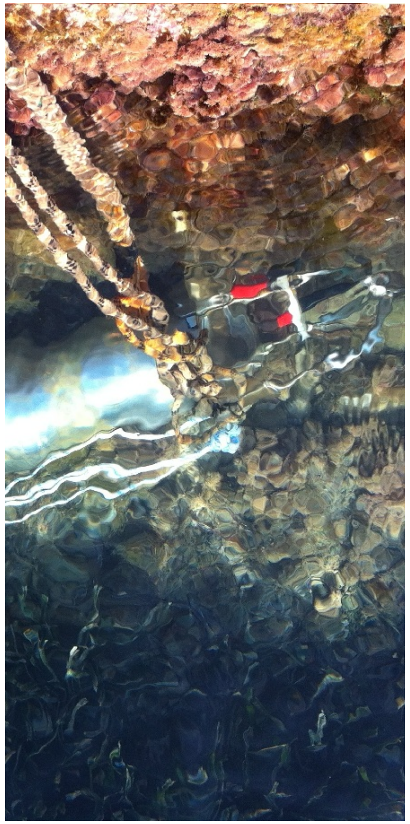
DESIGN AND APPLICATION OF A PASSIVE ACOUSTIC MONITORING SYSTEM IN THE SPANISH IMPLEMENTATION OF THE MARINE STRATEGY FRAMEWORK DIRECTIVE

GUILLERMO LARA
MANUEL BOU-CABO
JOSE ANTONIO ESTEBAN
VICTOR ESPINOSA
RAMÓN MIRALLES



DESIGN AND APPLICATION OF A PASSIVE ACOUSTIC MONITORING SYSTEM …

1. DESIGN AND MODEL

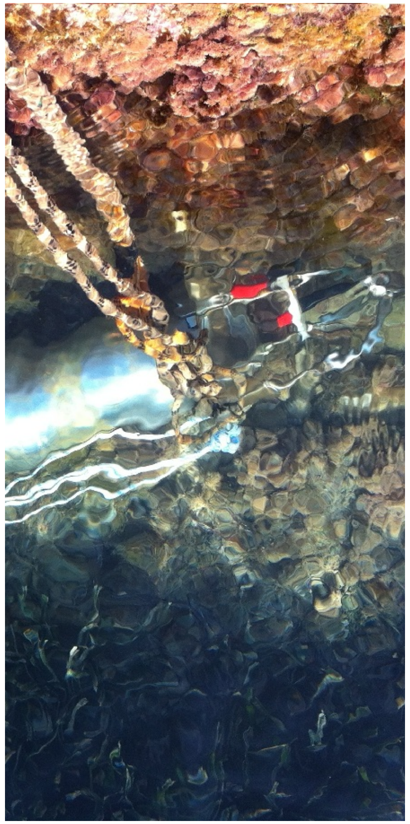
Development of a passive acoustic monitoring device (SAMARUC) to acquire underwater sounds following the specifications of the Monitoring Guidance for Underwater Noise in European Seas [1]

Implemetation of ray aproximation numerical model based on Bellhop 3D model

2. APPLICATION

Data obtained by the SAMARUC at El Gorguel (Cartagena, Spain) in 2018 were compared to a theoretical underwater noise map created using AIS data.

This was done following the Descriptor D11.2 by means of the ambient noise level indicators at two one-third-octave frequency bands (63 Hz and 125 Hz), mainly related to marine traffic and noise pollution.

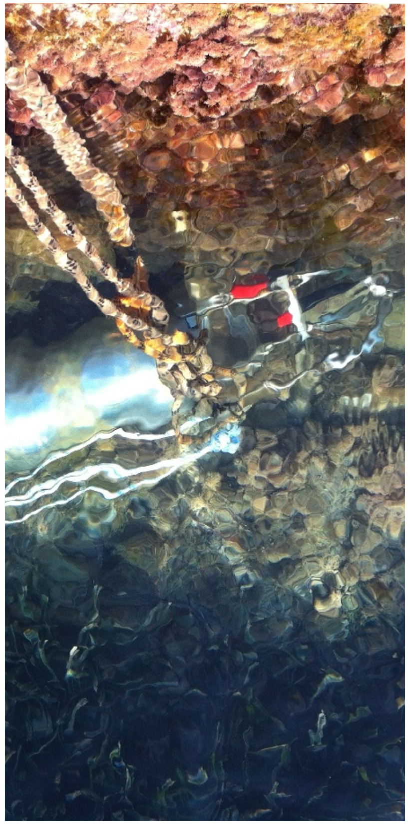


SPECIFICATIONS OF SAMARUC DEVICE (1)

