A buoy network system for acoustic monitoring

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Contributors

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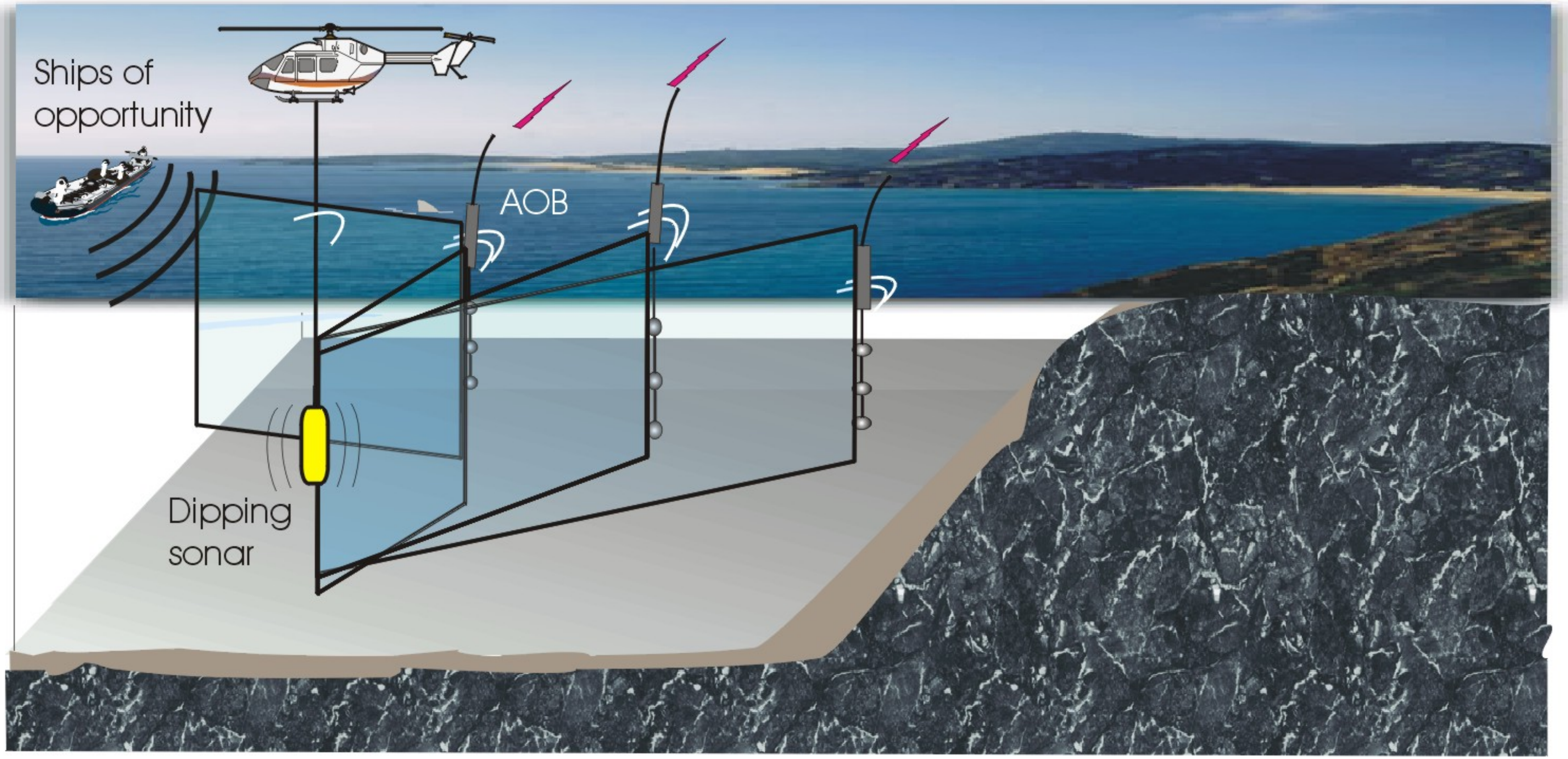
The Acoustic-Oceanographic Buoy (AOB) network concept

Easily deployable/reconfigurable AOB - based system



Cape Teulada

Drifting buoy-based initiatives: historical perspective

1996 SEAGO EU proposal, sonobuoy network for geo-acoustic inversion
1997 ENVERSE'97 & 98, geo-acoustic inversion (Hermand, NURC)

2002 LOCAPASS project (MoD, Portugal) - develop AOB1, 4 sensors
2003 **AO-Buoy JRP**: NURC, UALG, ULB, NLDA and IH
⇒ MREA'03 sea trial - AOB1 test at sea (Elba, Italy)
2004 MREA'04: AOB1 test (Setúbal, Portugal)

2004 **RADAR** (FCT, Portugal) w/ ULB participation - 2×AOB2, 16 sensors
2005 MakaiEx (Hawai, USA): AOB2 first test (Kauai(HI), US)
2007 ⇒ MREA BP'07: AOB2 network test (S. Elba, Italy)
⇒ RADAR'07: AOB2 network test (Setúbal, Portugal)

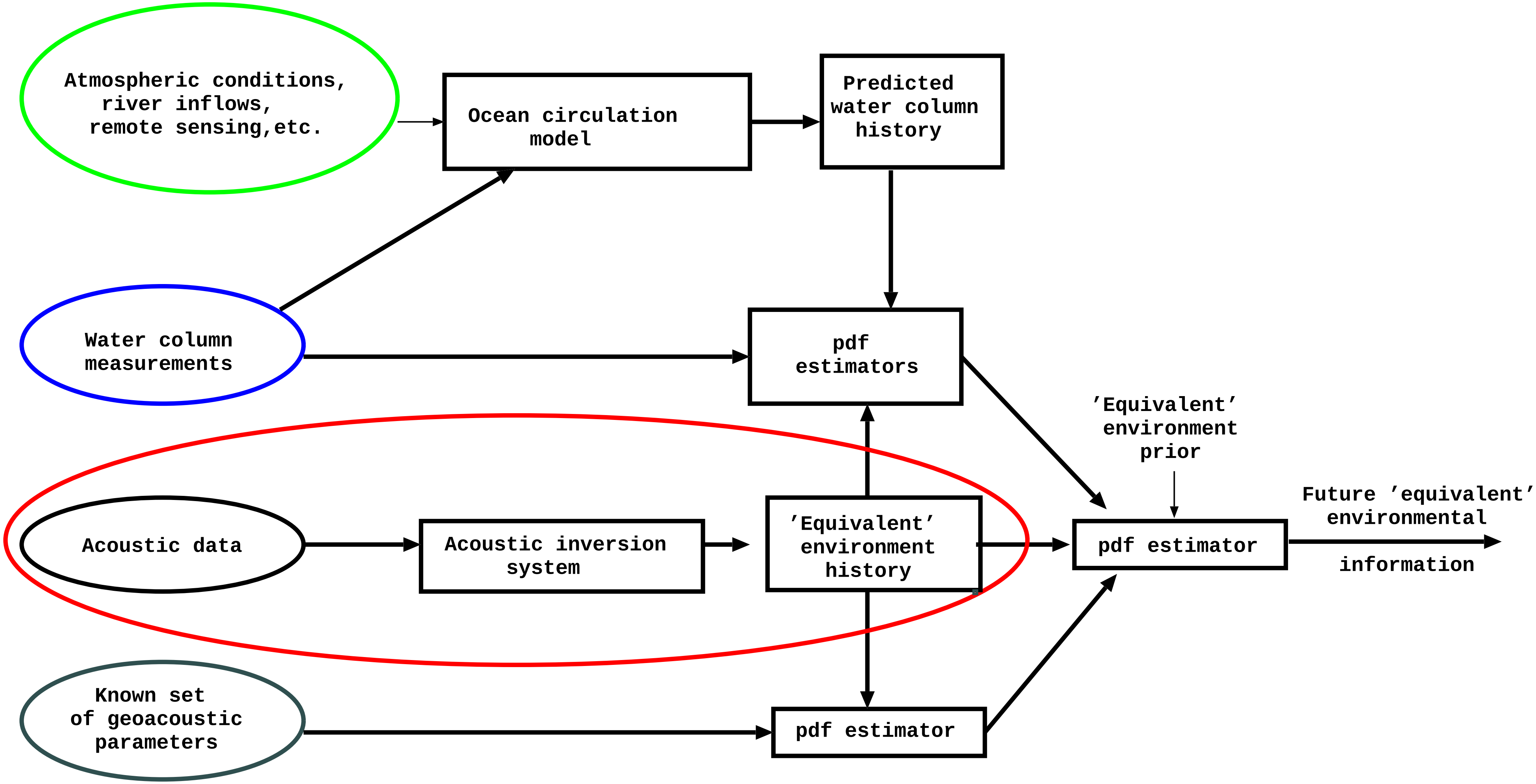
Simple statement

"There is no garantee that the best environmental prediction provides the best acoustic prediction"

$\Rightarrow$ imperfect data / physical model

$\Rightarrow$ geometrical / model mismatch

An approach to the acoustic prediction problem



An approach to the acoustic prediction problem (cont.)

$$p(\mu_F|\omega, o_F, g, \alpha, \psi) \propto \int\int \frac{\delta(\mu_F - U(n_{wF}, n_b))\, p(n_{wF}|\omega, o_F, \psi)\, p(n_b|g)}{p(n_b)} \times \int \frac{p(\nu_w, n_b|\alpha)\, p(\nu_w|\psi)}{p(\nu_w)}\, d\nu_w\, dn_b\, dn_{wF}$$

$p(n_{wF}|\omega, o_F, \psi)$: future 'equivalent' water column | measurements, ocean forecast,

$p(n_b|g)$: equivalent geoacoustics | history geoacoustics,

$p(n_b)$: prior on 'equivalent' geoacoustics,

$p(\nu_w, n_b|\alpha)$: acoustic inversion 'equivalent' environment | acoustic data,

$p(n_w|\psi)$: 'equivalent' water column | water column measures,

$p(n_w)$: 'equivalent' water column prior.

An approach to the acoustic prediction problem (cont.)

