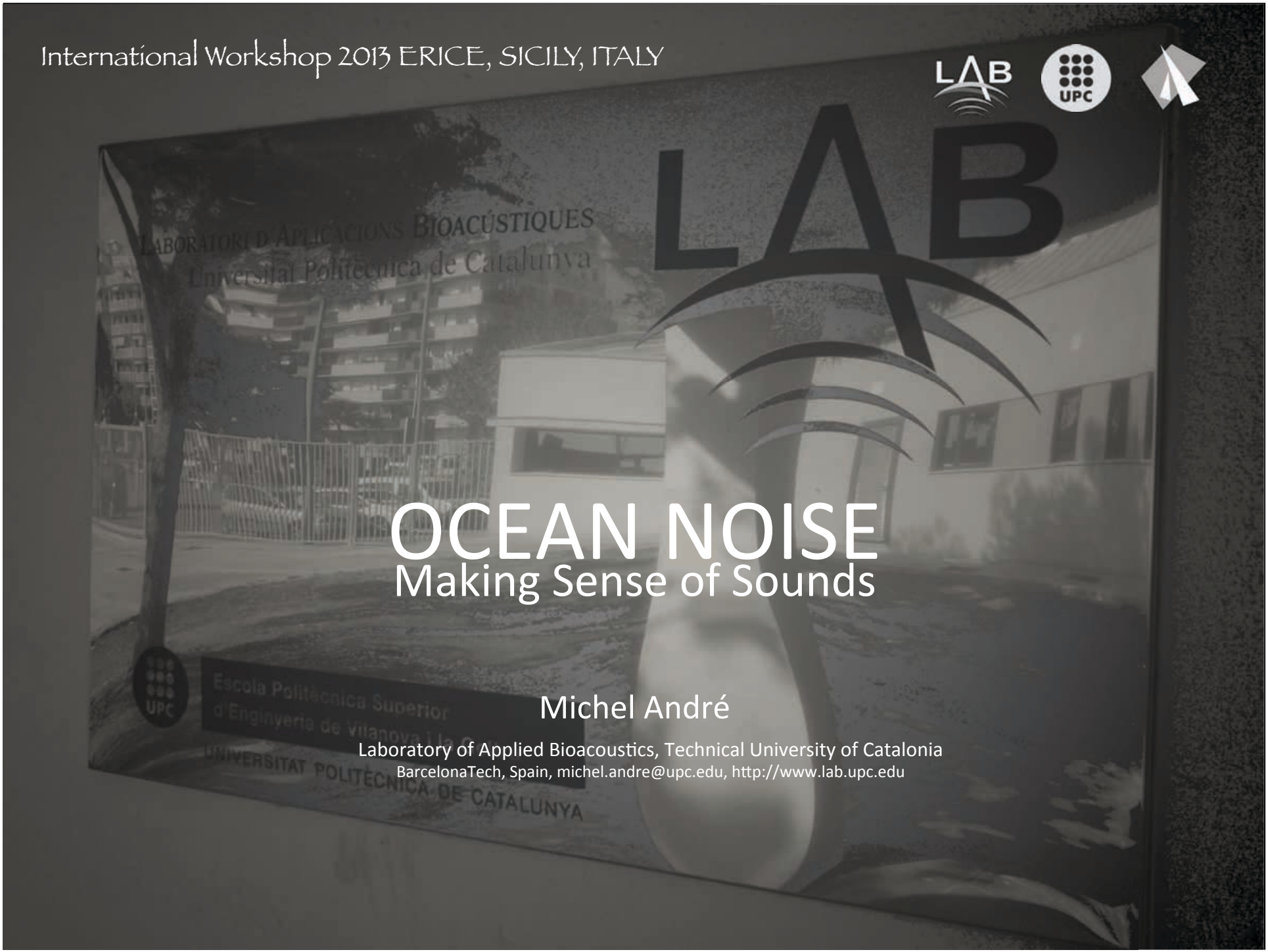

OCEAN NOISE
Making Sense of Sounds

Michel André

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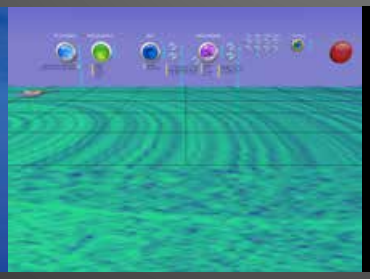
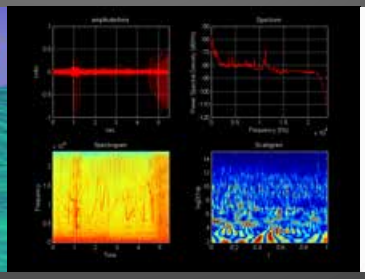
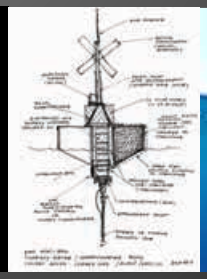
BarcelonaTech, Spain, michel.andre@upc.edu, http://www.lab.upc.edu

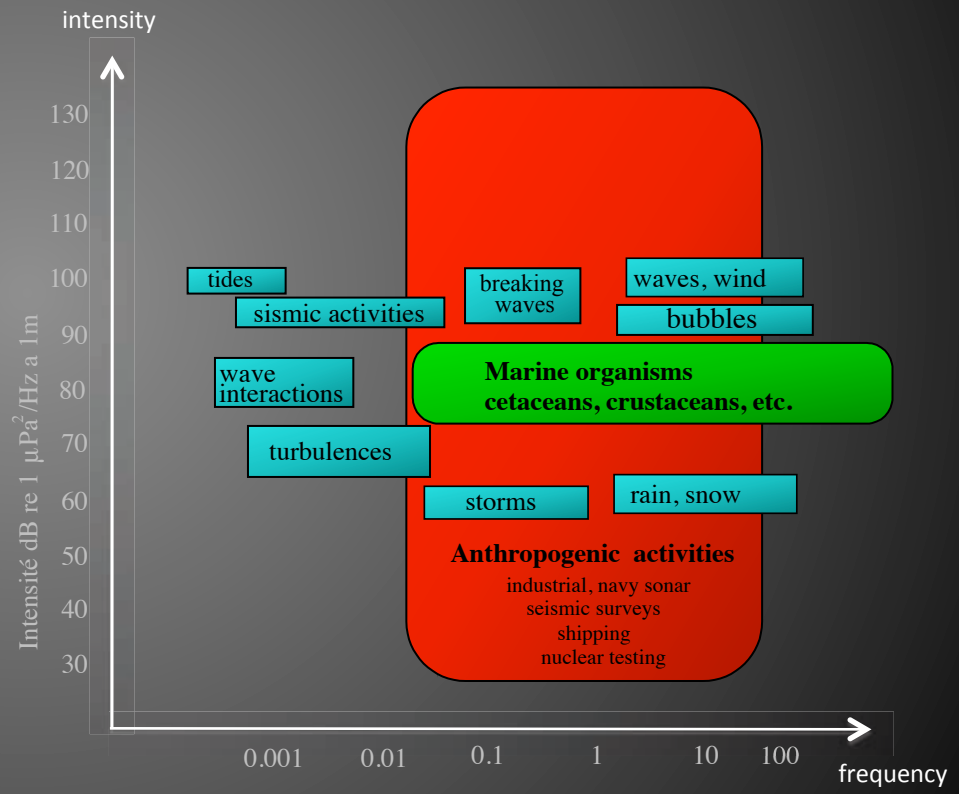
The Noise Issue:

- ✓ Ocean noise is likely to increase in the future
- ✓ A global problem requiring a global solution
- ✓ Increasing pressure from ocean stakeholders – public, NGO's, governments are expressing concerns
- ✓ Offshore economical interests could be at risk
- ✓ Lack of scientific approach could lead to precaution and excessive regulation
- ✓ Ocean users need a scientific management approach – i.e. risk management tools to predict and mitigate potential impact


The Noise Issue:

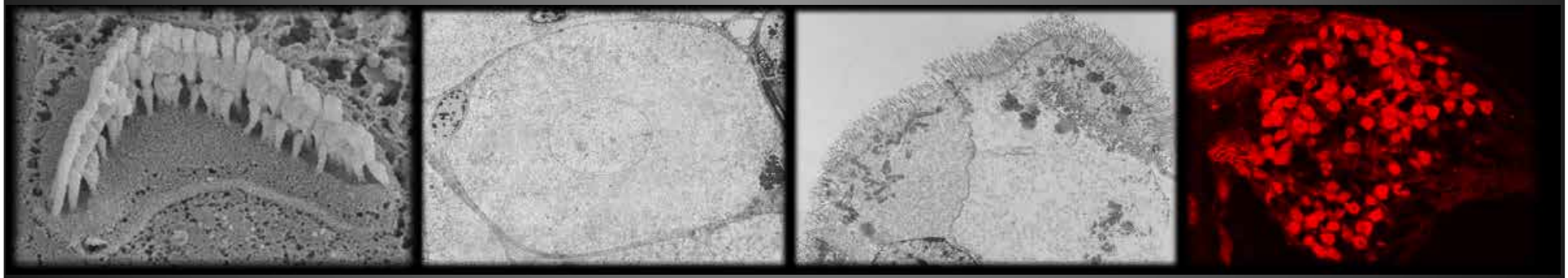
UNCERTAINTIES:
-species affected
-behaviour concerned
-sound characteristics
-cumulative effects
-available tools for monitoring, mitigation, modelling, stranding response, environment impact assessment