- High bandwidth submarine audio recordings via the AIC3204 (sampling rate of 192 kHz at 16 bits).
- Possibility of amplify the signal depending on the deployment category (A quiet placement, B noisy placement)

Sensitivity of the preamplified hydrophone	-167 dB re 1V/uPa (Cetacean Research C57) *
# batteries used (with/without preamplification)	36/28 (type D)
AIC3204 programmable gain	0 - 30 dB *
Storage capacity	Currenty: (1+1) Tbytes
Sampling rate	192 kHz *
System bandwidth $\pm$ 3dB	10 Hz - 96 kHz *
Maximum depth	500 m. (Housing and buoys) *
Autonomy	Up to 4 months **

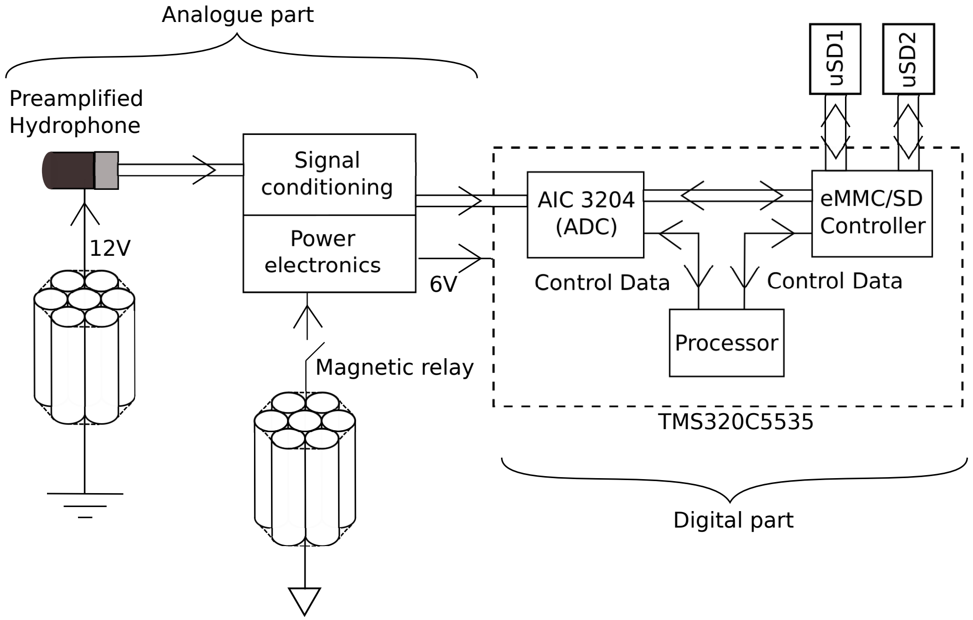
*Specificactions obtained by means of the calibration carried out in the IEO-UPV facilities located in the port of Gandía (Valencia, Spain).
** Depending on the duty cycle

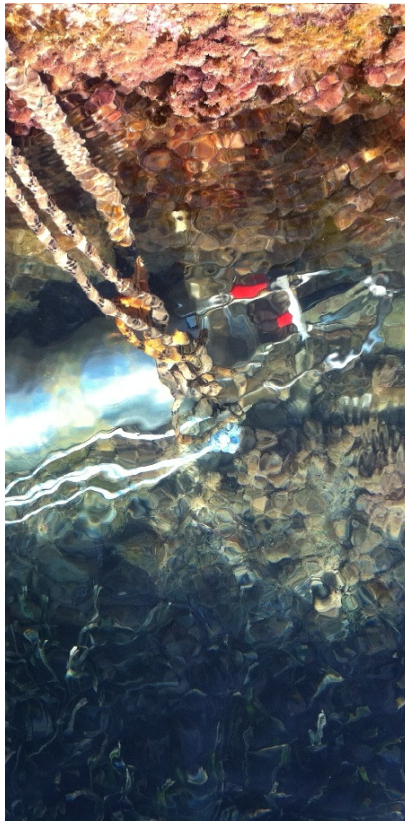


SPECIFICATIONS OF SAMARUC DEVICE (2)

