed results and graphical plots), the SeaState software serves as the link for all your AWAC wave and current data.

New AWAC features

- 400 kHz version of the AWAC
- ProLog Internal Processor
- Special Ice detection algorithm
- Improved pressure sensor
- SeaState 2.0 for online data collection


1 MHz

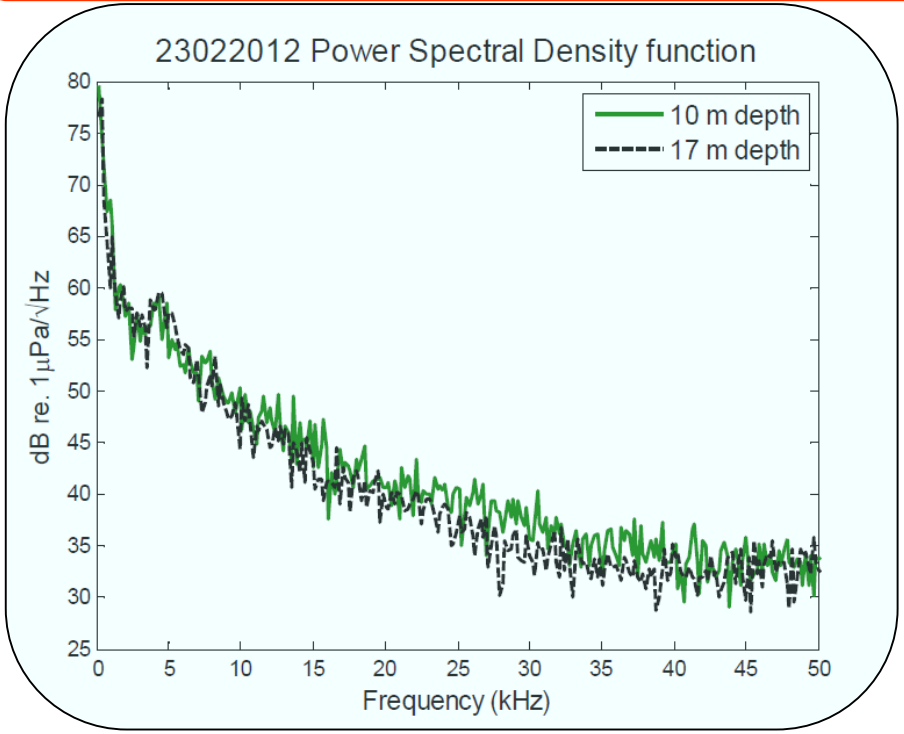

600 kHz


400 kHz


Platform mount

MISURA SEA-NOISE

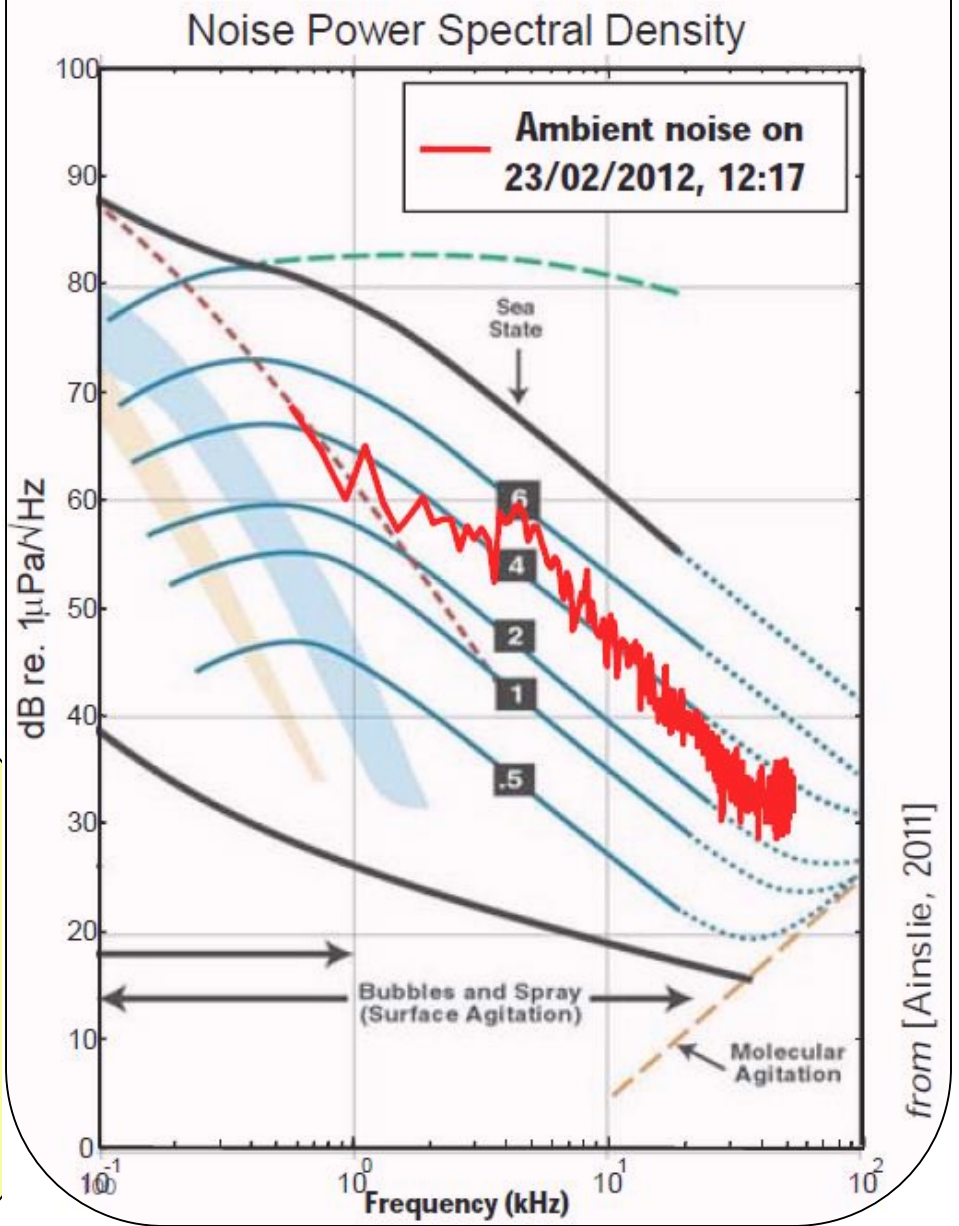
23 Feb 2012

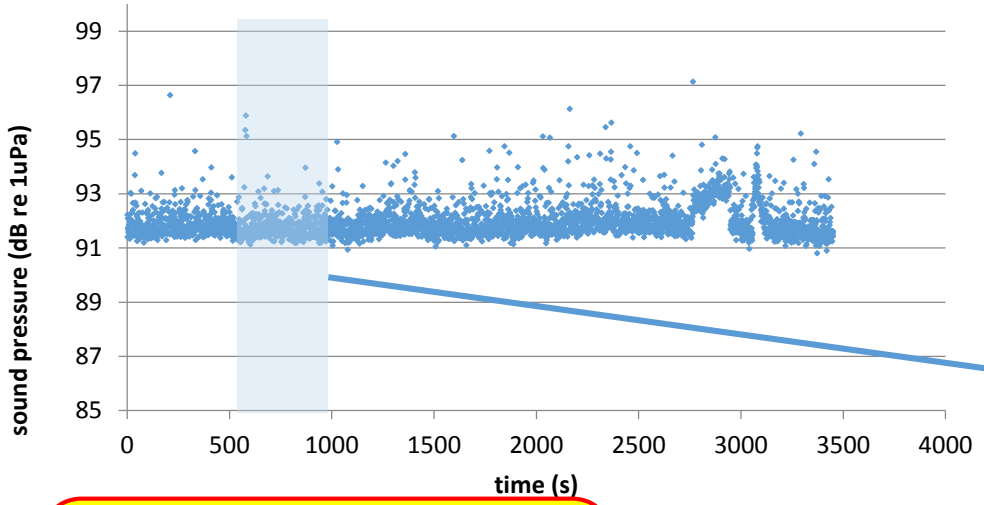


eseguite misure sea-noise
- **depth: -10m e -17m**
- **sea-state apparente: 2-3**
- **sea-state misurato : 3-4**