The Noise Issue:

- -Regulation and International Initiatives
- -Biological Sensory Systems
- -Passive Acoustic Monitoring
- -Modeling

Assessment of Acoustic Trauma in Marine Mammals



Morell, M., Degollada, E., Alonso, J.M., Jauniaux, T., Leopold, M., Camphuysen, K.C.J., André, M. Decalcifying protocol of odontocete ear samples with RDO®. Journal of the Acoustical Society of America, vol 123, p.3619, 2008

Morell, M., Degollada, E., van der Schaar, M., Alonso, J.M., Delory, E., López, A., Dewez, A., André, M. Comparative morphometry of odontocete ears through computerized tomography. Journal of the Marine Biological Association of the United Kingdom, vol 87, issue 1, p.69-76, Feb 2007

The Noise Issue:

- -Regulation and International Initiatives
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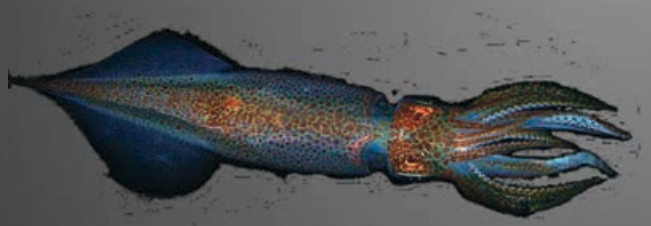
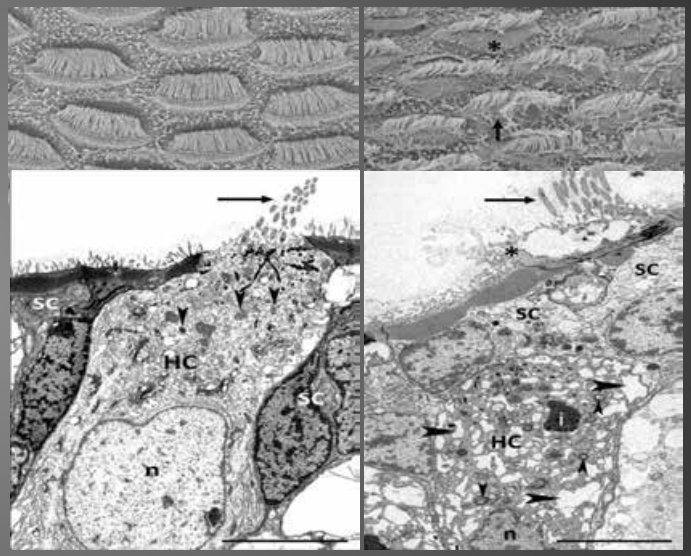


Low Frequency Noise and Acoustic Trauma in Cephalopods



André, M., Solé, M., Lenoir, M., Durfort, M., Quero, C., Mas, A., Lombarte, A., van der Schaar, M., López-Bejar, M., Morell, M., Zaugg, S., Houégnigan, L. Low frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment , p.doi:10.1890/100124, 2011. Available at www.lab.upc.es/frontiers

Solé, M., Lenoir, M., Durfort, M., López-Bejar, Lombarte, A., van der Schaar, M., André, M. 2012. Does exposure to noise from human activities compromise sensory information from cephalopod statocysts? Deep-Sea Res. II (2012), http://dx.doi.org/10.1016/j.dsr2.2012.10.006

Solé M, Lenoir M, Durfort M, López-Bejar M, Lombarte A, et al. (2013) Ultrastructural Damage of *Loligo vulgaris* and *Illex coindetii* statocysts after Low Frequency Sound Exposure. PLoS ONE 8(10): e78825. doi:10.1371/journal.pone.0078825

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The Noise Issue:

-Regulation and International Initiatives
-Biological Sensory Systems
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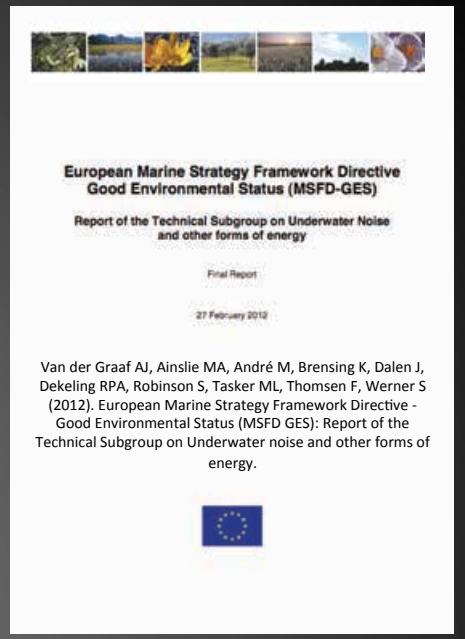
-Modeling



European Marine Strategy Framework Directive
Good Environmental Status (MSFD-GES)

Report of the Technical Subgroup on Underwater Noise and other forms of energy

Final Report

27 February 2012

Van der Graaf AJ, Ainslie MA, André M, Brensing K, Dalen J, Dekeling RPA, Robinson S, Tasker ML, Thomsen F, Werner S (2012). European Marine Strategy Framework Directive - Good Environmental Status (MSFD GES): Report of the Technical Subgroup on Underwater noise and other forms of energy.

THE APPROACH

-EU Marine Strategy Framework Directive
-An International Quiet Ocean Experiment http://www.iqoe-2011.org/
-Cetacean and Sound Mapping http://www.st.nmfs.noaa.gov/cetsound/
- BOEM Effects of Noise on Fish, Fisheries and Invertebrates http://www.boemsoundworkshop.com/
- The effects of Noise on Aquatic Life http://www.aquaticnoise.org/
-E&P Sound and Marine Life Program http://www.soundandmarinelife.org/
-The Office of Naval Research (ONR), Marine Mammal Biology Program (MMB), http://www.onr.navy.mil/
-Several EU funded programmes: SILENV, ACCESS, AQUO, SONIC, PERSEUS, COCONET
-EU Initiatives: ASCOBANS, ACCOBAMS

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The Noise Issue:

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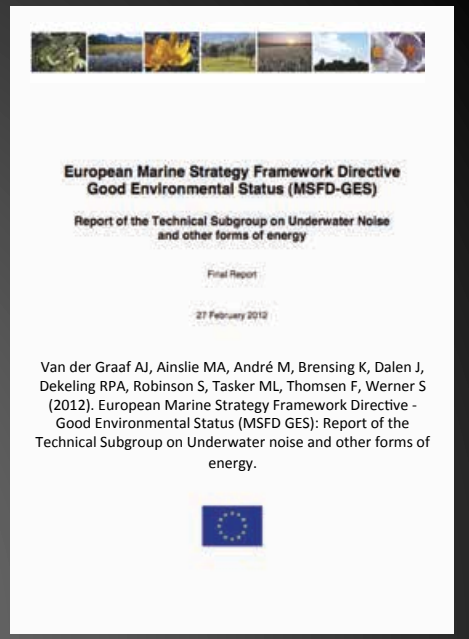
-Modeling



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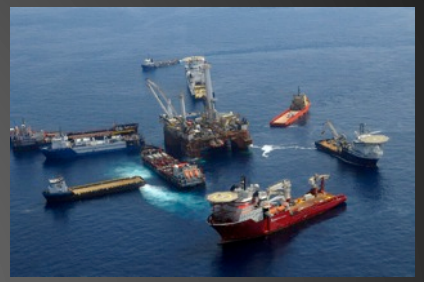
THE APPROACH

-EU Marine Strategy Framework Directive

INDICATORS OF GOOD ENVIRONMENTAL STATUS FOR UNDERWATER NOISE AND OTHER FORMS OF ENERGY

-10 Hz-10kz impulsive sounds
-1/3 bands centred at 63 Hz and 125 Hz

- EU funded projects on ship noise (SILENV, AQUO & SONIC)
- Measuring ship noise
- Modeling ship noise
- Masking effects of ship noise
- Implications during E&P Operations



SILENV, Ships oriented Innovative soLutions to rEduce Noise and Vibrations (N&V), http://silenv.eu/ (2009-2012)

AQUO, Achieve QUieter Oceans by shipping noise footprint reduction http://aquo.eu (2012-2015)

SONIC, Suppression Of underwater Noise Induced by Cavitation (2012-2015)

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OBJECTIVES: Towards a Green Label for Ships

- Onboard Noise & Vibration Guidelines
- Airborne Radiated Noise Guidelines
- Underwater Radiated Noise Guidelines