The TMS320C5535 processor controls the digital data from AIC3204 ADC so that it arrives through the data bus to the microSD cards.

To enhance the signal-to-noise ratio, the grounds of the power supply circuit and the conditioning circuit have been isolated.





DEVICE CAPABILITIES (1)

Specific electronics

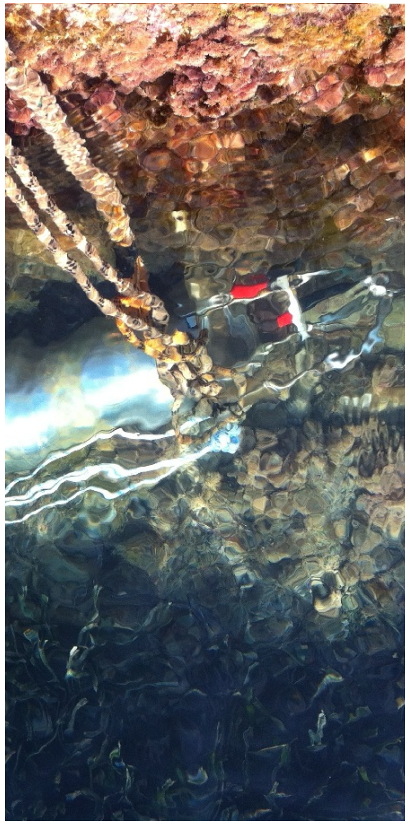
- Double the available storage capacity.
- Allows the hydrophone (audio) power circuit to be isolated from the evaluation board's power supply by adding two independent grounds.

Fyle system

- New low latency file system to use the maximun of the microSD card's storage capacity.

Housing and battery pack

- A pressure case was built from a tube of 6082 aluminium anodized with NITUFF, measuring 12 x 70 cm (diameter x length).
- Battery pack designed for the main electronics and composed of 7 x 4 D-type batteries, in order to maximize the energy density in the cylindrical housing



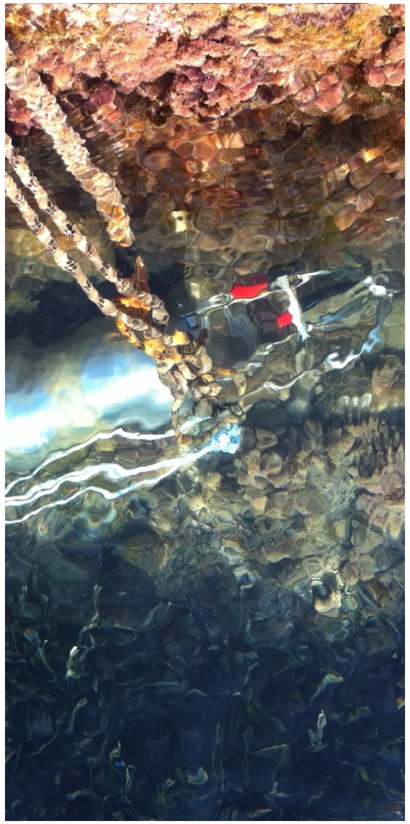
DEVICE CAPABILITIES (2)

Ringed buoys and hydrophone protection

- Enable handling of the device
- Avoid acoustic shadows
- Providing the system with the necessary buoyancy and allowing deployments down to depths of 500 m.
- Removable cage was designed to keep the hydrophone in a vertical position, isolate it from vibrations and protect it from shocks.