Advantages

- acoustic prediction satisfies an acoustic cost criteria
- acoustic modeling/mismatch trends are ‘learned’ for future detrending
- optimal combination of ocean predictions, measurements and inversion outcomes

Expected drawbacks:

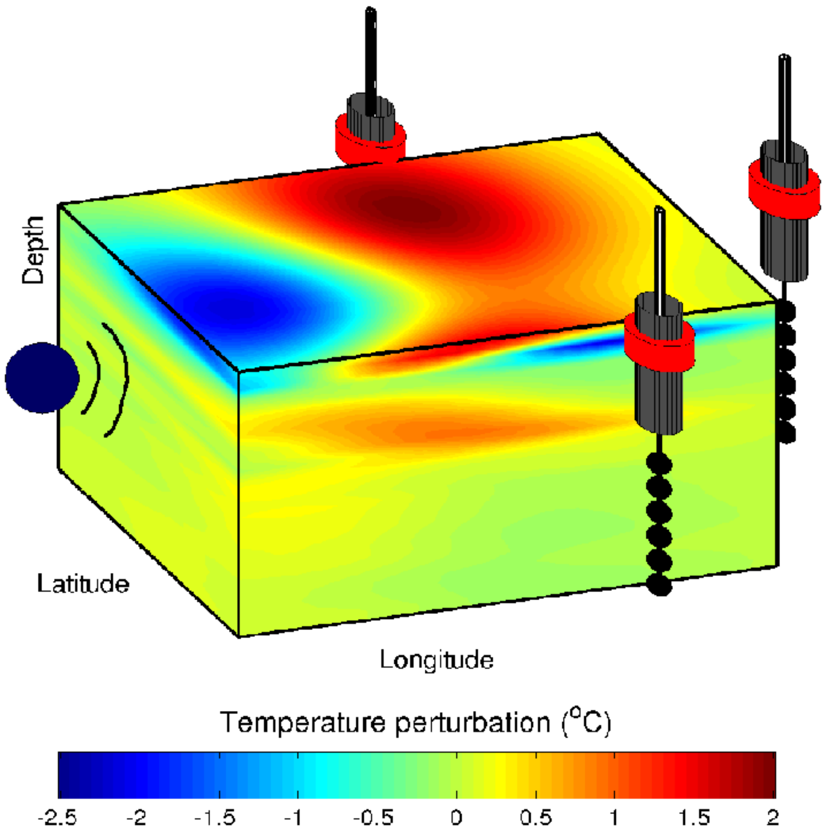
- stationarity assumptions required for pdf estimation not met
- lack of data, to estimate pdfs in early stages of the iterative process
- pdfs interp/extrap may lead to unrealistic statistical relationships

Environmental Inversion: the strategy

Bottom		low/mid frequency 0.3 - 1.6 kHz
		a priori information
		adaptive geoacoustic sampling (patches)
	$\Rightarrow$	"known" space-variant geoacoustic parameters
Water Column		a priori information
		regularization / constraining
		spatial coverage / coherence
	$\Rightarrow$	$a\ posteriori$ pdfs for 'equivalent' model

Acoustic Rapid Environmental Assessment (AREA)

Measured CTD from MREA'03 (N.Elba)



Actual:

- up to 20×20 km
- water column and geo-acoustic inversion
- sources of opportunity

Objective:

- 3D EOF's constrained
- multiple array coherent inversion

Acoustic Oceanographic Buoy V1 (AOB1)

AOB1 - main characteristics
weight: 90 Kg in air
dimensions: 1.5 $\times$ 0.30 m
autonomy: 6 hours
bandwidth: 16 kHz
hydrophones: 4


MREA'04, April 2004, Setúbal (Portugal)

MREA'03/04: setup and environmental model

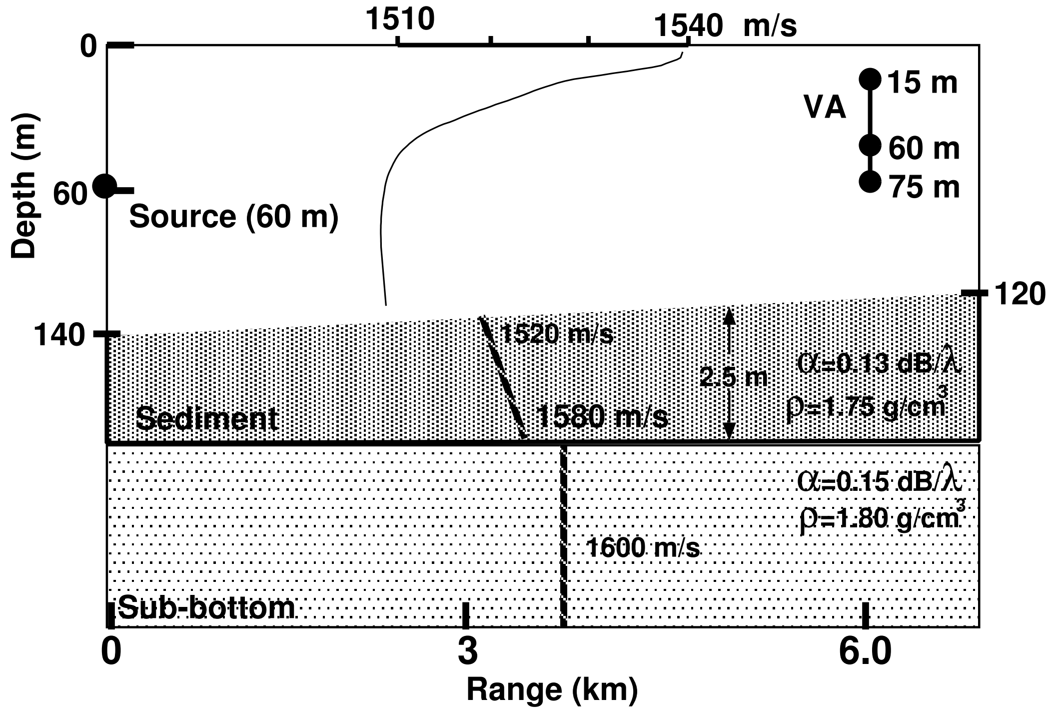
AOB1 - prototype

- single buoy
- small aperture/3-4 phones

Processing issues

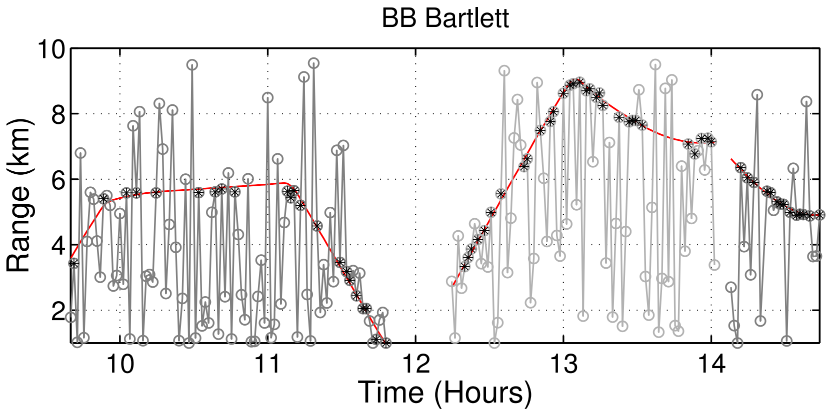
- high ambiguity
- high parameter adaptivity

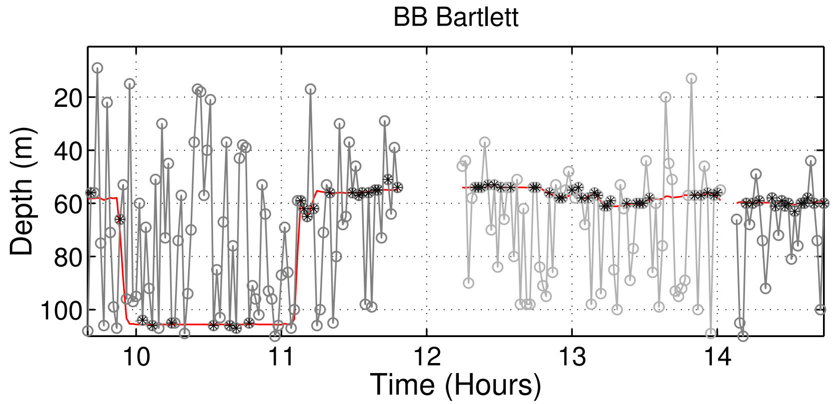
⇒ broadband: 500 -1200
⇒ high-resolution hypersurfaces
⇒ focalization
⇒ validation of results



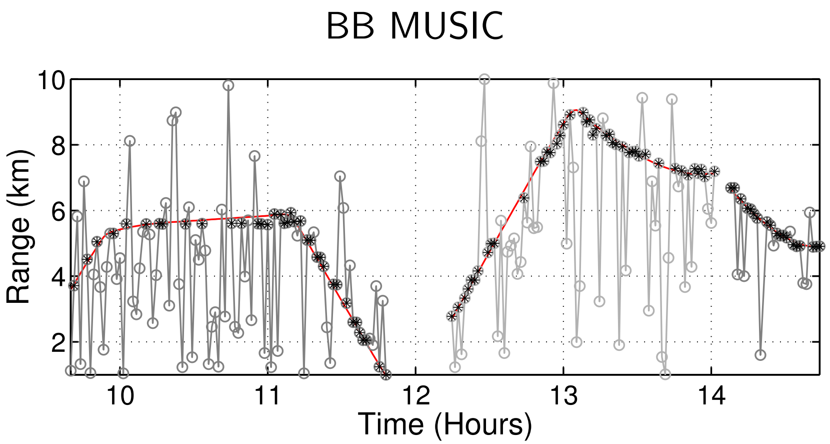
MREA'03/04 conceptual RD model.

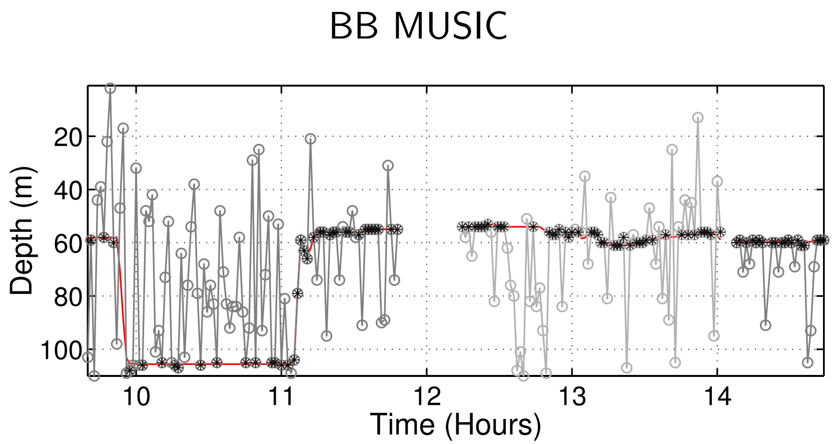
MREA'03/04: inversion validation by source localization.