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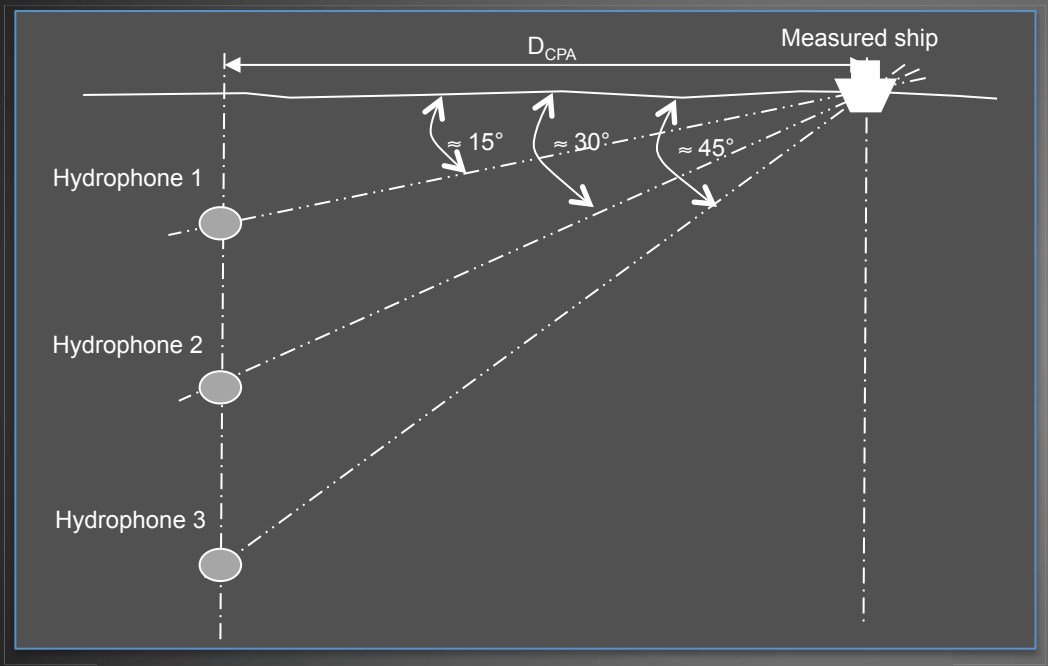
Underwater Radiated Noise Guidelines

Directivity test run configuration



If two (2) hydrophones are used, they shall be positioned at depths that result approximately in 15° and 30° angles from the sea surface at a distance equal to the nominal distance at CPA .
The additional hydrophones (if any) shall be positioned at a depth which results approximately in 45° angles from the sea surface at a distance equal to the nominal distance at CPA.

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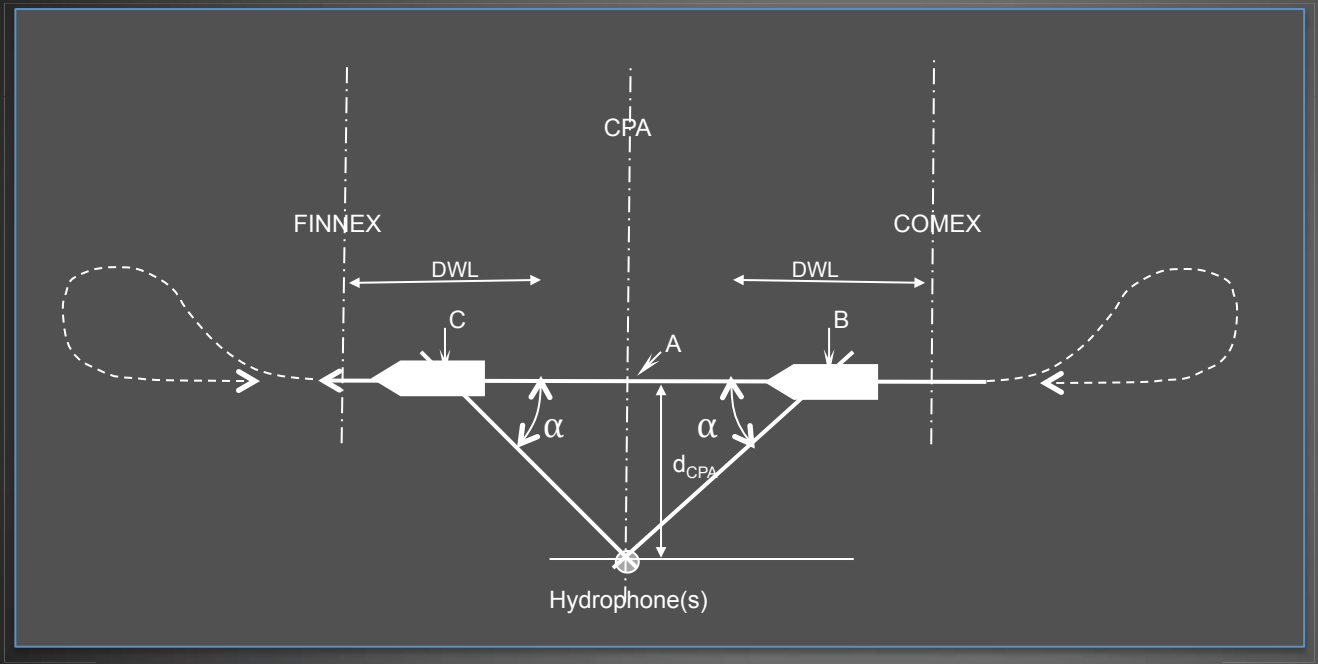
Underwater Radiated Noise Guidelines

Directivity test run configuration



To assess horizontal and vertical directivity, at least three noise spectrums shall be calculated for each run and each hydrophone: Noise at CPA (DWL centered in A), Noise radiated from the bow (DWL centered in B) and noise radiated from the aft (DWL centered in C.
DWL: Data Window Length

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Recording	Ship	tmin (s)	tmax (s)	dcpa (m)	std dcpa (m)	tcpa (s)	std tcpa (s)	v (ms-1)	std v (ms-1)
SP_BAL_3,ship1	Fast Ferry	297	530	297.7	3.6	388.79	0.0061	15.53	0.019
SP_BAL_4,ship 1	Fast Ferry Catamaran	0	192	109.538	4.16	62.73	0.04	11.23	0.013
SP_BAL_5,ship 1	Fast Ferry	528	985	1392.6	237.8	793.64	4.6	13.43	0.73
SP_BAL_7,ship 1	Fast Ferry	1224	1680	403.5	4.4	1407.8	0.11	13.6	0.019
SP_BAL_8,ship 1	Ferry	123	360	755.8	1.8	246.2	0.003	13.03	0.01
SP_BAL_14,ship1	Ferry	499	788	736.15	3.9	581.7	0.14	10.1	0.002
SP_BAL_15	Eco Ferry	425	876	234.7	2.74	562	0.14	9.5	0.02
SP_BAL_18	Merchant	192	690	399.49	57.9	398.49	2.58	9.9	0.2
SP_BIL_3,ship 1	Merchant	90	772	1128.2	7.39	275.27	0.4	5.7	0.014
SP_VLG_1	fisherman small	25	163	186.9	2.52	102.8	0.12	4.62	0.02
SP_VLG_2	Passangers Small	69	269	108.8	0.97	180	0.07	6.15	0.015
SP_GIB_1	Cargo	460	1200	4774	184	861	2.8	14	0.2
SP_GIB_1	Ferry	1370	2046	714	2.69	1506	0.13	8	0.01
SP_GIB_2	Cargo	290	1455	2574	74	716	3.3	6.36	0.06
SP_GIB_3	Ferry	2086	2768	2762	40	2392	0.8	9.4	0.05
SP_GIB_7	Fast Ferry	1030	1540	1370	6	1228	0.14	14	0.014
SP_GIB_8	Fast Ferry	20	473	1323	252	239	4	16	0.75