Summary of capabilities

Element	Functionality
File system	Increase the system storage capacity, previously limited by the FAT32 system file (32 Gbytes)
Specific electronics	Isolate the grounds and use a second microSD card. Storage capacity x 2
Housing	6082 aluminium, widely used in marine applications
Battery block	Maximize energy density according to the tube dimensions
Flotation buoys	Ease of handling and avoidance of acoustic shadows
Protection cage	Hydrophone protection

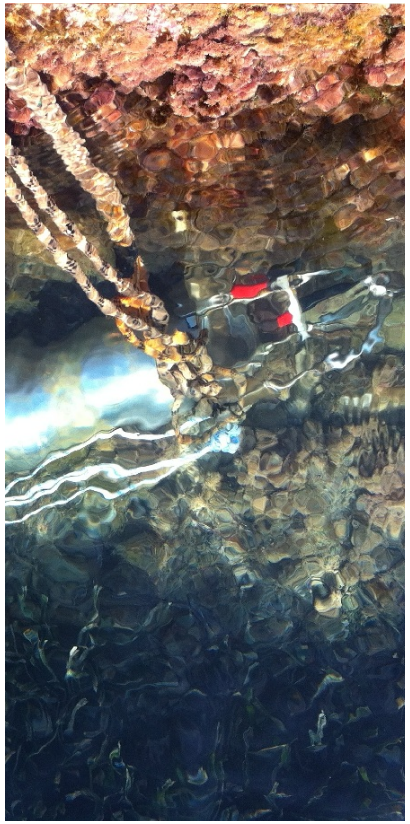


NUMMERICAL MODEL (1)

- Based on Bellhop 3D code [2] that implements Ray approximation (suitable to high frecuency signals in deep ocean environment)

- Speed of sound calculated for the water column range using Argo profiler data: temperature, salinity and depth/pressure available on the EMODnet portal website for the same month as the marine traffic data obtained from the Automatic Identification System (AIS) database.

- The RANDI model [3] was used to parameterize the source level of each ship considered as a low frequency noise source.



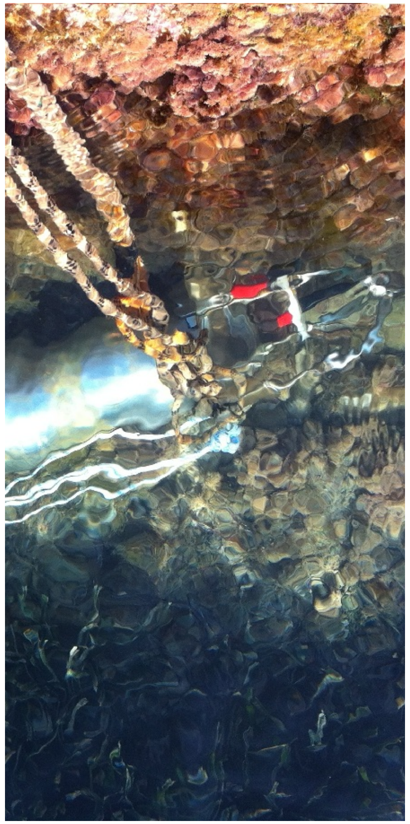
NUMMERICAL MODEL (2)

- The velocity of sound vs depth was calculated by applying the nine-term Mackenzie equation [4] considering:

  1. Temperature between 2°C and 30°C
  2. Salinity of 25 - 40 ppt (parts per thousand)
  3. Depth between 0 m to 8000 m.

- Bathymetric information used in 3D propagation model, was obtained from the General Bathymetric Chart of the Oceans

- The mean value of the Sound Pressure Level (SPL) over the location was calculated considering the AIS data of vessels that have non-zero speed over ground.