livello di sea-noise misurato e' risultato maggiore rispetto alle curve teoriche

Wenz curve *vs* data comparison





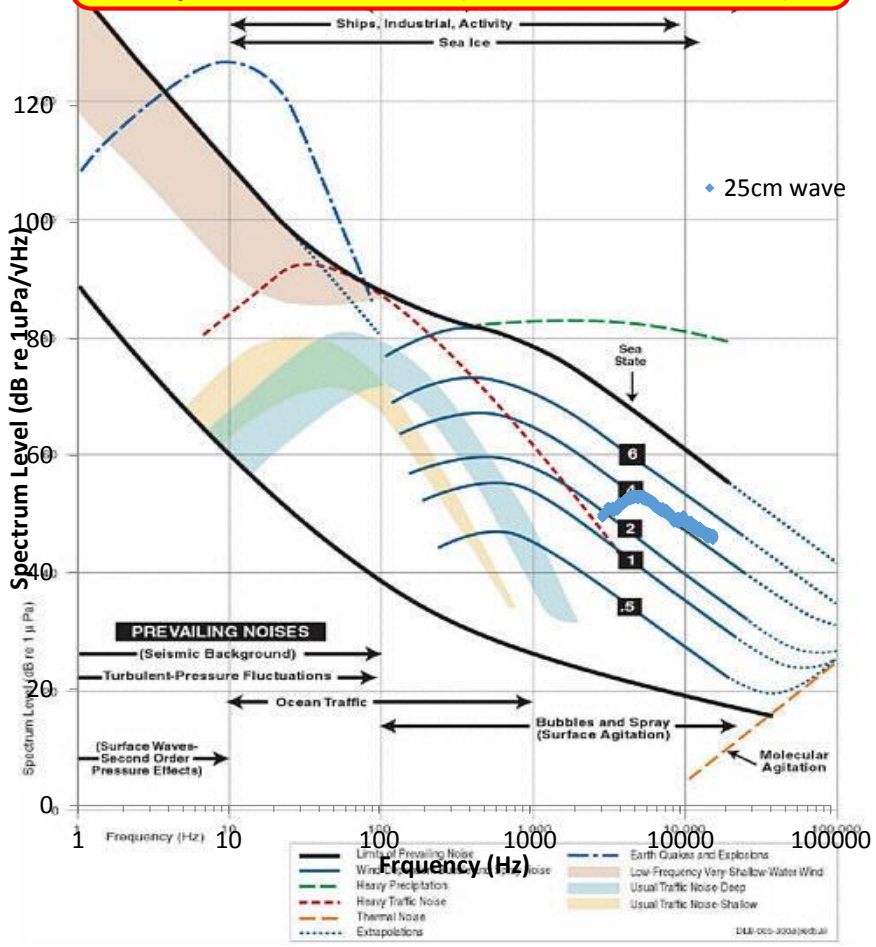
15-03-2014

from 00:02 to 01:02 UTC

wave height: **25 cm**

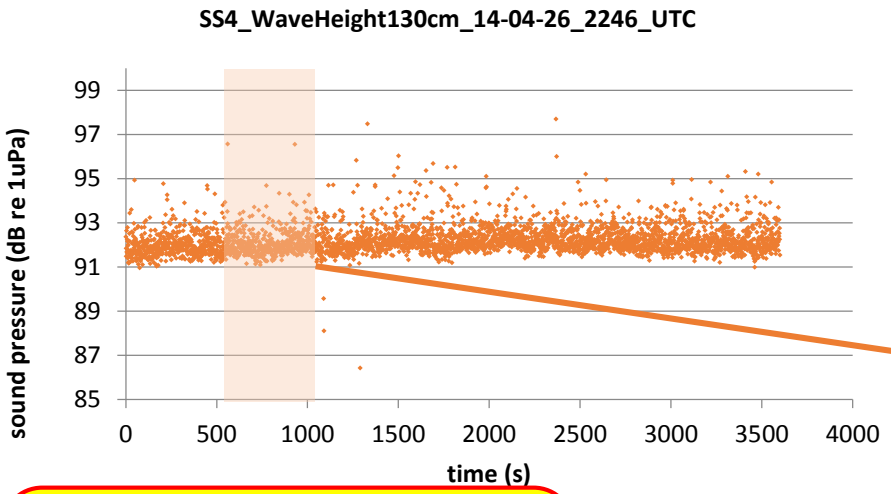
- Sea ambient noise pressure (dB re 1uPa)
- 1 hour recording