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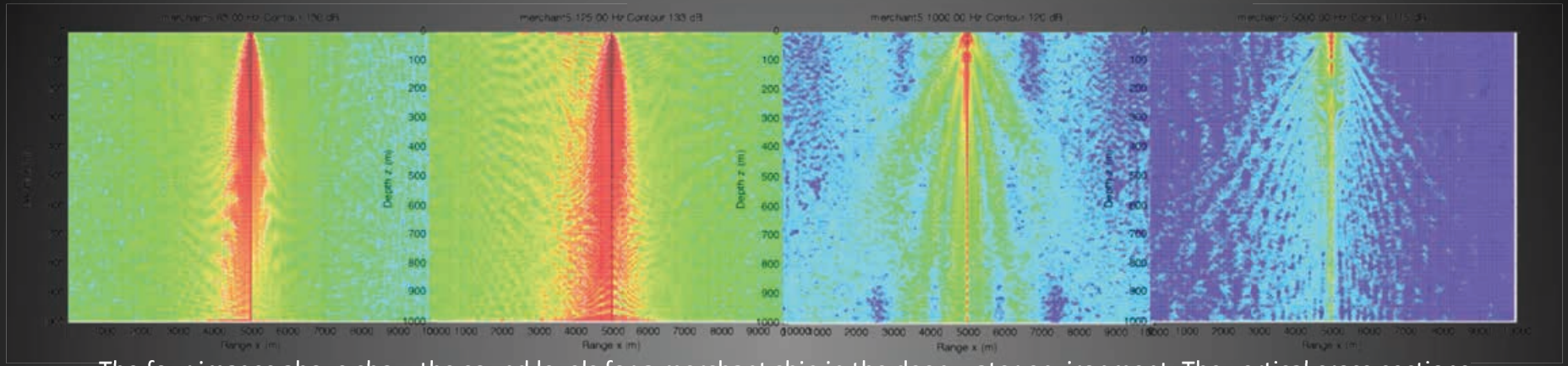
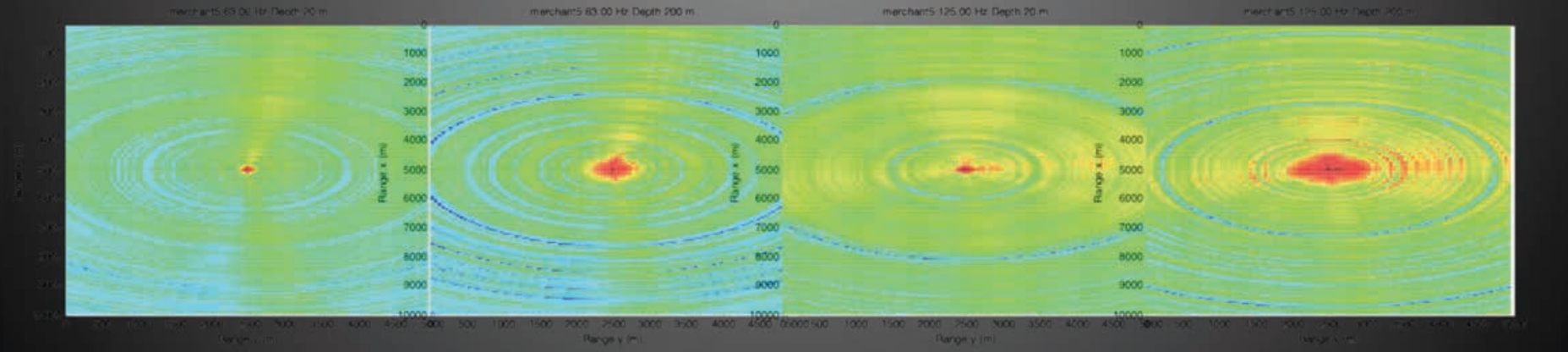
Underwater Radiated Noise Guidelines

Directivity pattern of a merchant ship



The four images above show the sound levels for a merchant ship in the deep water environment. The vertical cross-sections were taken along the length of the boat. To assist interpreting the graphs a contour level is plotted at certain dB levels. As the level can be quite different at different depths, horizontal cross-sections (below) were made at two depths, 20 and 200 m.



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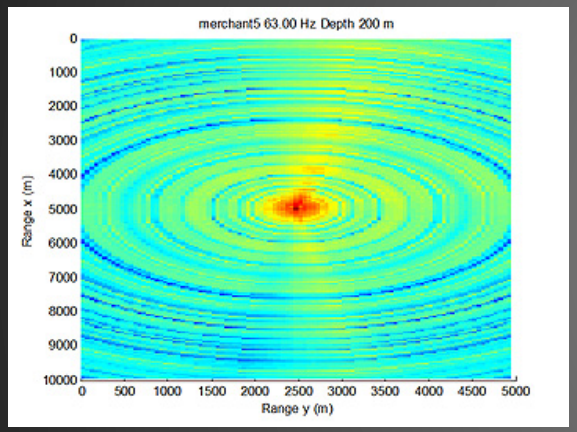

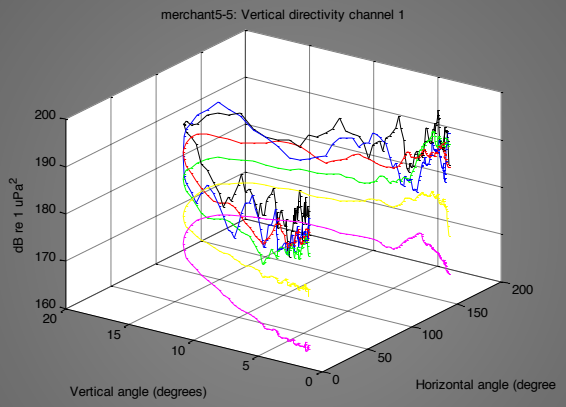

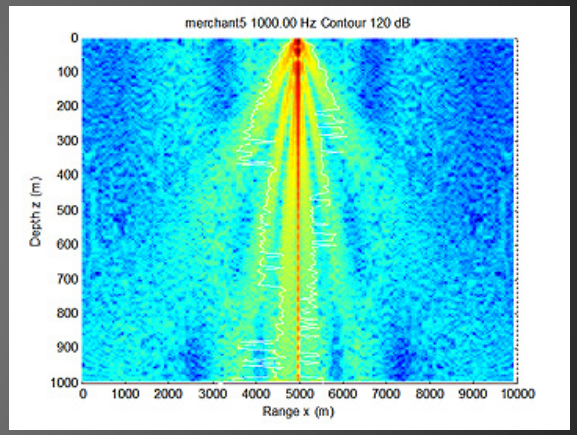

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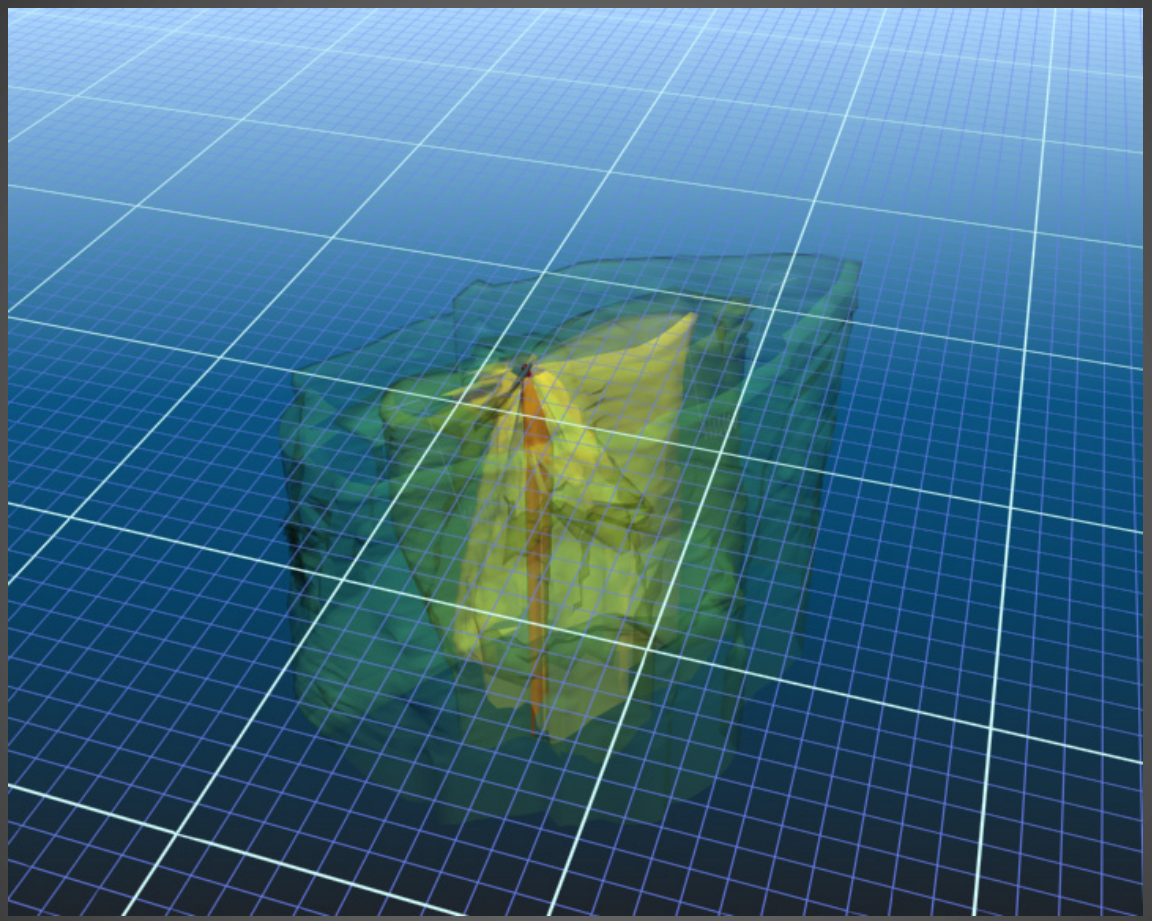