DESIGN AND APPLICATION OF A PASSIVE ACOUSTIC MONITORING SYSTEM …

DATA ACQUISITION AND STUDY AREA

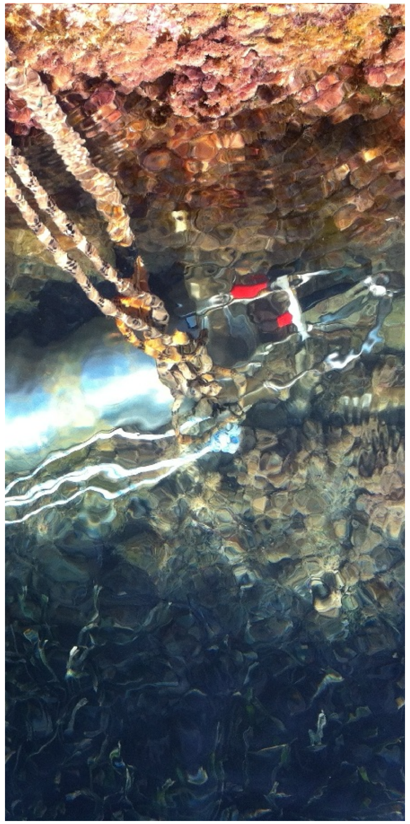
Data were collected using the SAMARUC device from 16 May 2018 to 30 July 2018 in the shallow waters of El Gorguel, on the Mediterranean Sea (Cartagena, Spain).

- Deploymeny category: B.

- The device was placed 10 m from the seabed (reducing its acoustic influence) at a depth of 50 m using a 70 kg anchoring weight.

- Deployed for two months

- Duty cycle: 5 minutes ON and 10 minutes OFF.



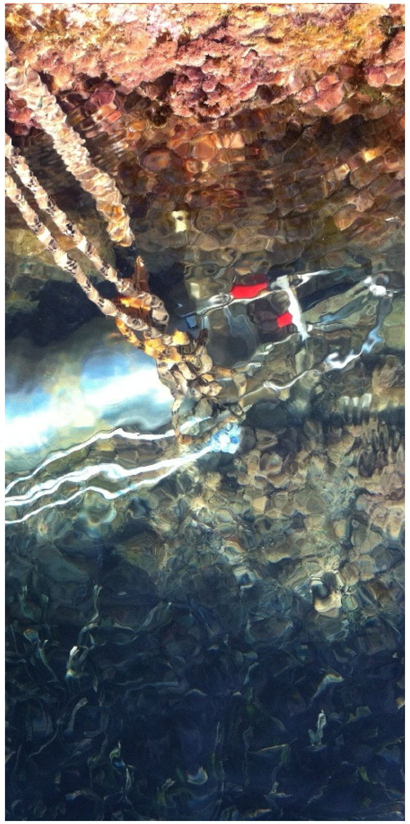
DESIGN AND APPLICATION OF A PASSIVE ACOUSTIC MONITORING SYSTEM ...

RESULTS AND DISCUSSION (1)

Both one-third-octave band indicators from the real and theoretical data were calculated following the framework of Descriptor 11 of the European MSFD for a certain hours.

16 May 2018	**63 Hz**				
Hours	6:00h - 7:00h	14:00h - 15:00h	19:00h - 20:00h	23:00h - 00:00h	Average
SAMARUC	78 ± 13	85.3 ± 0.5	79.7 ± 0.7	83.1 ± 1.2	82 ± 6
Ray model	81 ± 3	91 ± 5	78 ± 3	84 ± 2	83 ± 5
	125 Hz				
Hours	6:00h - 7:00h	14:00h - 15:00h	19:00h - 20:00h	23:00h - 00:00h	Average
SAMARUC	85 ± 4	90 ± 2	83.8 ± 0.3	81 ± 2	85 ± 9
Ray model	83 ± 4	93 ± 3	81.4 ± 1.1	81 ± 4	85 ± 6