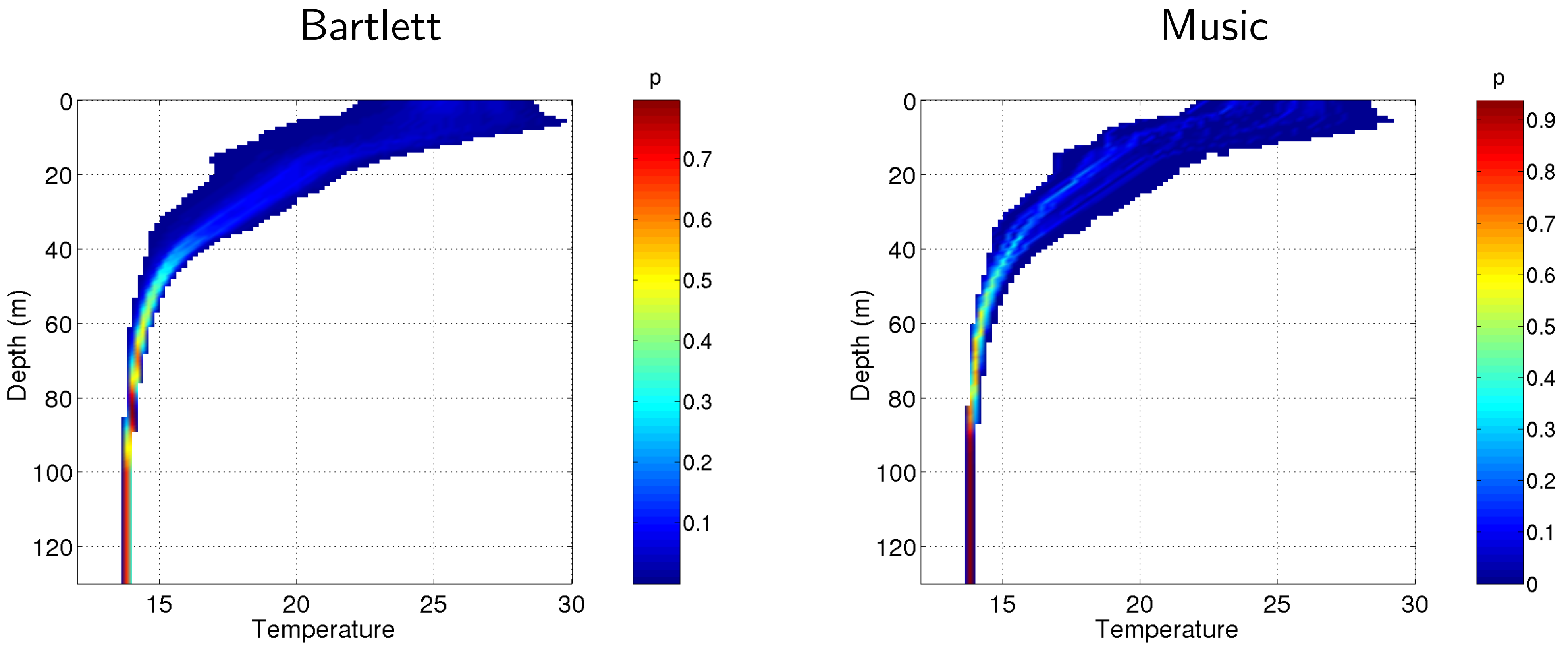
32%





48%

MREA'03/04: inversion statistics.



Acoustic Oceanographic Buoy V2 (AOB2)