3D reconstruction of a merchant ship underwater radiated noise

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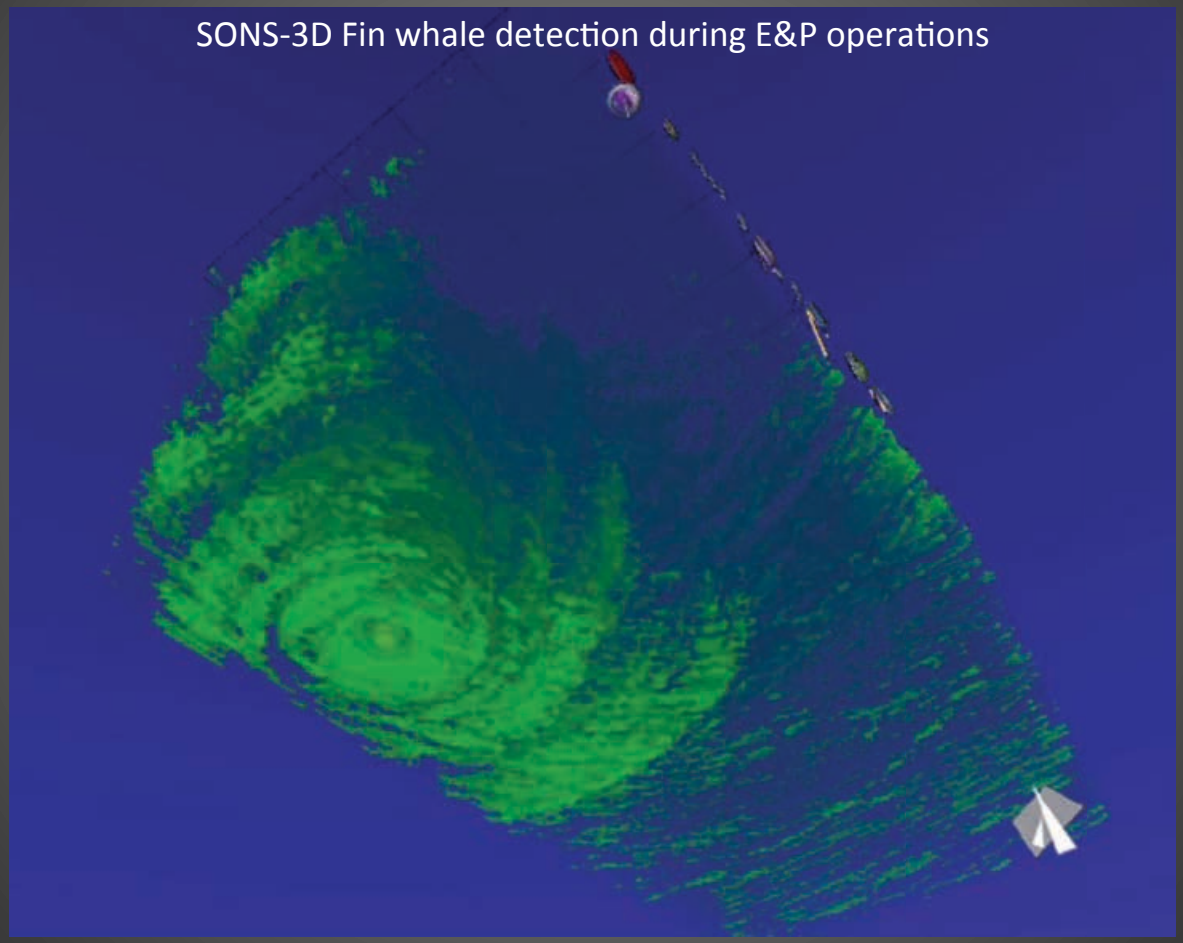
SONS-3D Fin whale detection during E&P operations



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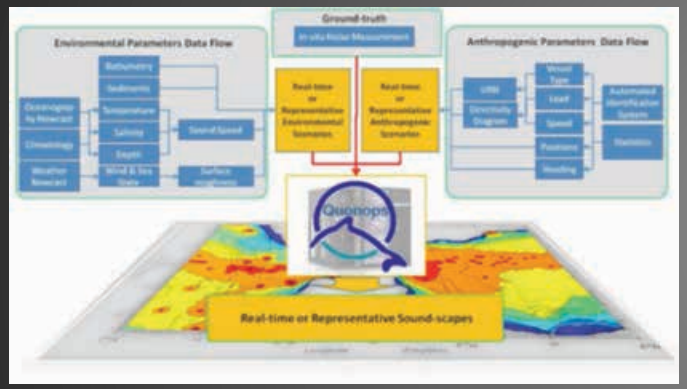

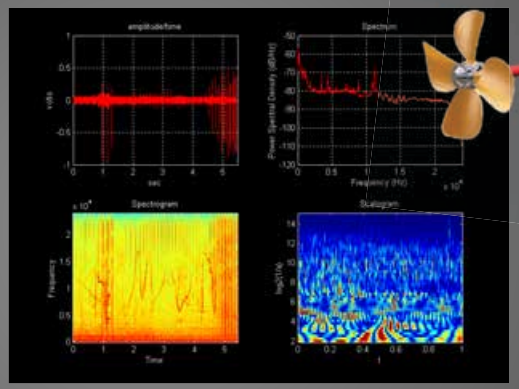

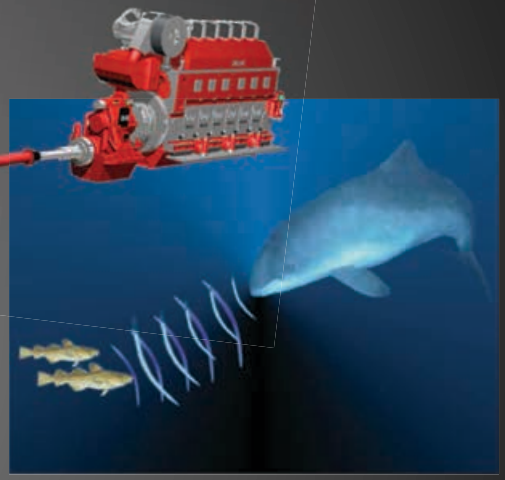

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Expertise:

- -Regulation and International Initiatives
- -Biological Sensory Systems
- -Passive Acoustic Monitoring
- -Modeling

Lido

LISTENING TO THE DEEP-OCEAN ENVIRONMENT

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Country/Location	Platform	Data stream
FRANCE	ANTARES	36 x 250 kHz
NEPTUNE CANADA	Folger Passage	1 x 96 kHz
NEPTUNE CANADA	Barkley Canyon	1 x 96 kHz
NEPTUNE CANADA	Barkley Slope	1 x 96 kHz
SPAIN (MED SEA)	OBSEA	1 x 96 kHz
JAPAN (JAMSTEC)	Hatsushima	1 x 100 Hz
JAPAN (JAMSTEC)	Kushiro	3 x 100 Hz
ITALY (ESONET)	NEMO TSS/TSN	2x 4 x 96 kHz
SPAIN (ATLANTIC)	BIMEP	1 x 96 kHz
CTBTO	11 HA	11 x 200 Hz
IRELAND	Shannon Estuary	1 x 96 kHz