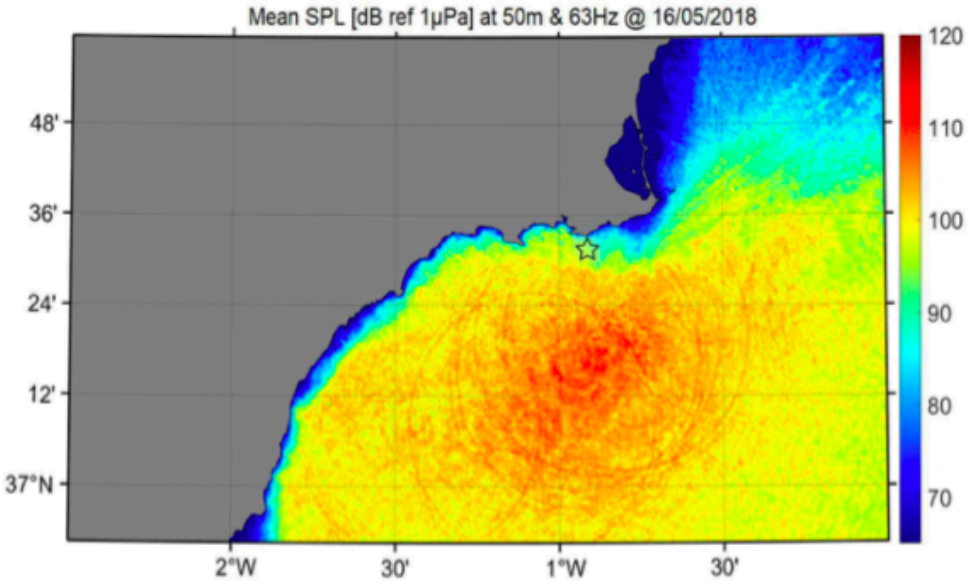
→ Good agreement between experimental and theoretical calculations, verifying not only that the device worked properly and the numerical simulations were valid, but also the calibration of the system performed at IEO-UPV's facilities.

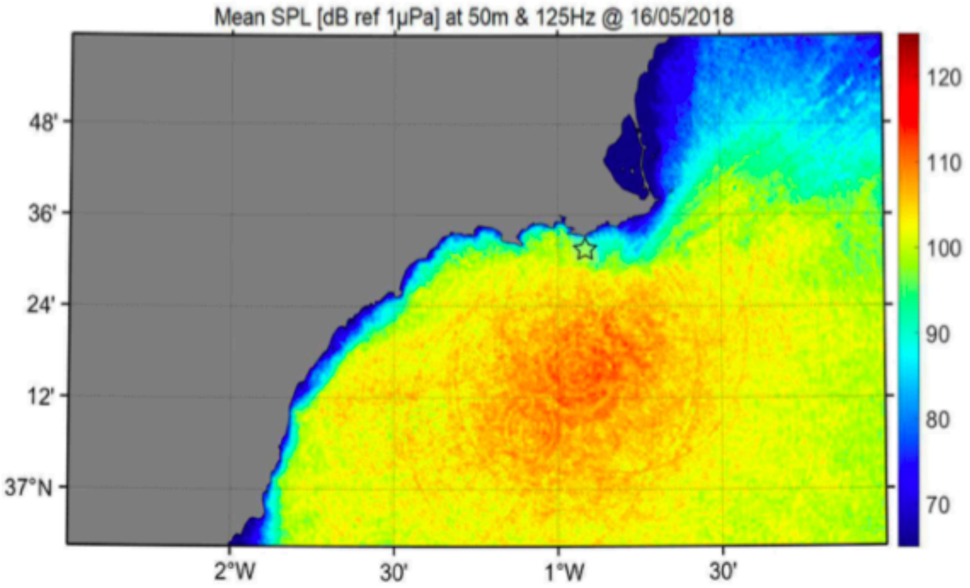


RESULTS AND DISCUSSION (2)

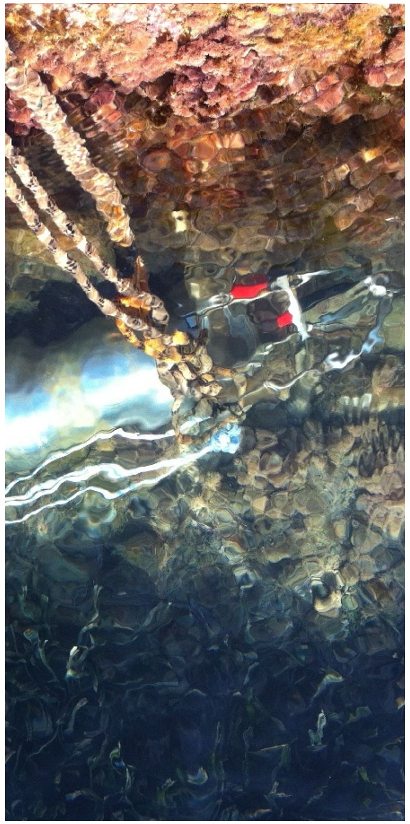
The results obtained considering ray theory approximation are summarized in the sound maps of daily SPL dB re 1V/uPa at a depth of 50 m after computing AIS data in the propagation model at 63 Hz and 125 Hz on 16/05/2018.