- 4 hydrophone average

- 500 s portion, flat pressure
- spectrum level (dB re 1 uPa/√Hz)



RESULTS

- Wave height recorded by wavemeter:25 cm → SS2
- Spectrum level recorded: corresponds to SS4 (Wenz curves)



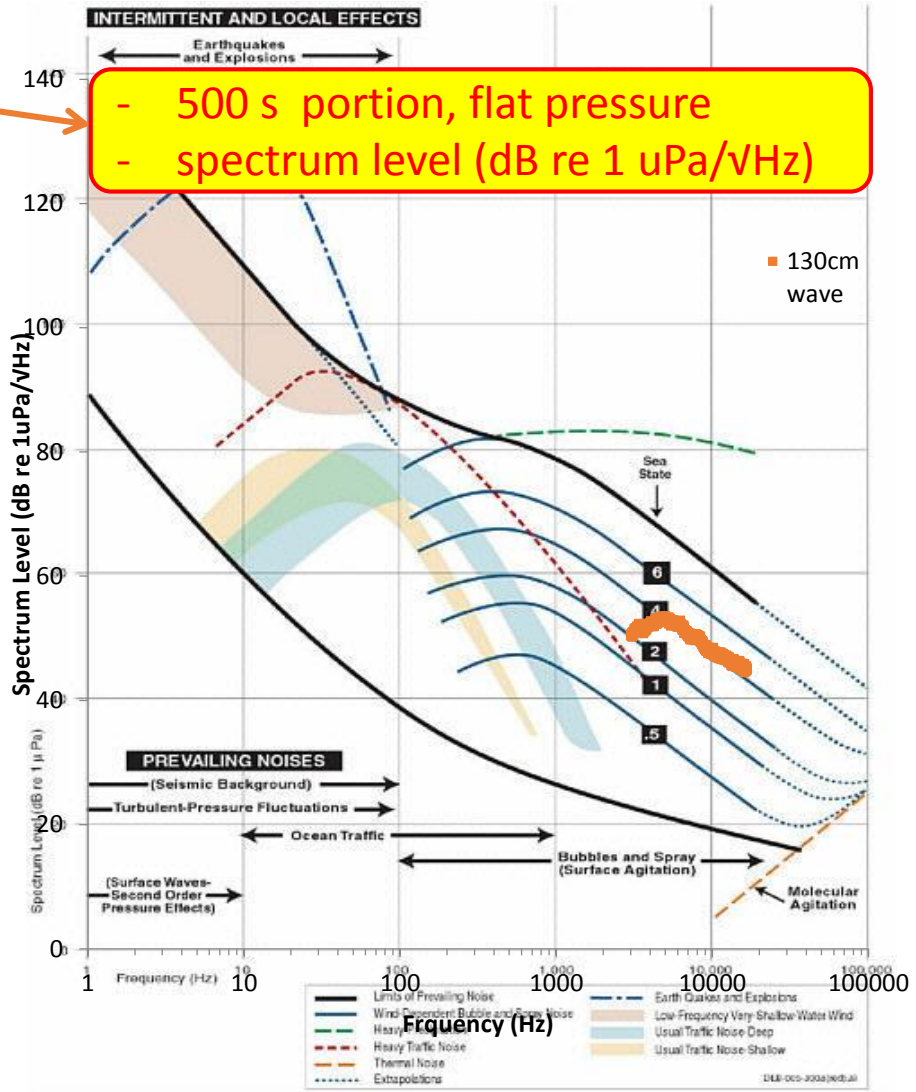
- Sea ambient noise pressure (dB re 1uPa)
- 1 hour recording
- 4 hydrophone average