AOB2 - main characteristics

DSP on the buoy processing

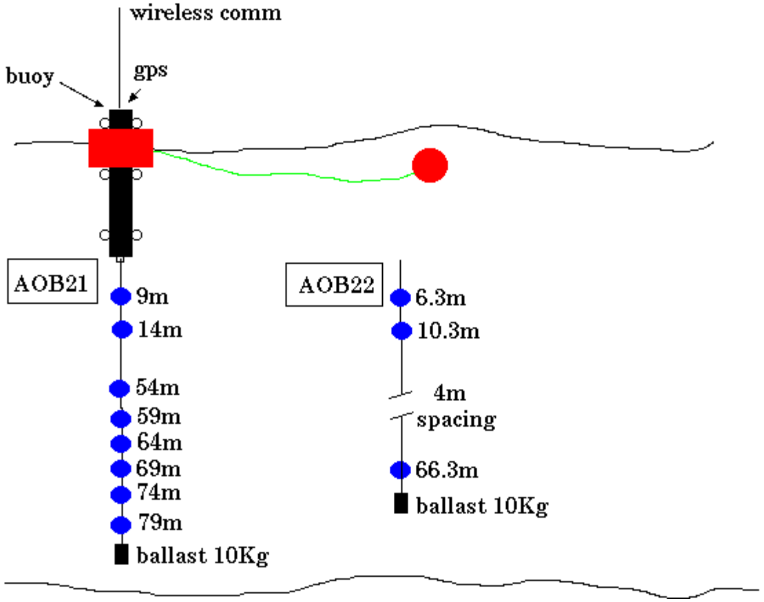
weight: 40 Kg in air

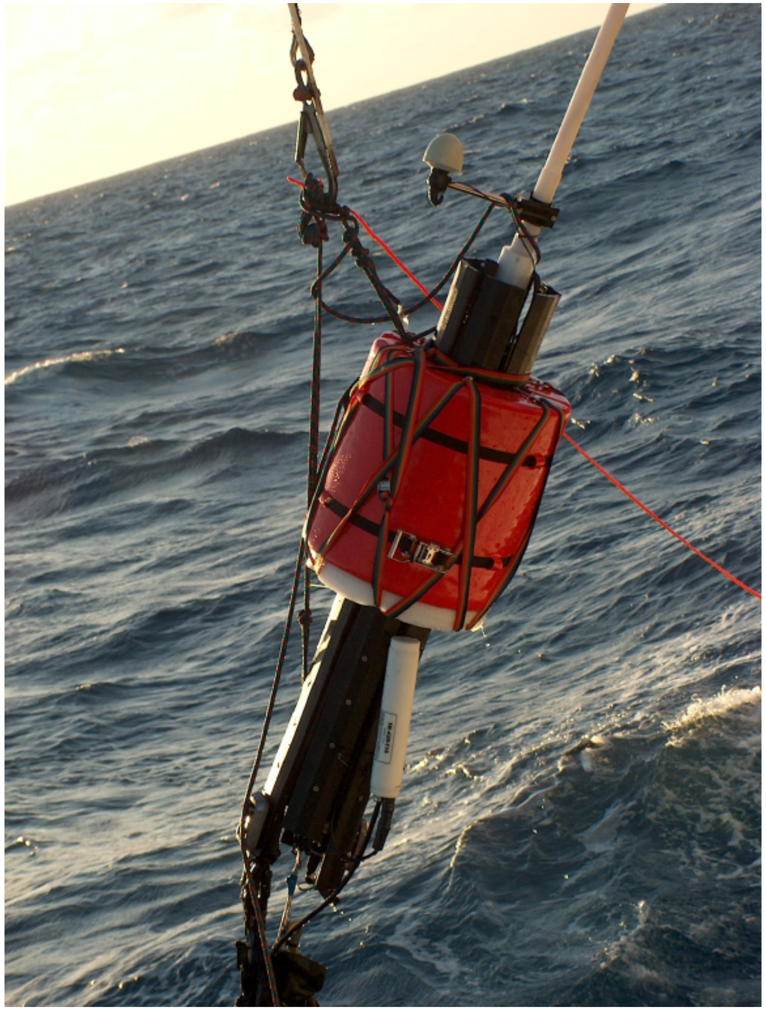
dimensions: 1.2 × 0.16 m

autonomy: 12 hours

bandwidth: 16 kHz

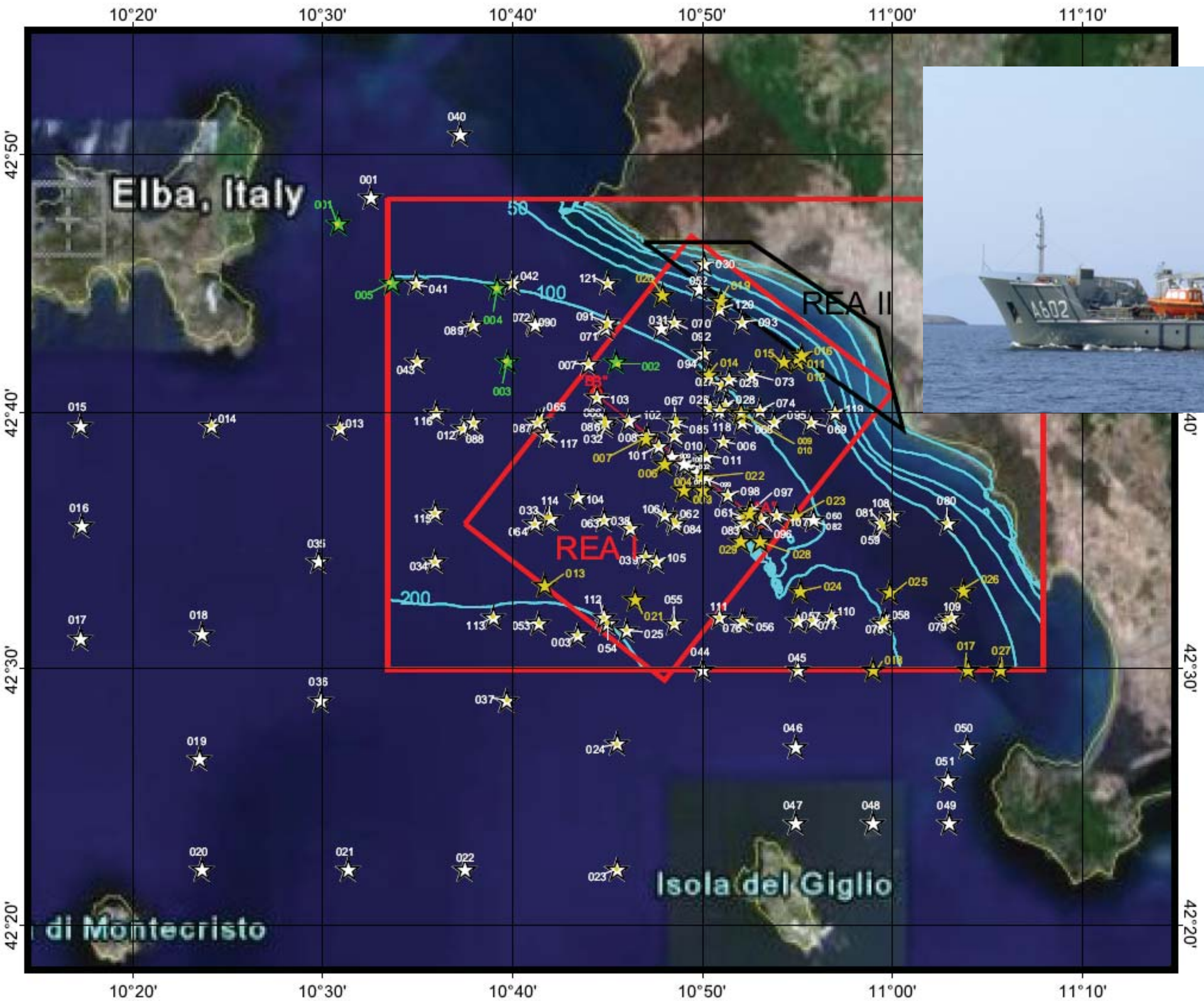
16 temp. sensors





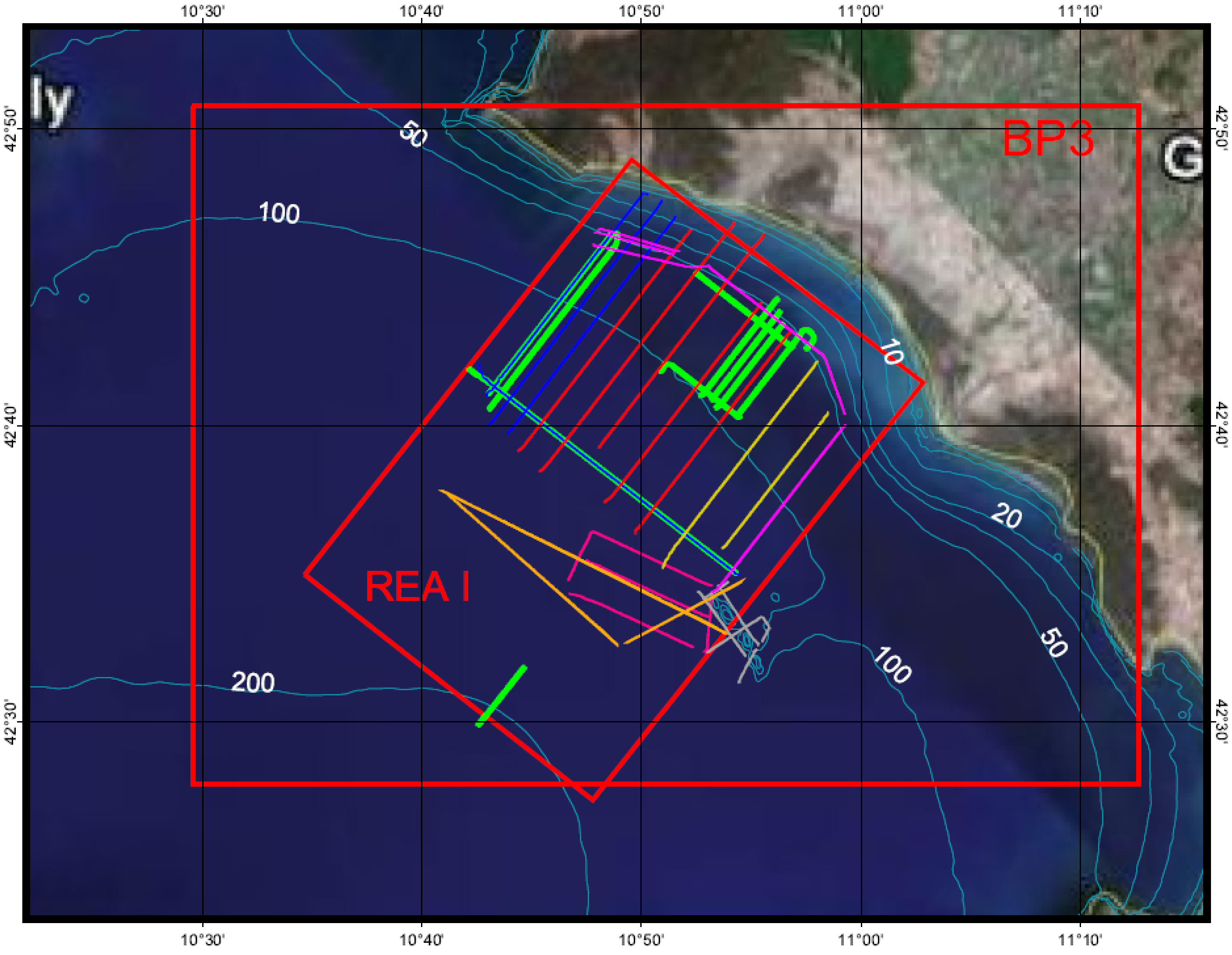
Makai Ex, Sep 2005, Hawaii (USA)

MREA/BP'07 (April/May 2007)