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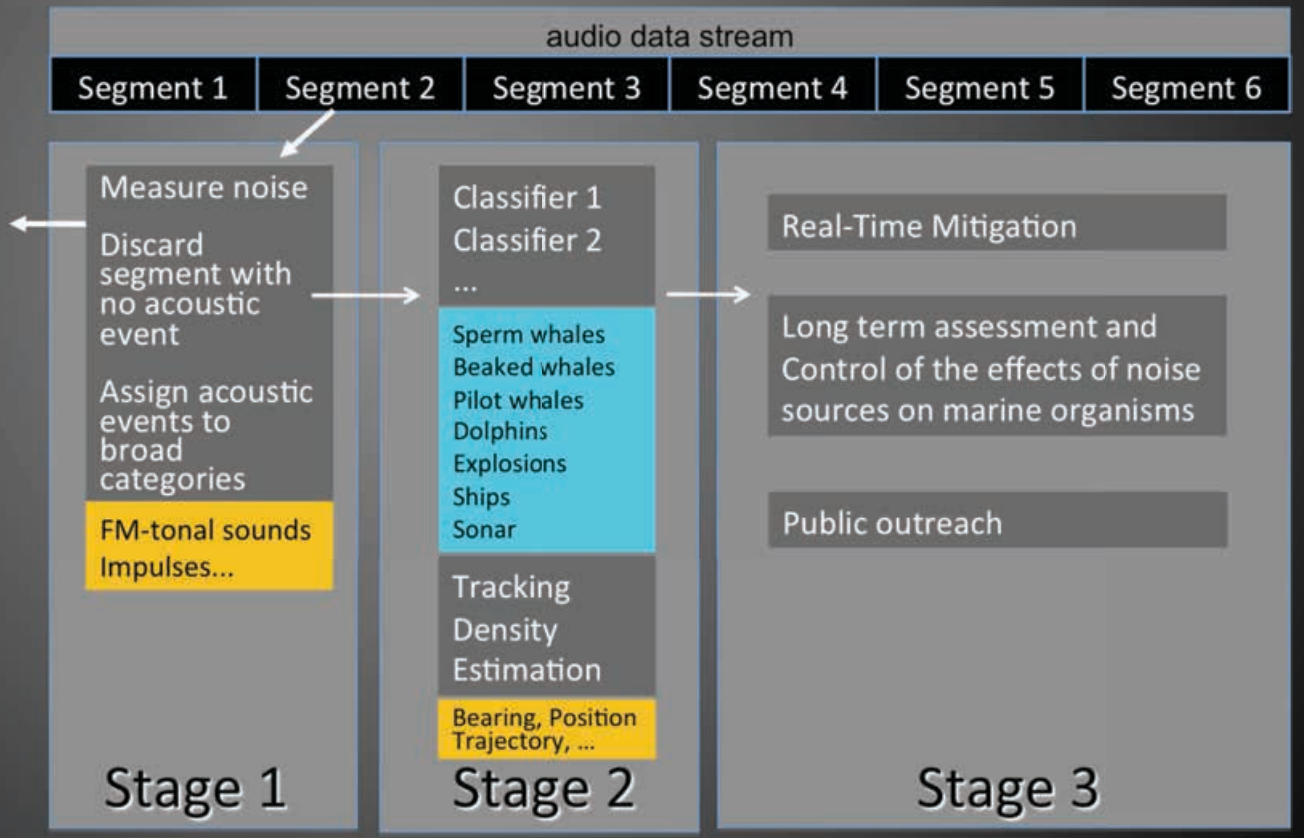
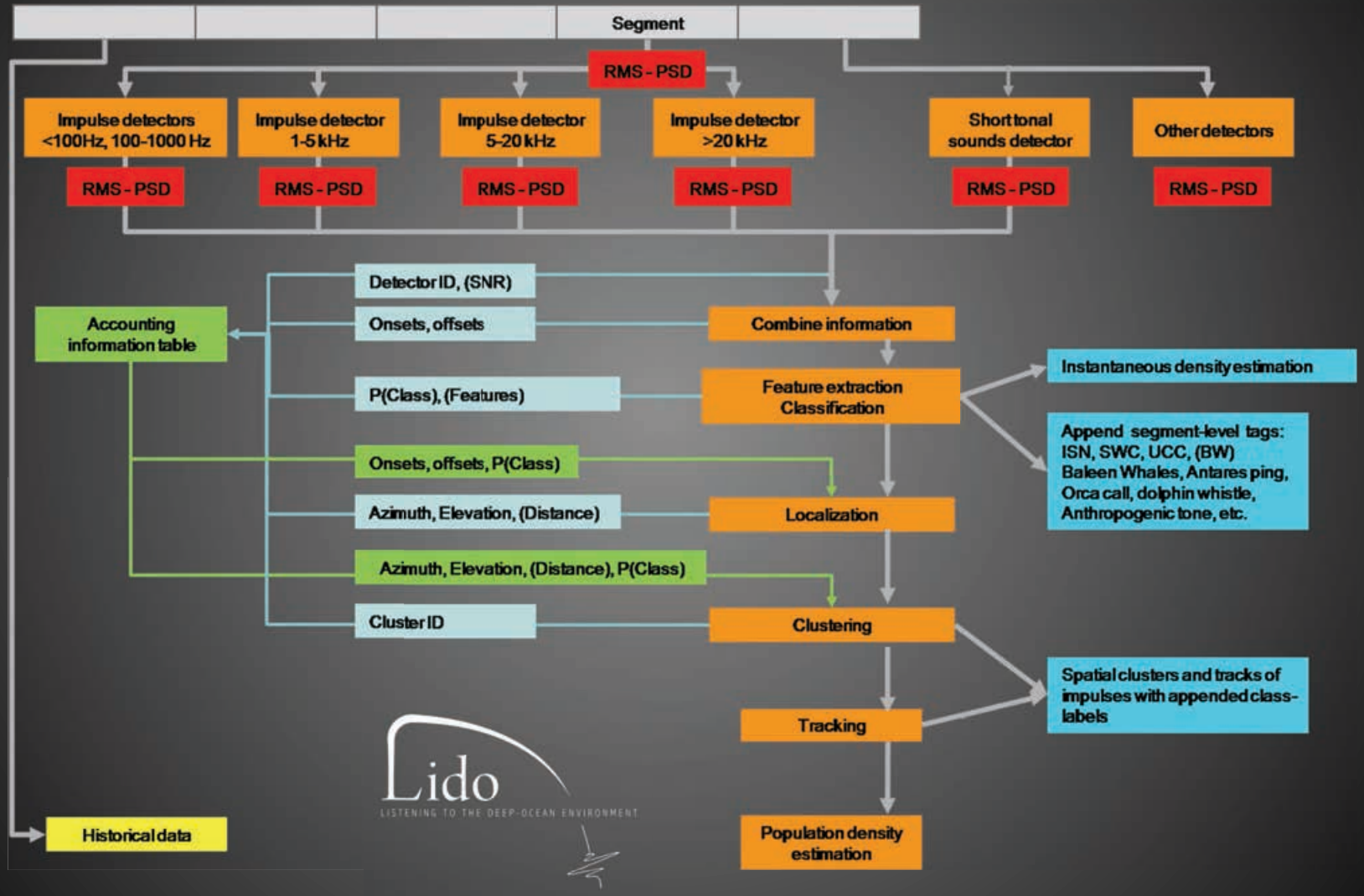


SONS-DCL Software Package



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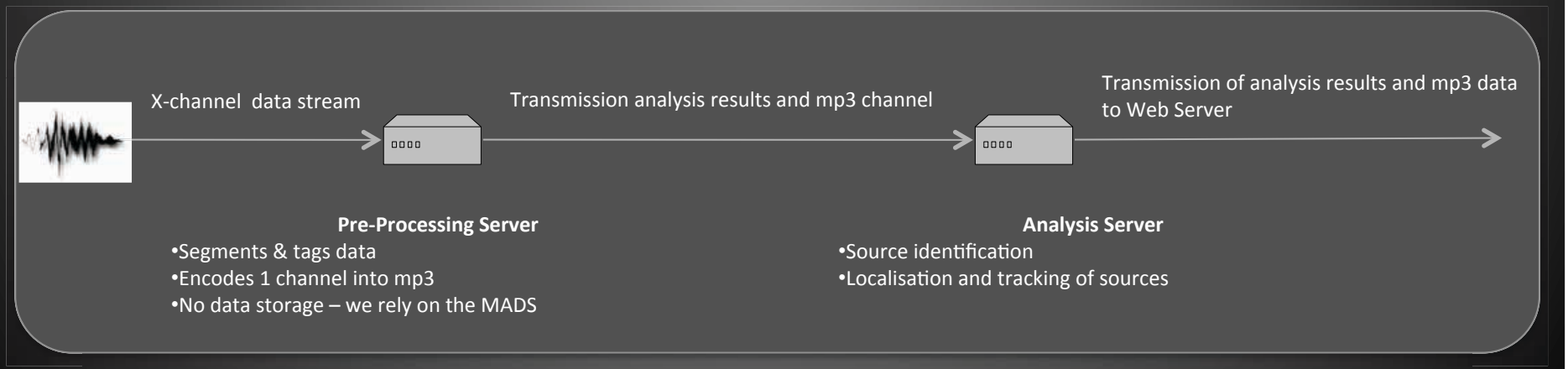
RT Acoustic Software Development
Acoustic Data Management



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Expertise:

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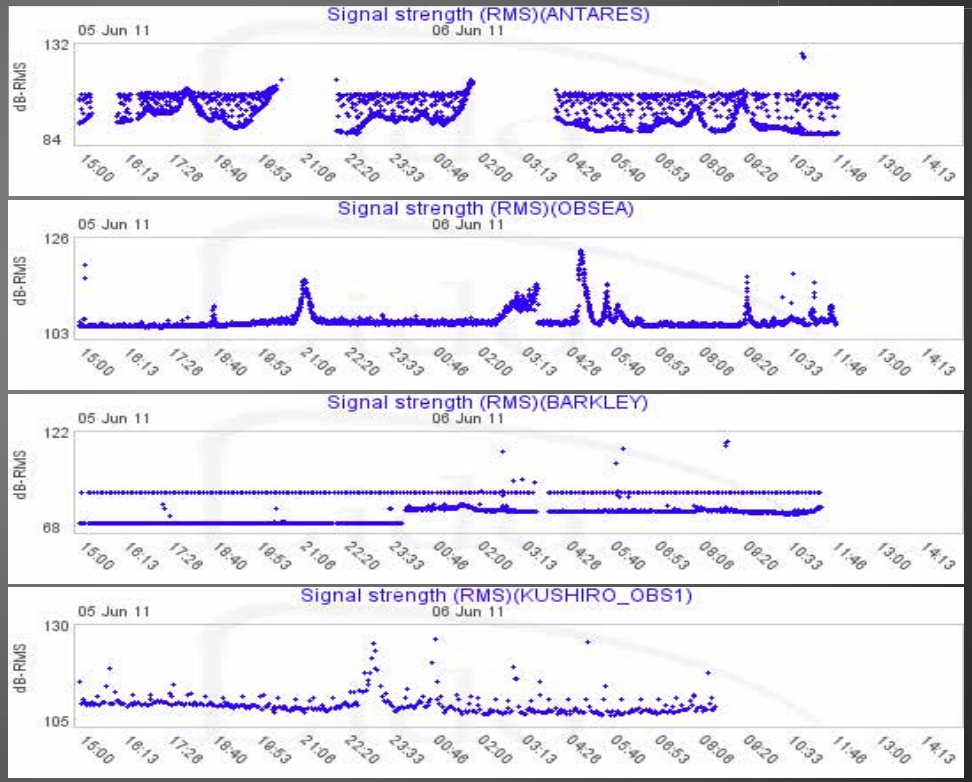
Global Noise Measurement