26-04-2014

from 22:46 to 23:46 UTC

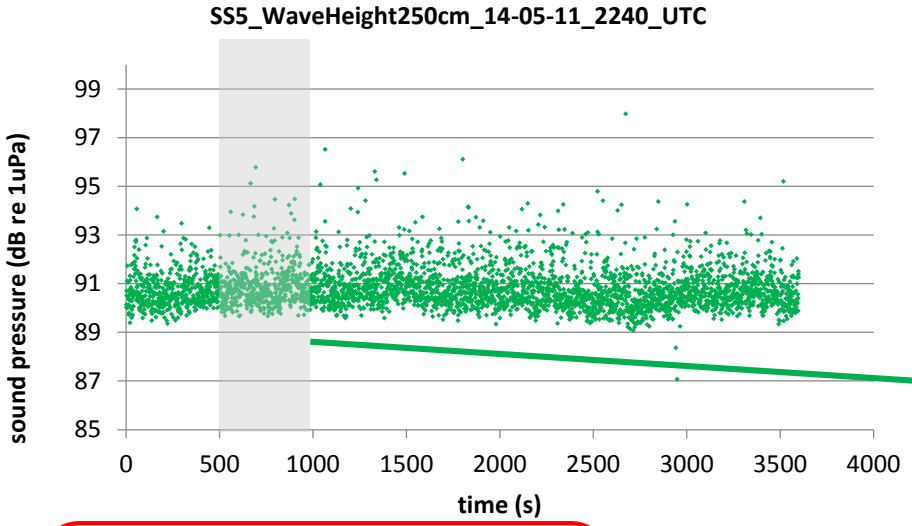
wave height: **130 cm**

- 500 s portion, flat pressure
- spectrum level (dB re 1 uPa/√Hz)



RESULTS

- Wave height recorded by wavemeter:130 cm → SS4
- Spectrum level recorded: corresponds to SS4 (Wenz curves)