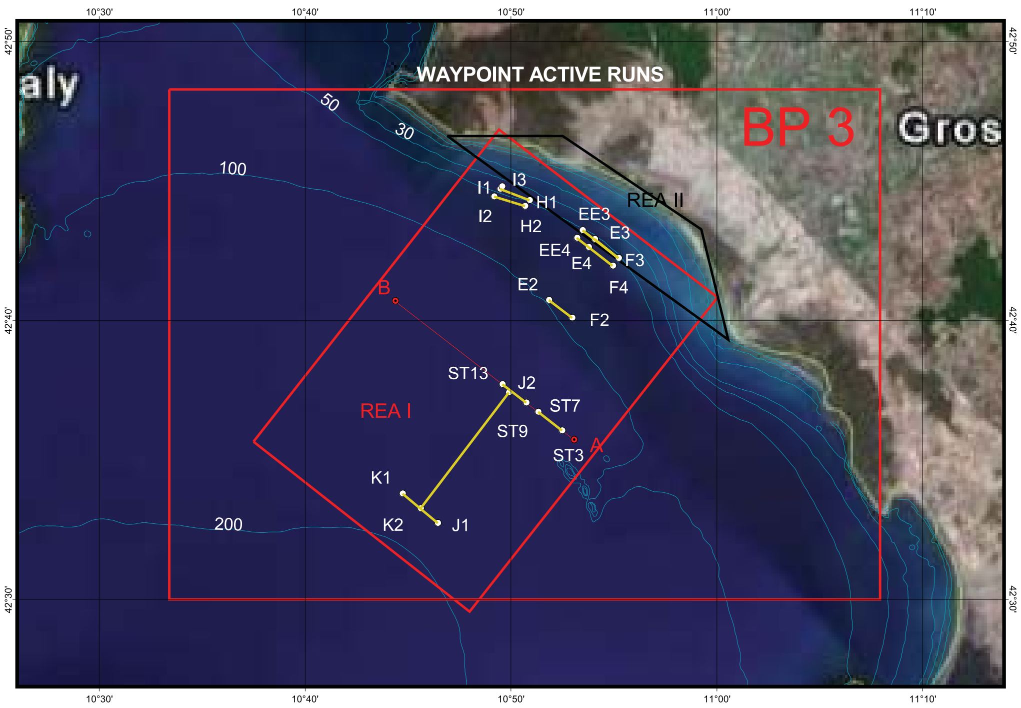


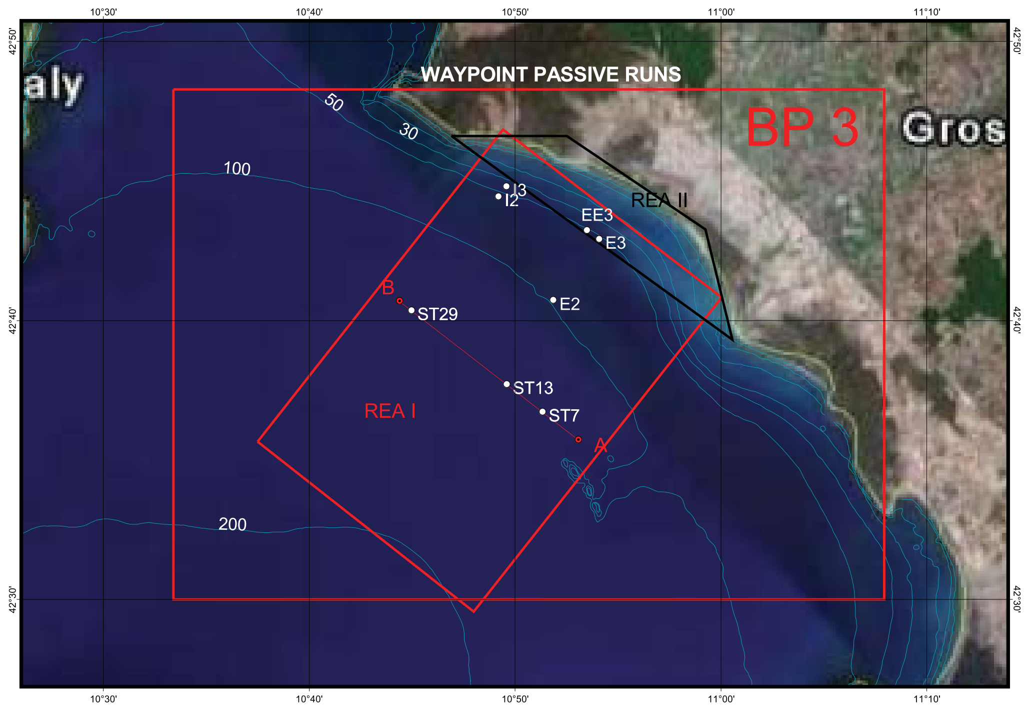
CTD Aretusa
CTD Leonardo
CTD Snellius

MREA/BP'07: geophysical survey

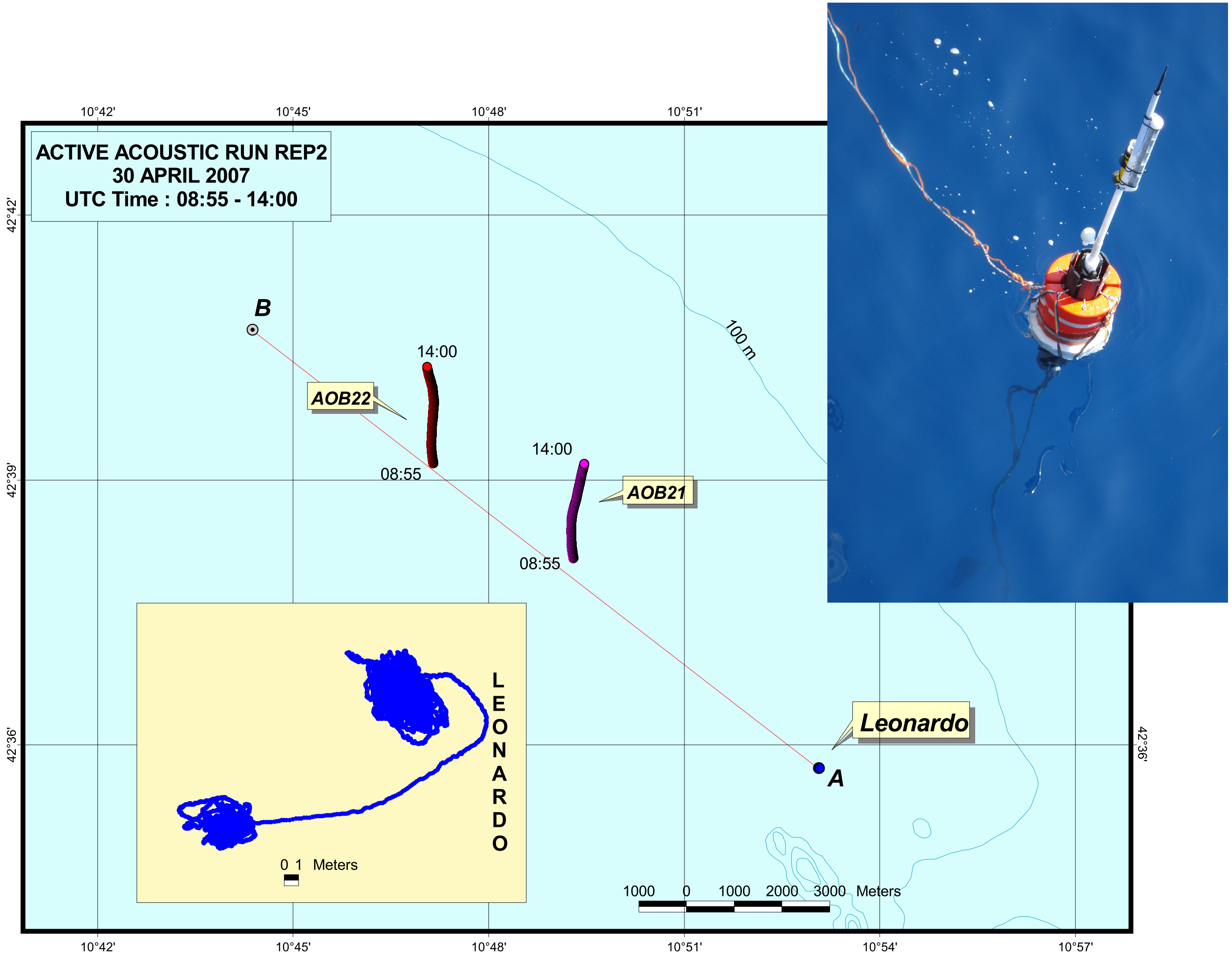


MREA/BP'07: active and passive runs





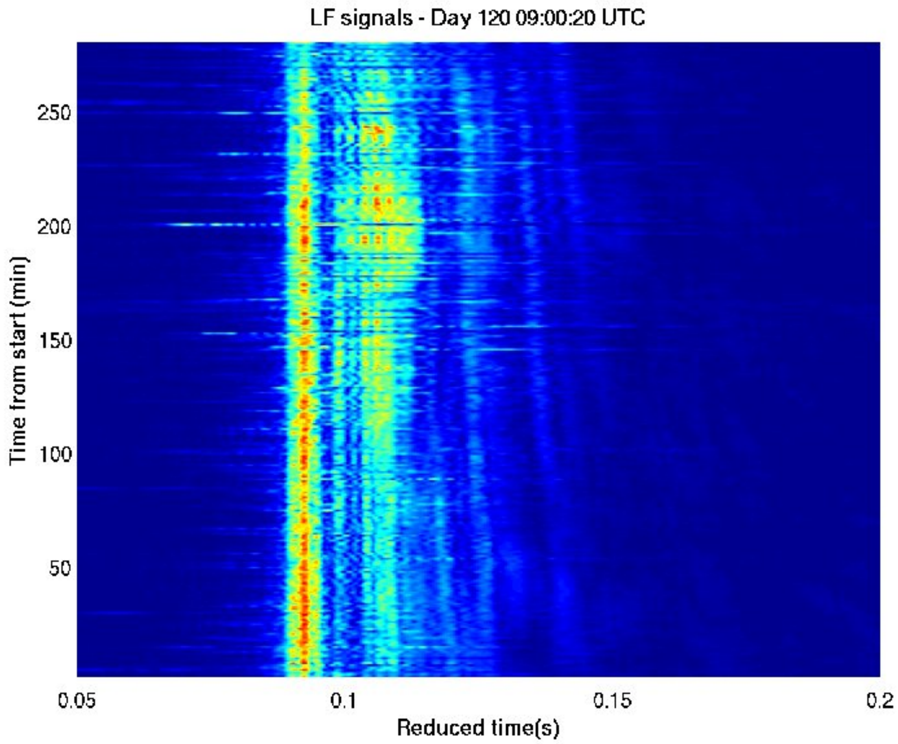
MREA/BP'07: AOB drift April 30, 2007



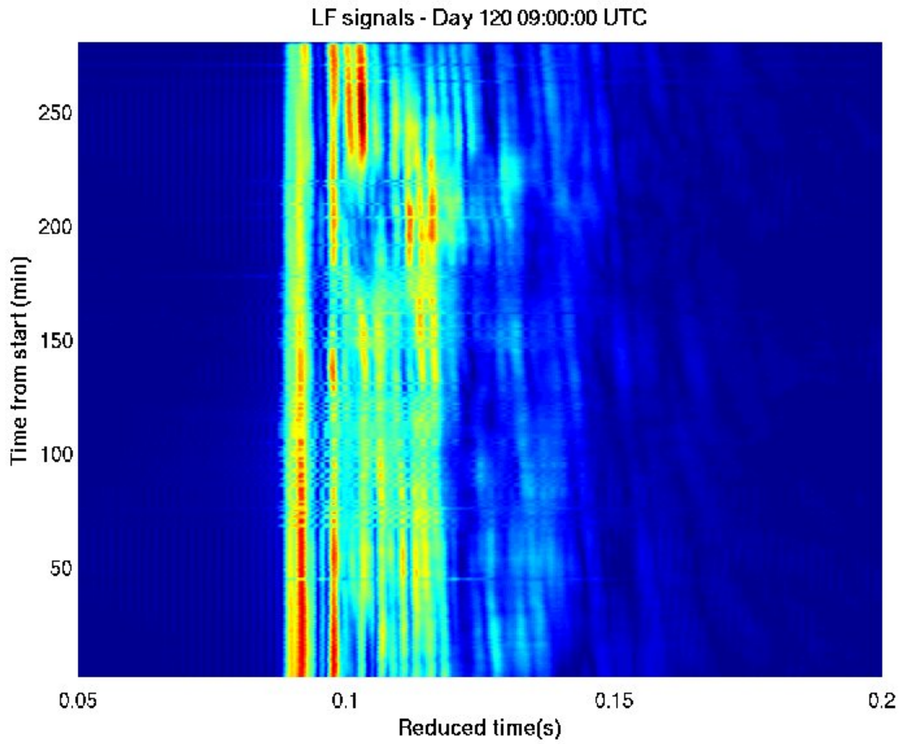
MREA/BP'07: data collection April 30, A-B line

Band: 300 - 800 Hz

7 km range, 62 m depth



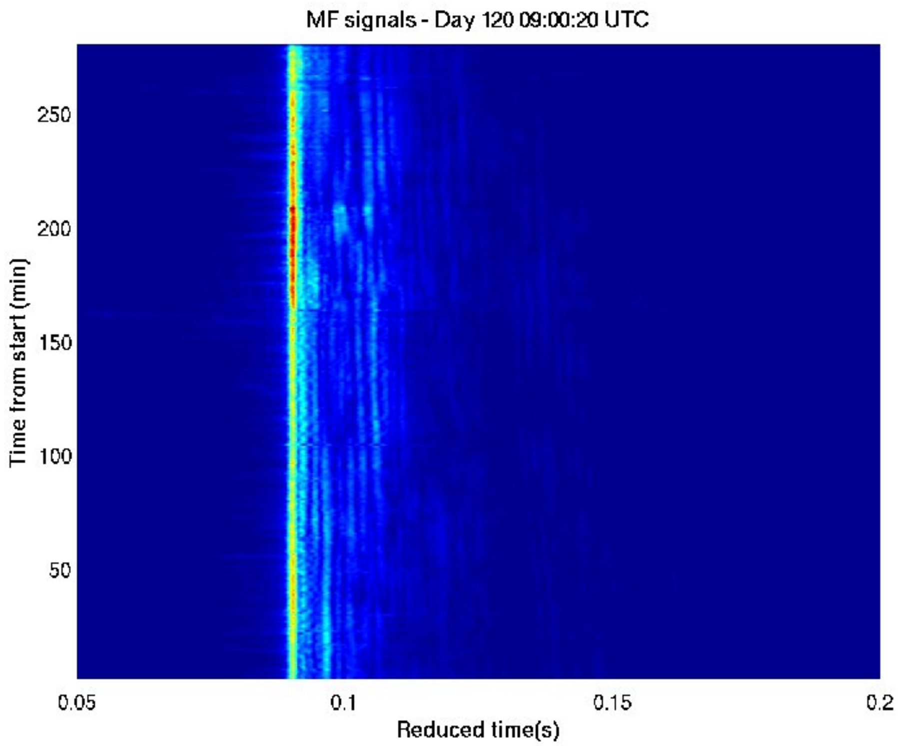
11 km range, 70 m depth



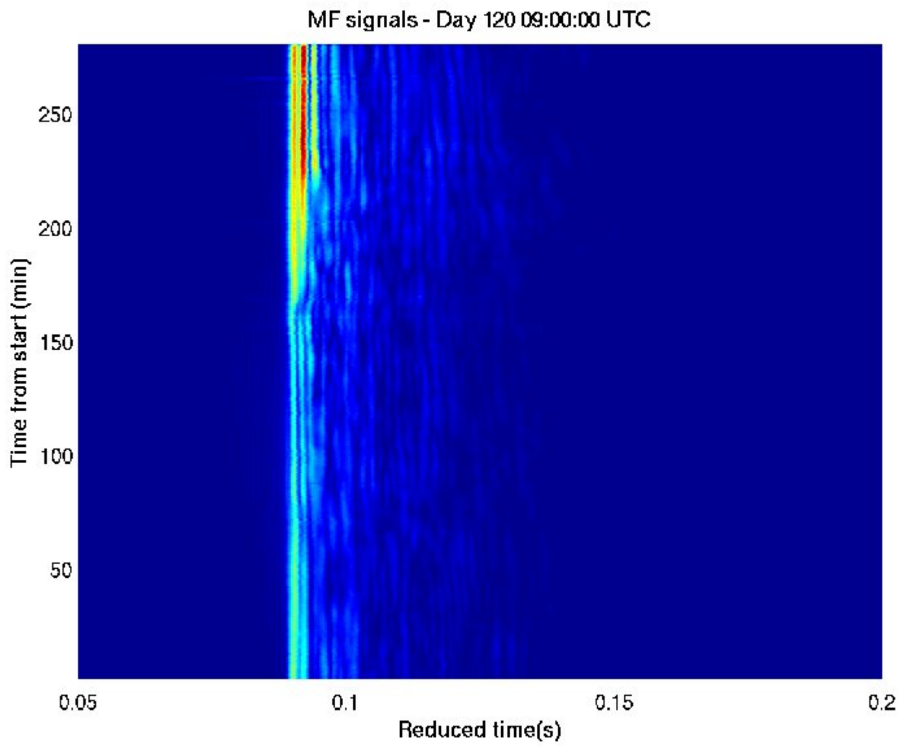
MREA/BP'07: data collection April 30, A-B line