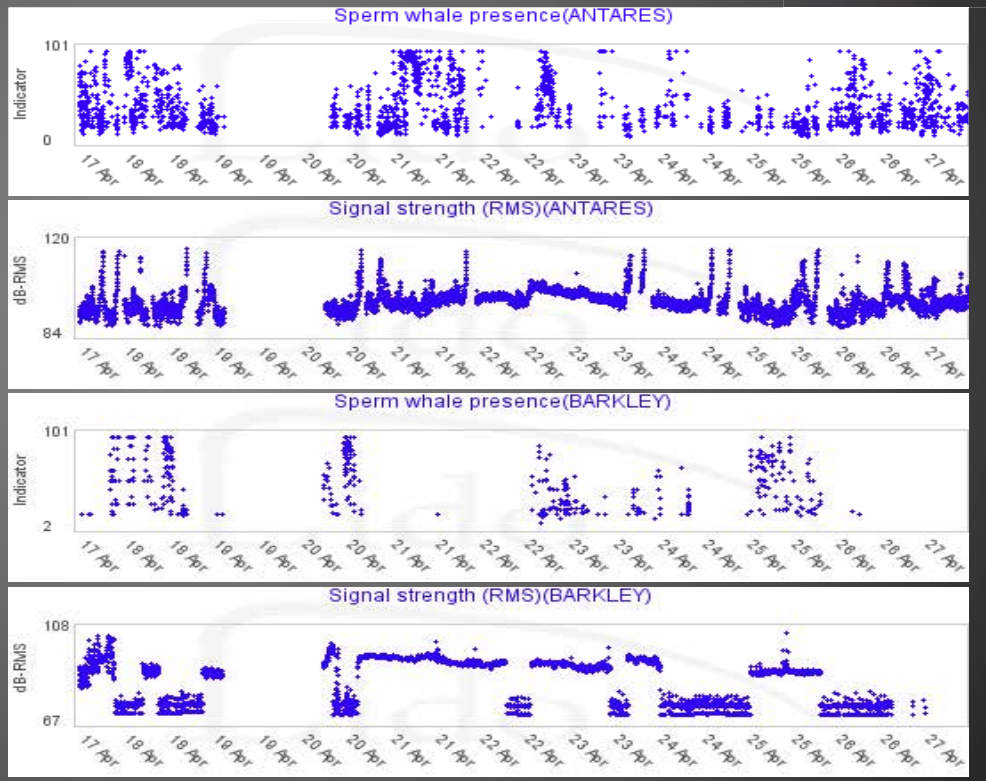


Detection of short tonal sounds in the band 0.2-16 kHz. Acoustic data from Neptune, 3-24 March 2010, 10 min recorded every 3.5 hour.

Expertise:

- -Regulation and International Initiatives
- -Biological Sensory Systems
- -Passive Acoustic Monitoring
- -Modeling

Global marine mammal distribution



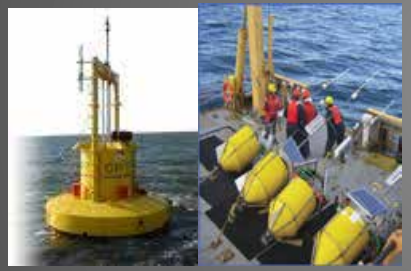
Detection of short tonal sounds in the band 0.2-16 kHz. Acoustic data from Neptune, 3-24 March 2010, 10 min recorded every 3.5 hour.

Integrated Systems

Deep-sea or shallow water cabled observatories

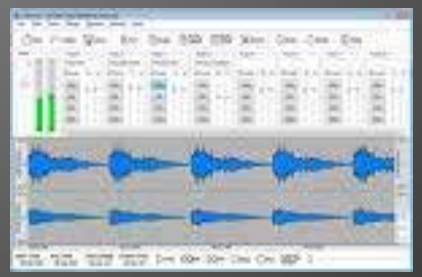
Towed arrays

Radio-linked , expandable or moored stand-alone buoys



Underwater vehicles, e.g. gliders

Geophysics sensors



Offline recordings

Domains of Application

Oil and Gas E&P Activities		 Offshore windmills & renewable energy
Shipping		 Navy Manoeuvres
Controlled Exposure Experiments		 Harbour & Offshore Construction

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- -Passive Acoustic Monitoring
- -Modeling

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International Workshop 2013 ERICE, SICILY, ITALY

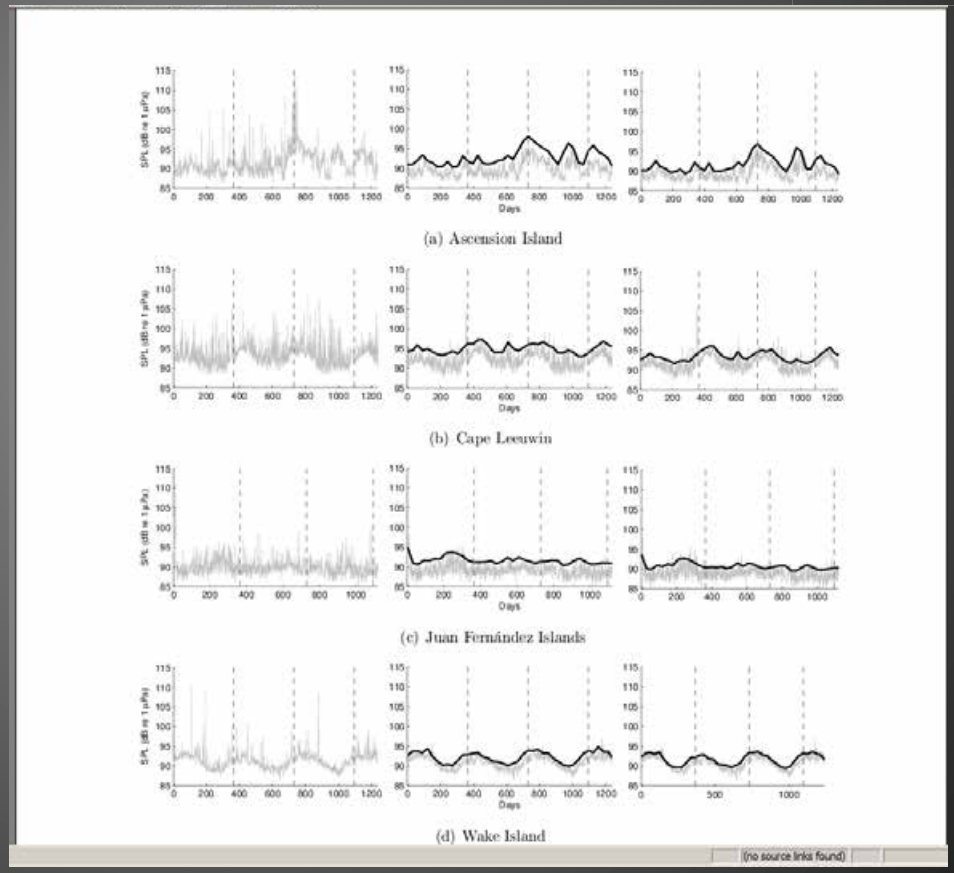
Expertise:

- -Regulation and International Initiatives
- -Biological Sensory Systems
- -Passive Acoustic Monitoring
- -Modeling

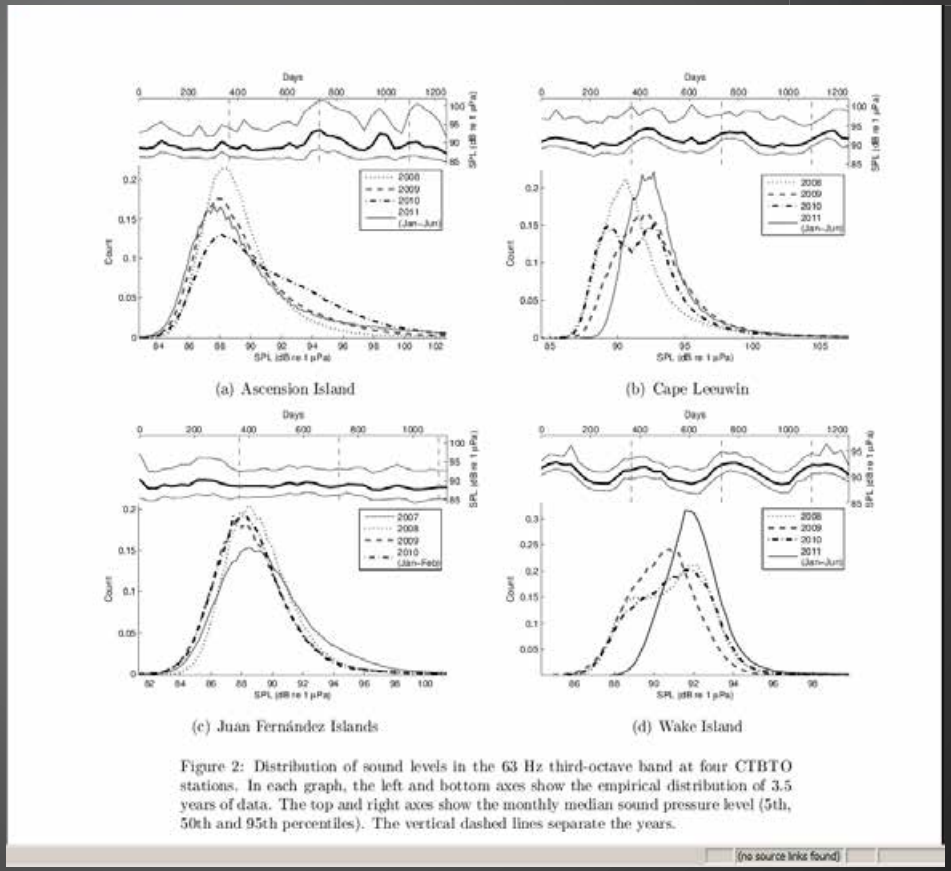
Changes in the 63 Hz noise band over 42 months recorded at 4 deep-ocean observatories.