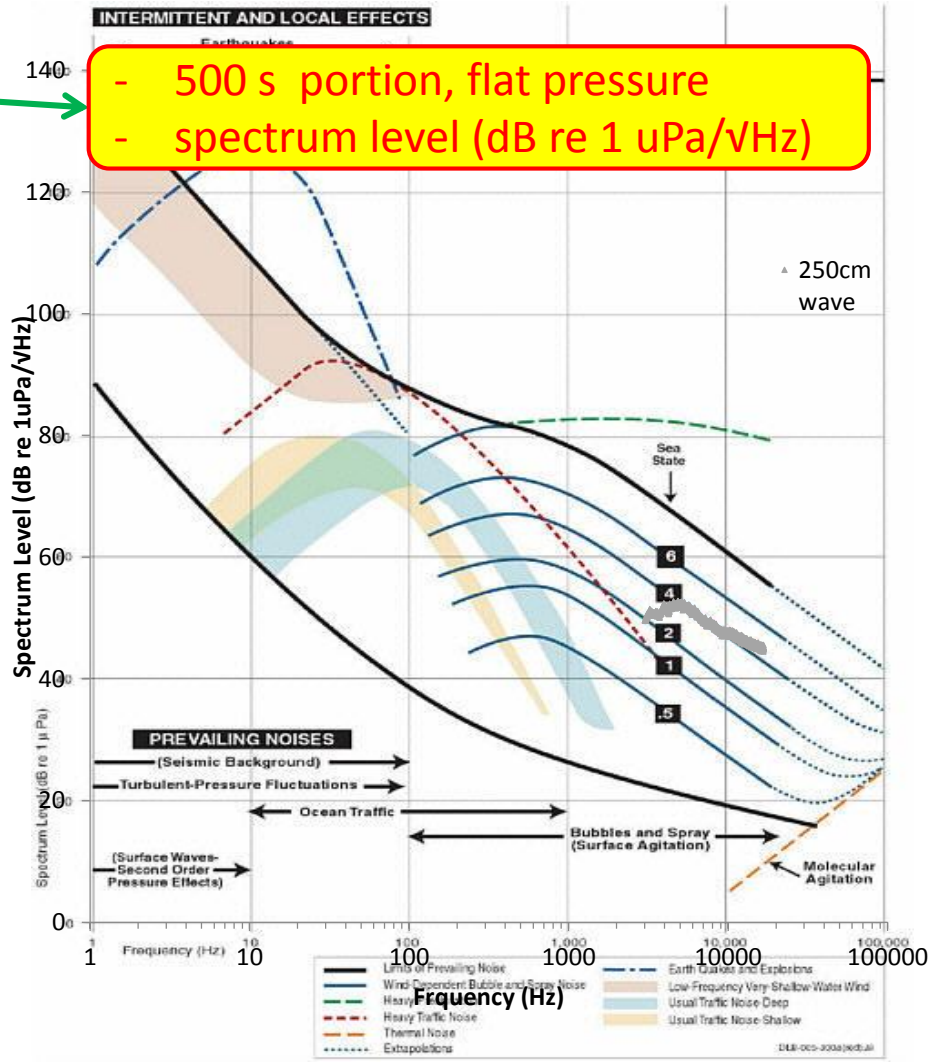
- Sea ambient noise pressure (dB re 1uPa)
- 1 hour recording
- 4 hydrophone average