Band: 800 - 1600 Hz

7 km range, 62 m depth



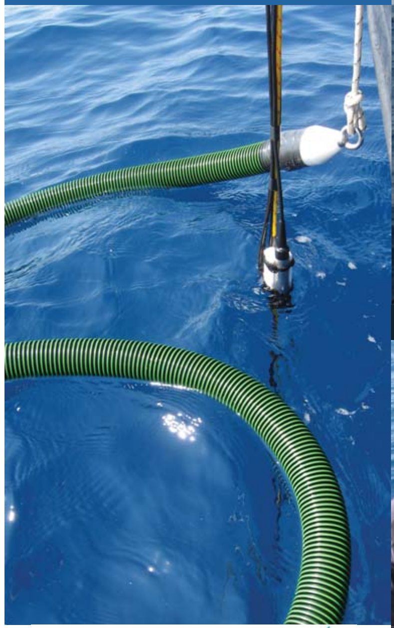
11 km range, 70 m depth



MREA/BP'07: geoacoustic inversion with sources of opportunity

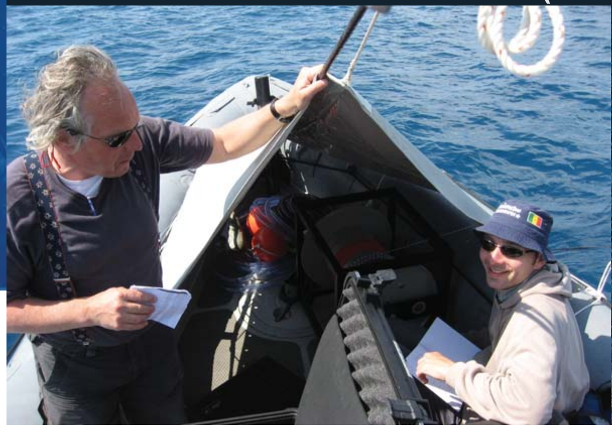
NURC R/V LEONARDO AS A SOURCE OF OPPORTUNITY

SPARSE RECEIVING ARRAY

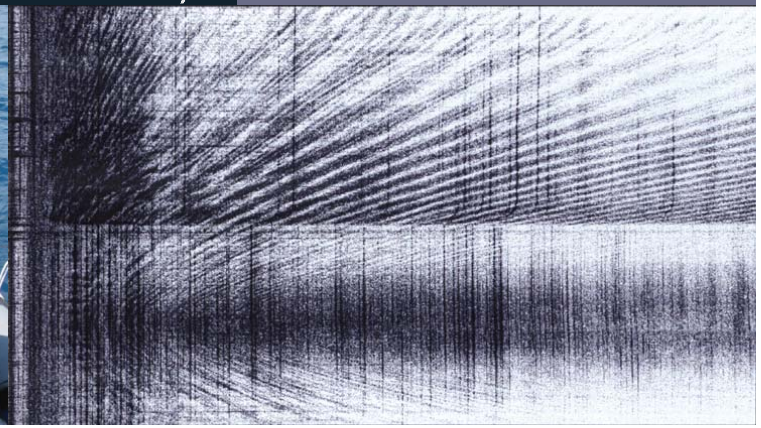


Royal Netherlands Navy

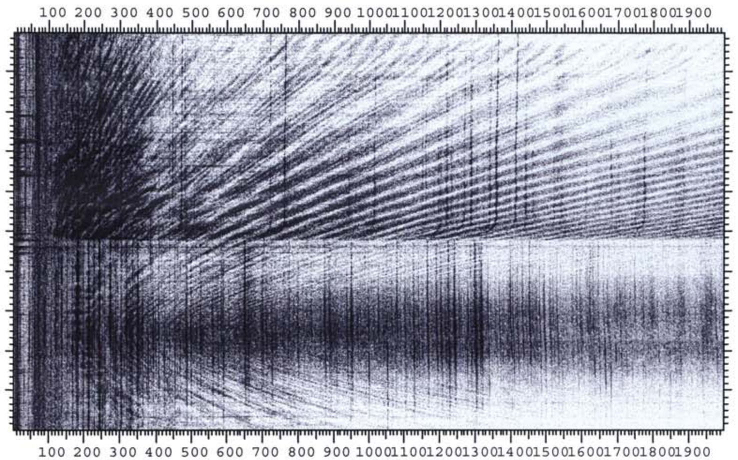
ROYAL NETHERLANDS NAVY RHIB (HRMS SNELLIUS)



ACOUSTIC DATA



MREA/BP'07: inversion results



SPECTROGRAM OF LEONARDO SELF-NOISE
TIME (10 MIN) VS. FREQUENCY (0 - 2 KHZ)

<u>Objective function is based on:</u>

8 frequencies (Hz):

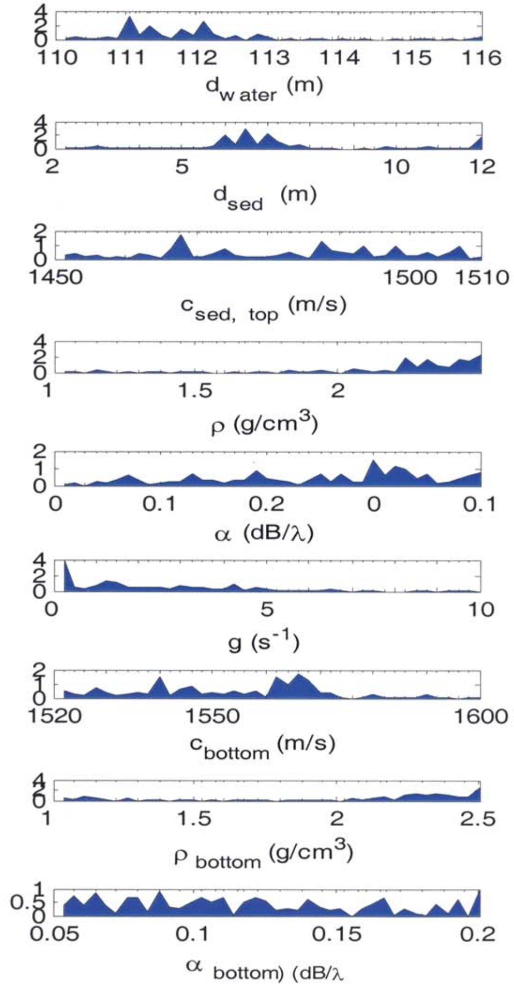
226.2	452.6	486.1	582.9
698.5	948.5	1163.4	1239.3

9 ranges(km):

0.689	0.706	0.723	0.740
0.758	0.775	0.792	0.809
0.827			

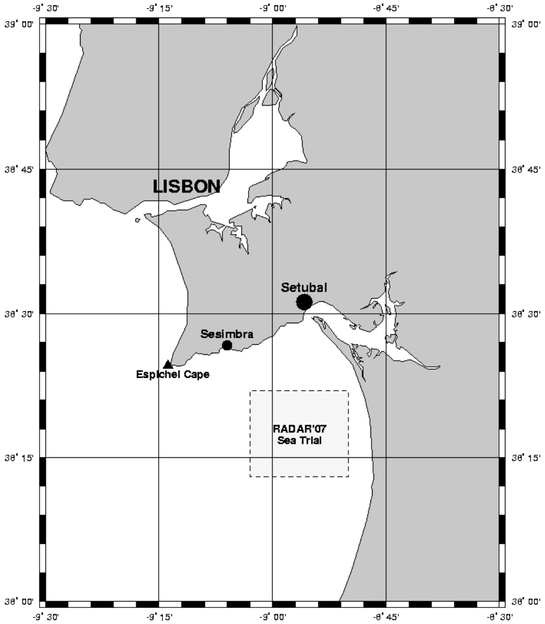
4 depths (m):

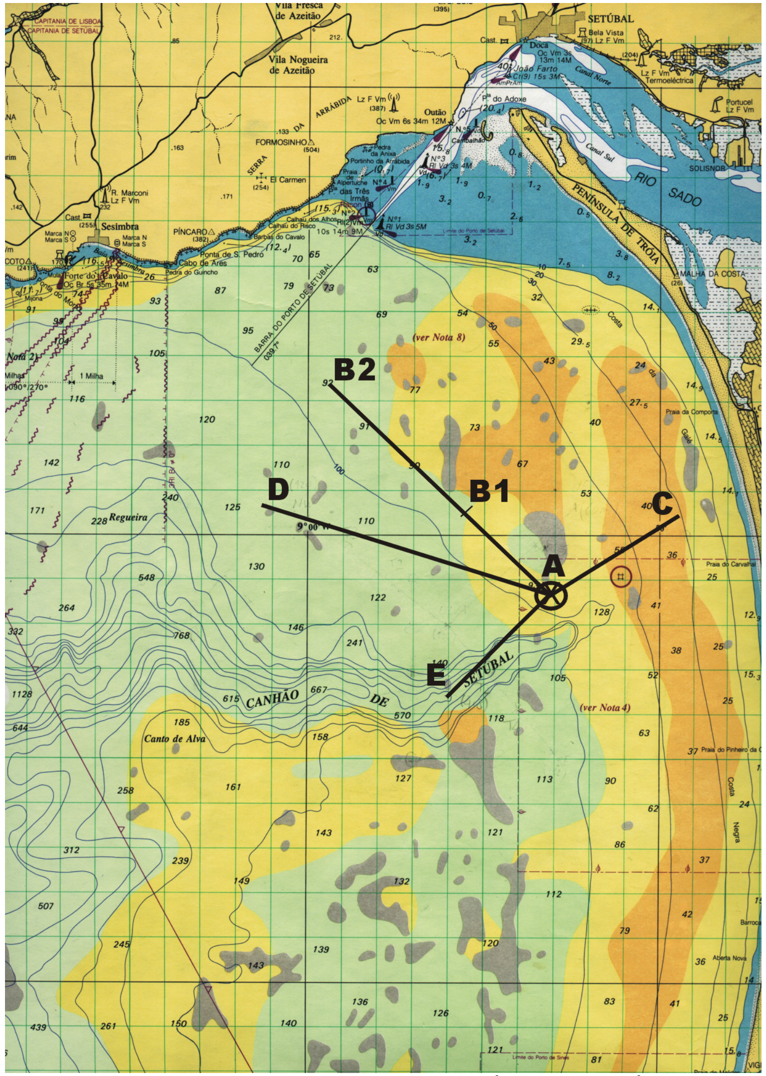
19.04	24.01	28.98	33.95



GEOACOUSTIC PARAMETERS
PROBABILITY DISTRIBUTIONS

RADAR'07: area and ressources



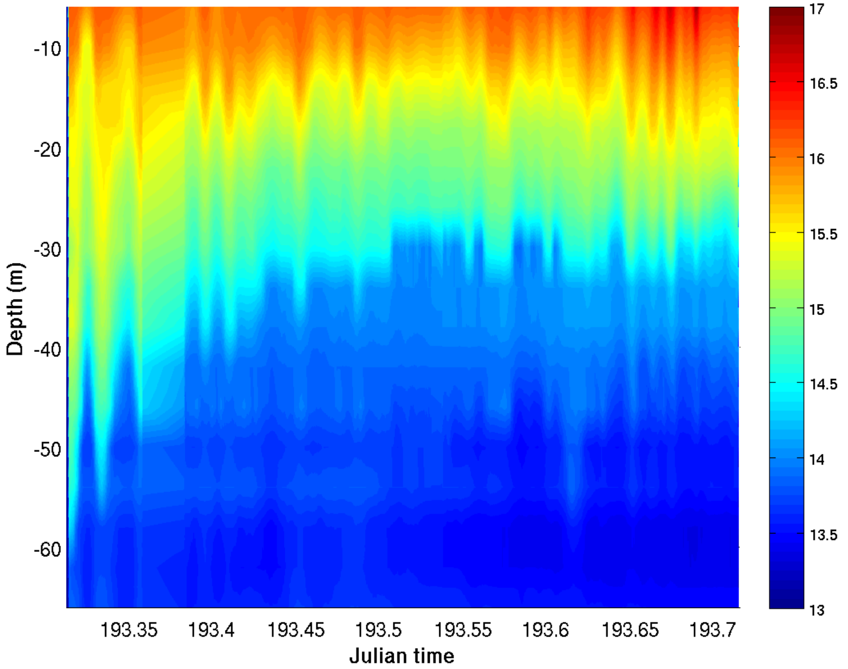


Setúbal test area (Portugal)