Sound maps were calculated at a depth of 50 m (SAMARUC depth) using four samples of AIS data (corresponding to the previous slide).





SAMARUC location marked with black star

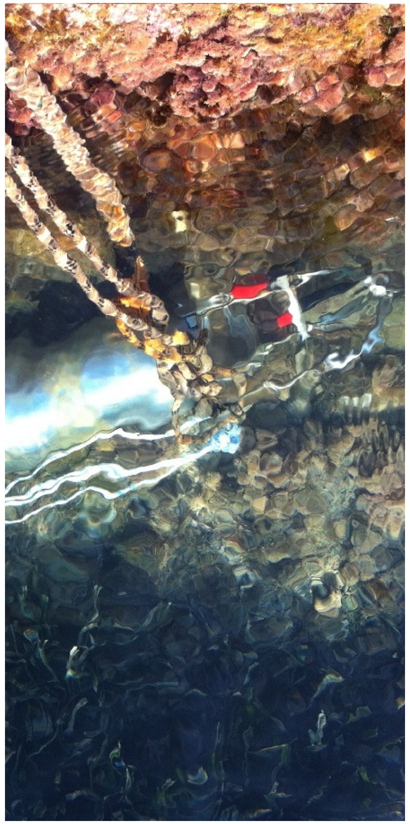


CONCLUSIONS

- The whole process of underwater noise assessment has been performed, from theoretical sound map simulation to validation by means of experimental measurements.

  This has been done with the aim of calculating the underwater sound pressure level associated with a continuous noise coming from anthropogenic activities (marine traffic).

- A PAM system has been specifically designed meeting all the specifications imposed by the technical guidelines. The system designed is modular and can be programmed to measure different kinds of categories, from quiet to noisy ones.



DESIGN AND APPLICATION OF A PASSIVE ACOUSTIC MONITORING SYSTEM ...

FUTURE LINES

Several features will be improved in future works:

- Explore new acoustic metrics looking for GES (Good Environmental Status) assesment using acoustic indicators.

- Look deeper into the assessment of acoustic noise effects on marine biota.

- Implement other kind of propagation models (e.g PE approximation), to characterize underwater noise over shallow water environment.

- Improve the capabilities of our PAM device, increasing the number of sensors installed (Temperature, Salinity, Pressure..) or the depth of operation.

BIBLIOGRAFY

[1] R. P. A. Dekeling, M. L. Tasker, A. J. Van der Graaf, M. A. Ainslie, M. H. Andersson, J. FAndré and Borsani, K. Brensing, M. Castellote, D. Cronin, J. Dalen, T. Folegot, R. Leaper, J. Pajala, P. Redman, S. P. Robinson, P. Sigray, G. Sutton, F. Thomsen, S. Werner, D. Wittekind, J. V. Young, Monitoring Guidance for Underwater noise in European Seas: Monitoring Guidance specifications, Scientific and policy reports, ISSN 1831-9424.

[2] M. B.Porter and Y. Liu, Finite element Ray Tracing. Theoretical and Computational acoustics 1994, 2, 947–956.

[3] J. E. Breeding, L. A. Plug, E. L. Bradley, M. H. Walrod and W. McBride, Research Ambient Noise Directionality (RANDI) 3.1 - Physics description, Technical Report NRL/FR/7176-95-9628, Naval Research Laboratory 1996

[4] K.V. Mackenzie, Nine-term equation for the sound speed in the oceans. JASA 1981, 70 (3), 807–812.

THANKS FOR YOUR ATTENTION

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

iTeAM
Instituto de Telecomunicaciones
y Aplicaciones Multimedia