11-05-2014

from 22:40 to 23:40 UTC

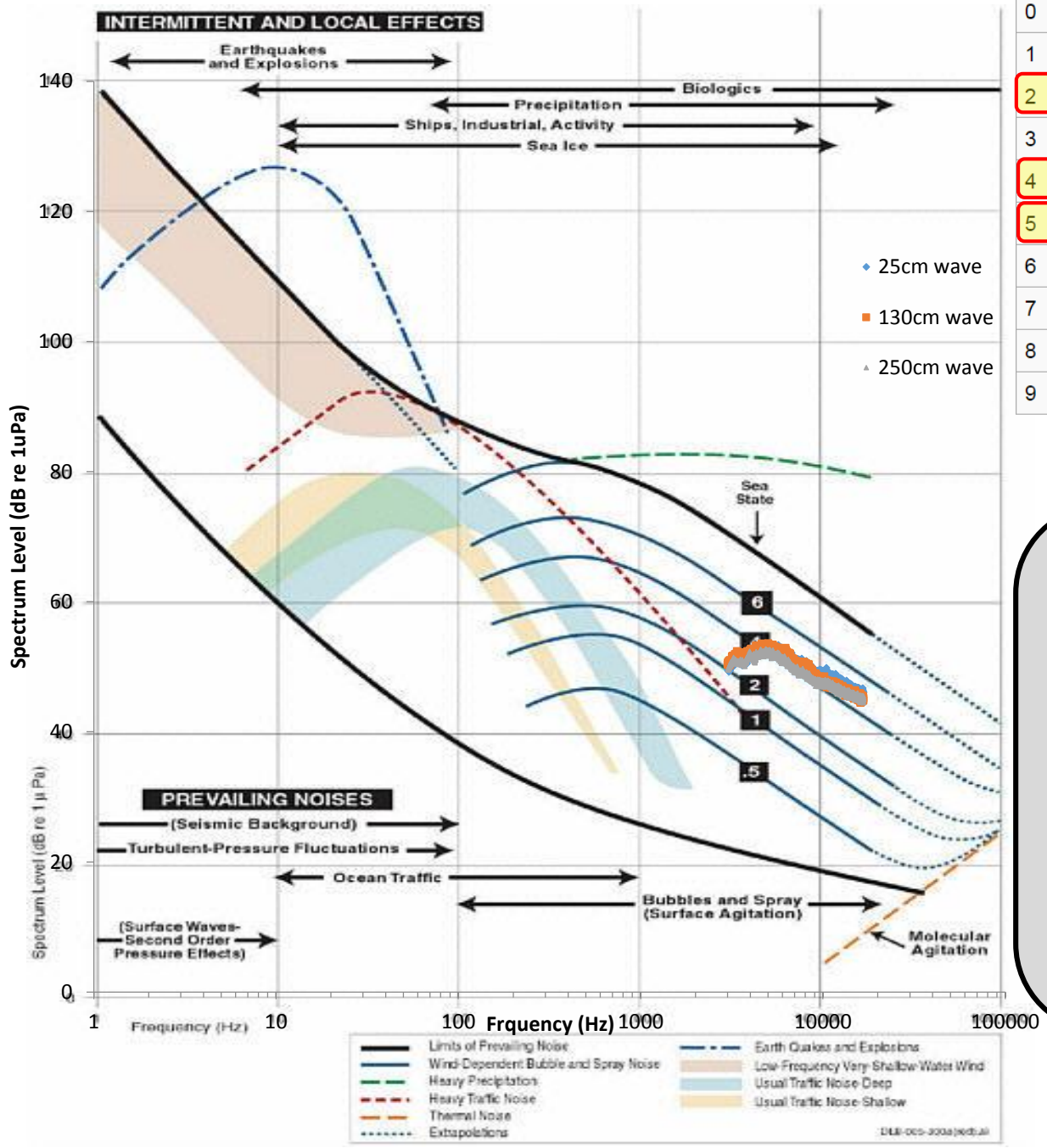
wave height: 250 cm

- 500 s portion, flat pressure
- spectrum level (dB re 1 uPa/√Hz)



RESULTS

- Wave height recorded by wavemeter:250 cm → SS4/5
- Spectrum level recorded: corresponds to SS4 (Wenz curves)



WMO Sea State Code	Wave height
0	0 metres (0 ft)
1	0 to 0.1 metres (0.00 to 0.33 ft)
2	0.1 to 0.5 metres (3.9 in to 1 ft 7.7 in)
3	0.5 to 1.25 metres (1 ft 8 in to 4 ft 1 in)
4	1.25 to 2.5 metres (4 ft 1 in to 8 ft 2 in)
5	2.5 to 4 metres (8 ft 2 in to 13 ft 1 in)
6	4 to 6 metres (13 to 20 ft)
7	6 to 9 metres (20 to 30 ft)
8	9 to 14 metres (30 to 46 ft)
9	Over 14 metres (46 ft)

RESULTS

- If compared to Wenz curves, the SEA AMBIENT NOISE spectrum levels recorded overlap to SS4

CONCLUSIONS / FUTURE WORK

- Absolute sound pressure levels have been extracted from raw acoustic data “flat” pressure (no boats)
- 3 random sea ambient noise 1h-samples, with no boats, from different groups, according to the height of the wave have been analyzed
- Significant wave height measurements corresponding to the 3 samples have been recorded by in-situ wavemeter (**25 cm, 130 cm, 250 cm**)
- portions (500 seconds, average of 4 hydrophones) were processed to get corresponding average spectrum levels in the **3 kHz-23 kHz** band

If compared to Wenz curves, all of the data samples overlap at SS4
This is in contrast with sea ambient noise spectrum levels expected by the recorded wave heights
This study indicates a general sea ambient noise level increase with respect of the Wenz curves in the proximity of Portofino headland.

We may confirm the presence of dolphins in the area, especially at night and/or when there are few small boats
We are now refining guidelines for people entering the marine protected area

- about **20 TBytes** (growing) of raw acoustic data are available by ARION project for further analysis
- a standard calibration of the whole acquisition system is scheduled to get precise absolute sound pressure levels in order to improve the analysis accuracy