Mike van der Schaar, Michael Ainslie, Stephen Robinson, Mark Prior, Michel André. Changes in 63 Hz third-octave band sound levels over 42 months recorded at four deep-ocean observatories, J. Mar. Syst. (2013), http://dx.doi.org/10.1016/j.jmarsys.2013.07.008

Measurement of the 63 Hz third-octave band at 4 CTBTO stations. The left graphics display the daily arithmetic mean in grey. The centre graphics show the daily geometric mean with the monthly standard deviation (over SPL). The right graphics show the daily median with 1.5 times the monthly Median Absolute Deviation (MAD over SPL). The vertical dashed lines separate the years.



Distribution of sound levels in the 63 Hz third-octave band at four CTBTO stations. In each graph, the left and bottom axes show the empirical distribution of 3.5 years of data. The top and right axes show the monthly median sound pressure level (5th, 50th and 95th percentiles). The vertical dashed lines separate the years



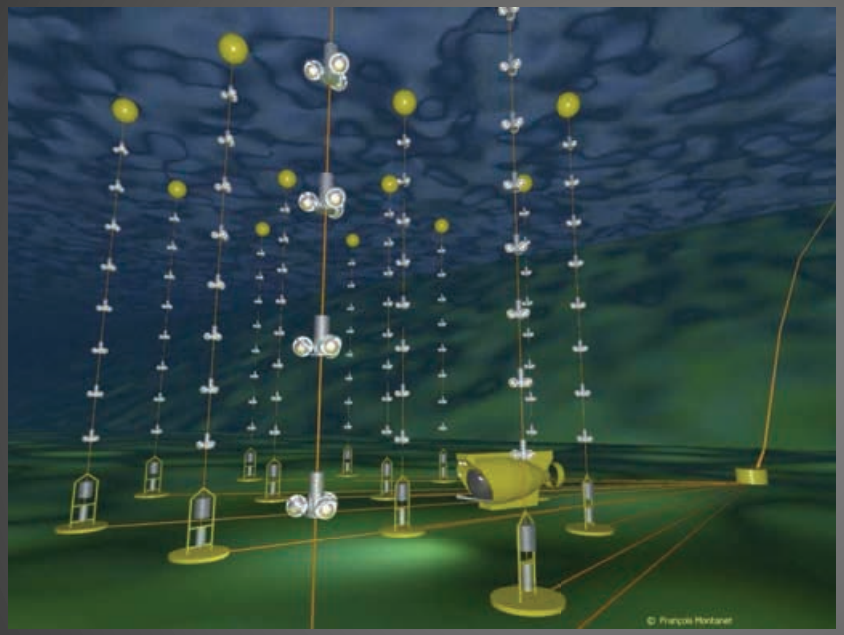
(a) Ascension Island (b) Cape Leeuwin

(c) Juan Fernández Islands (d) Wake Island

Figure 2: Distribution of sound levels in the 63 Hz third-octave band at four CTBTO stations. In each graph, the left and bottom axes show the empirical distribution of 3.5 years of data. The top and right axes show the monthly median sound pressure level (5th, 50th and 95th percentiles). The vertical dashed lines separate the years.

(no source links found)

Sperm whale behaviour in the Ligurian Sea



ANTARES Collaboration: 40km offshore Marseille, 2.500m depth

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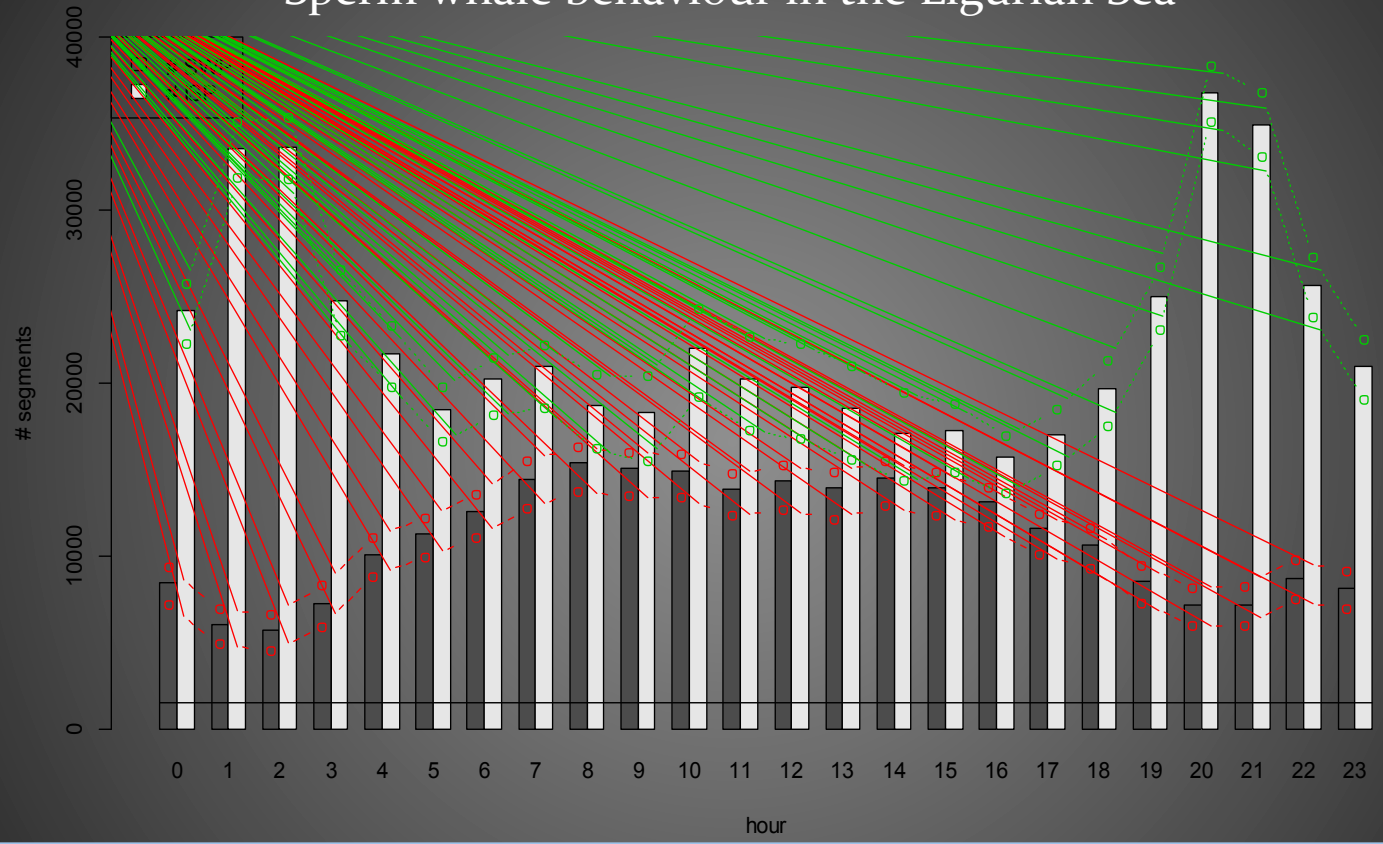

Hourly presence of sperm whales averaged over 12 months (2012) at ANTARES

Number of segments with sperm whales and shipping impulse presence per hour in 2012.
Sperm whale presence was higher during the daylight hours, whereas at night shipping impulses were more prominent.

CONCLUSIONS & PERSPECTIVES

Underwater observatories present a unique opportunity to measure and monitor noise changes at a global scale given standardised methods are applied

Marine fauna acoustic behaviour can be monitored in real-time at large spatial and temporal scales

The LIDO bio-acoustic approach is expanding and represents a promising platform to integrate knowledge and develop new generation technology

The data from the existing observatories under the LIDO initiative is available to the scientific community

The software package SONS-DCL behind LIDO is available to the community and can be operated by a non-expert on any oceanographic platform: cabled observatories, autonomous buoys, unmanned vehicles, towed arrays, archived data, etc.

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