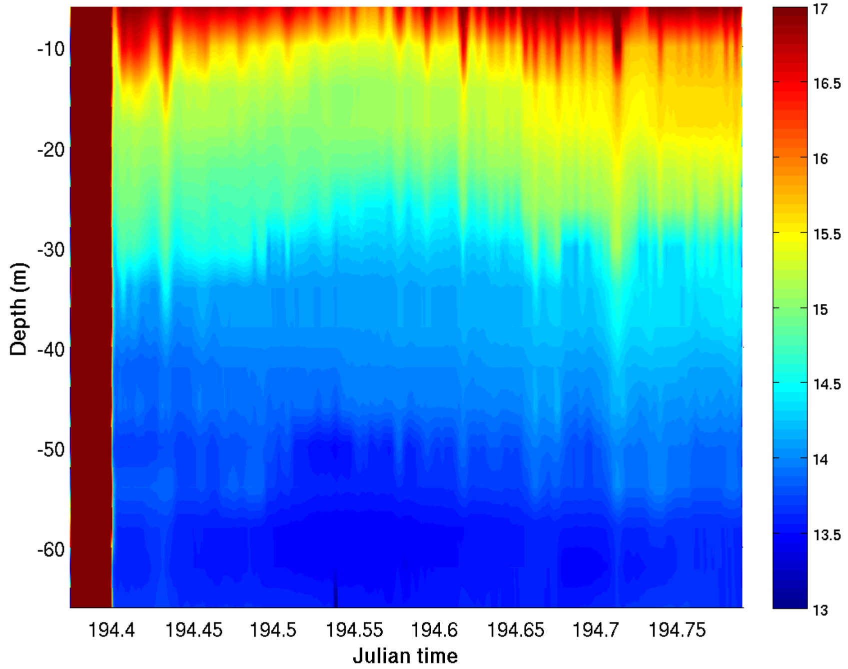
- NRP D. Carlos I (PO Navy)
- 2 drifting AOB2 (1 TS)
- 1 moored array
- 500 - 15 kHz
- 2 ADCP, 2 TS

RADAR'07: AOB low-resolution thermistor string

July 12,2007

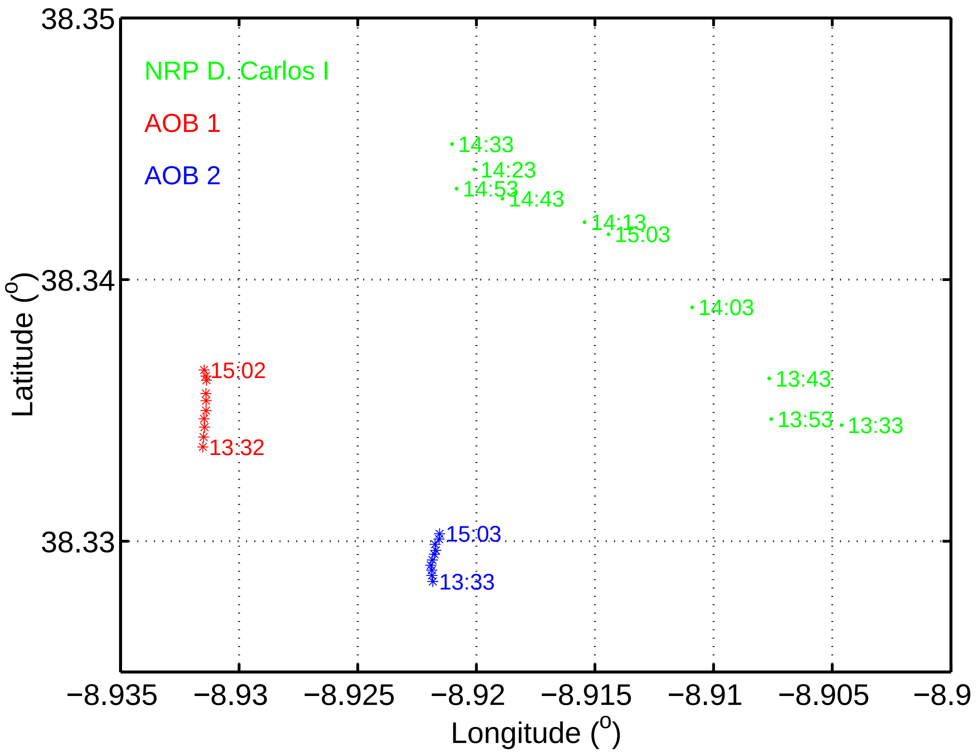


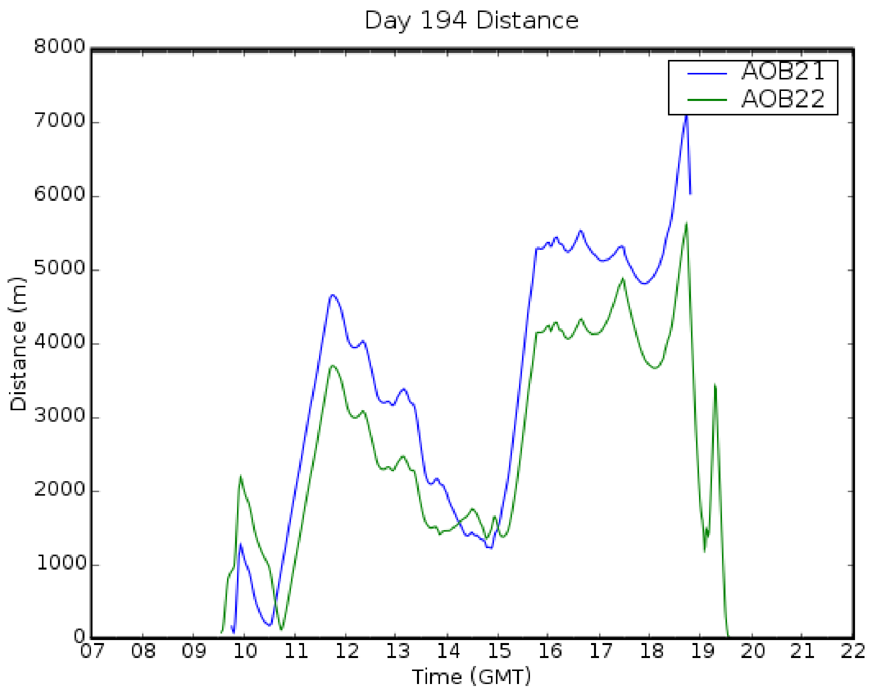
July 13, 2007



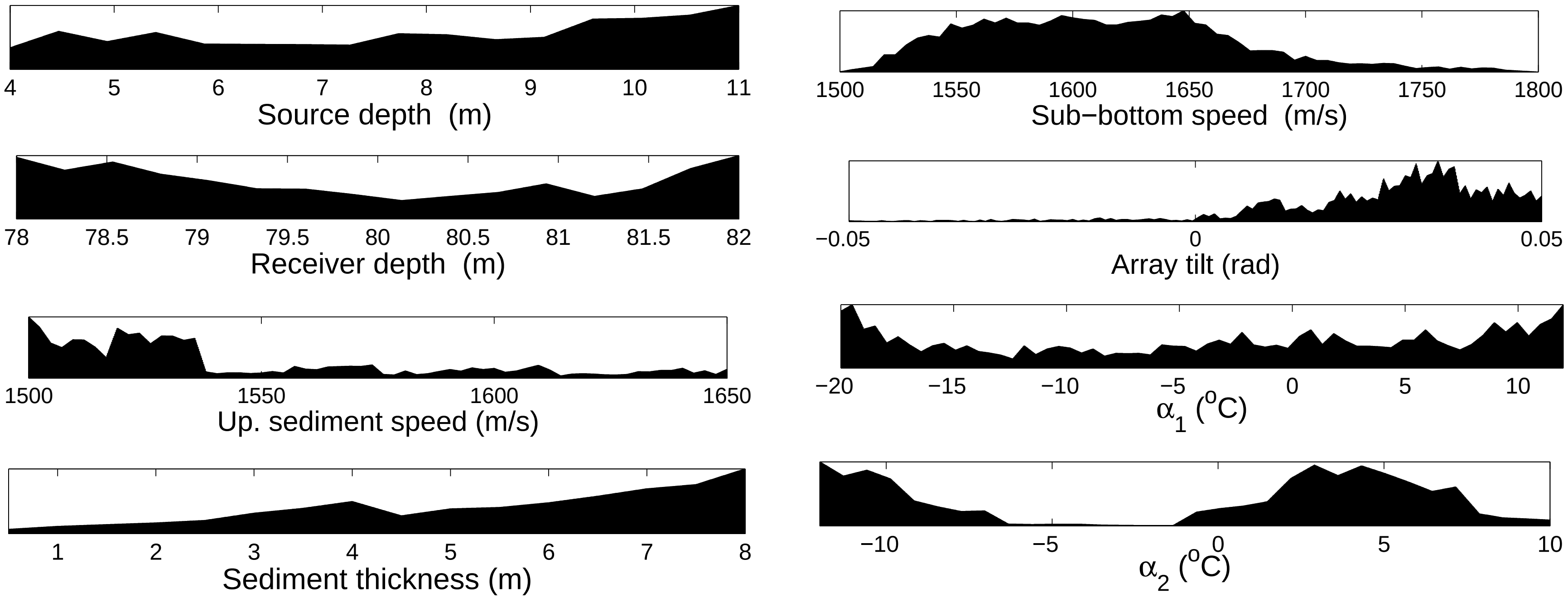
RADAR'07: experiment geometry

AOB drift, July 13, 2007

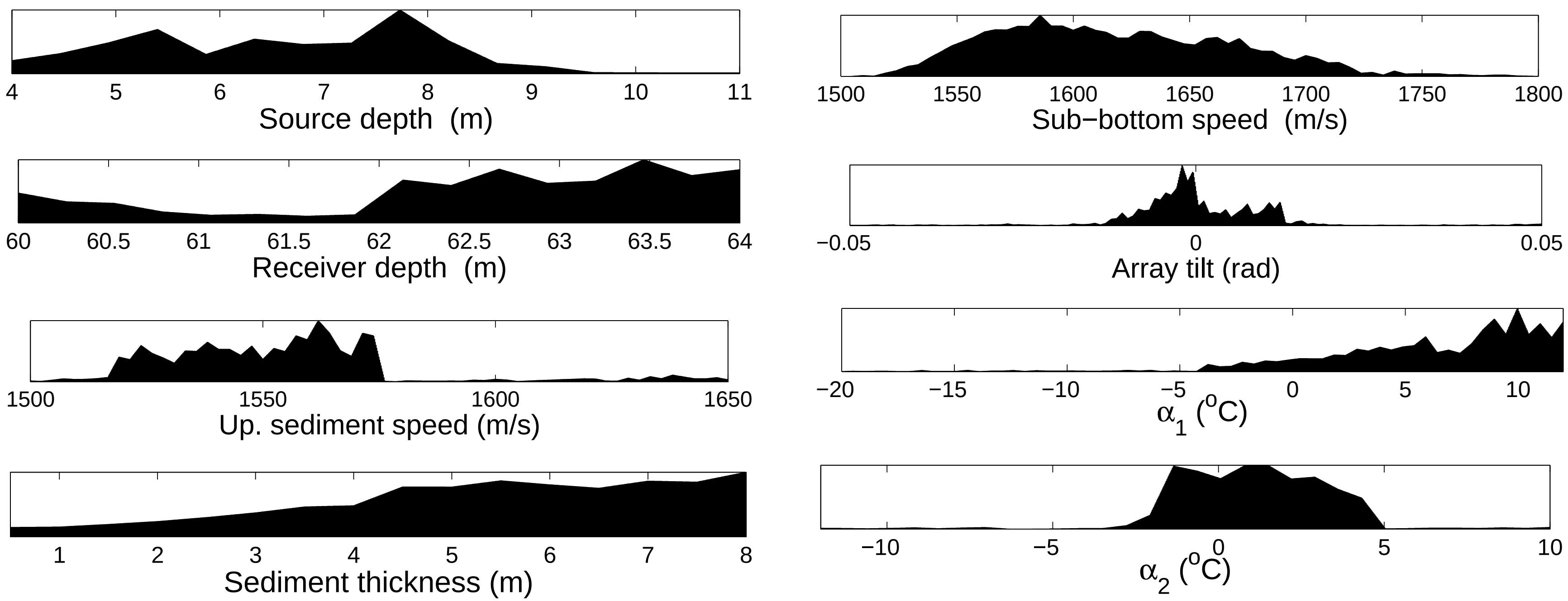




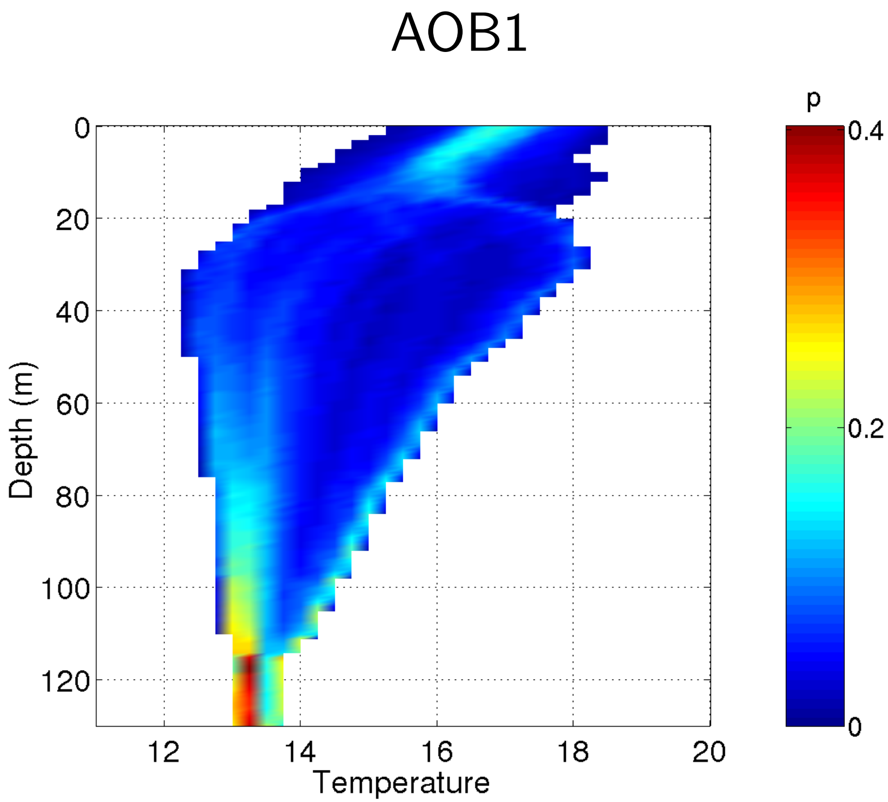
RADAR'07: AOB1 *a posteriori* distributions

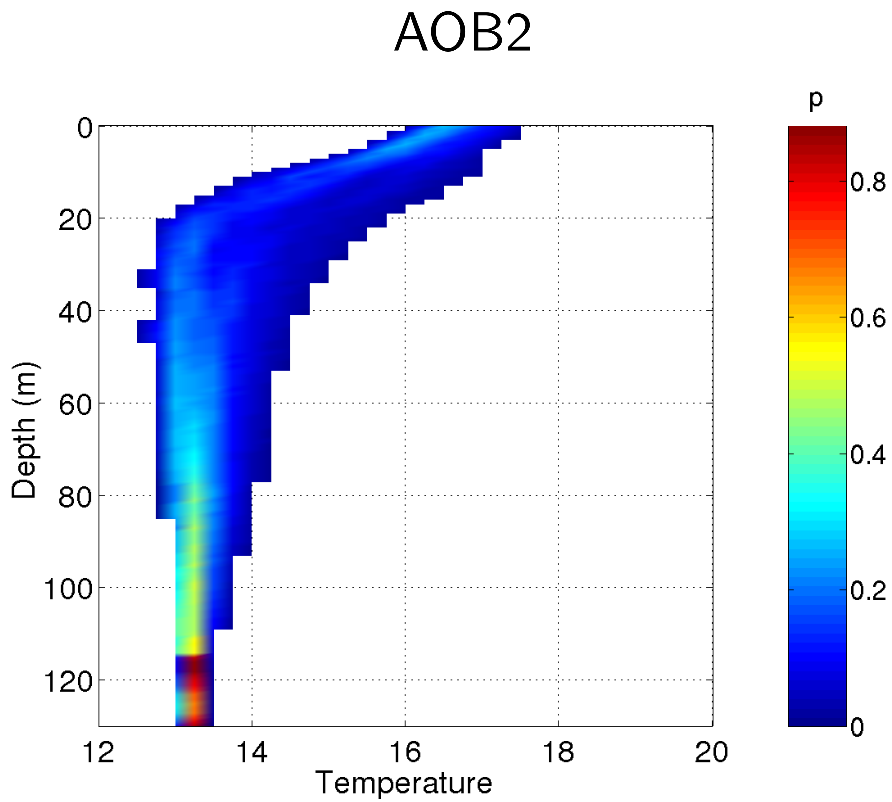


RADAR'07: AOB2 *a posteriori* distributions

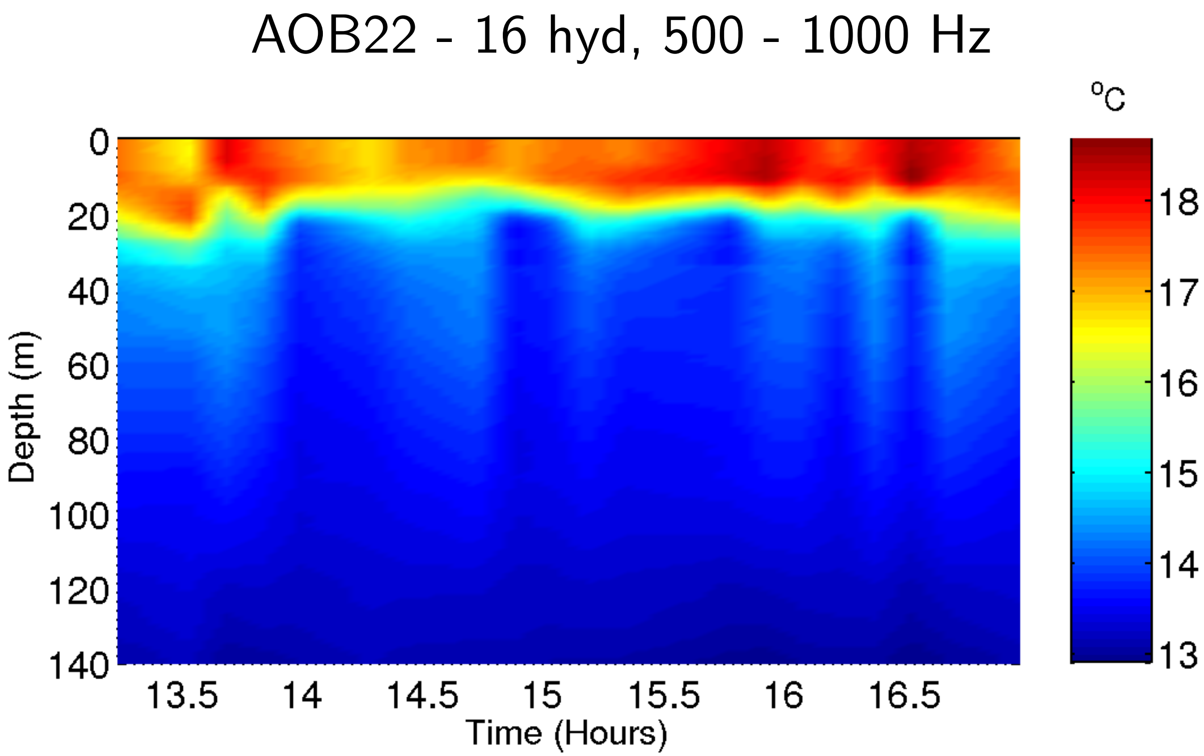


RADAR'07: inversion statistics.





RADAR'07: estimated temperature July 13, 2007



Conclusions and perspectives

- continuous evolution of both methodologies and required technologies for REA
- support of sea-based operations as demonstrated through MREA-BP-RADAR

- acoustic/oceanic model integration
- spatially coherent processed buoys/sparse arrays
- include adaptive geoacoustic estimation