CIBRA

Bioacoustic results in NEMO SN1 ONDE and way ahead with EMSO, the European Multidisciplinary Submarine Research Infrastructure

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& the SMO-NEMO, KM3NeT Italia and SN1 Teams

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Erice 10-2013

NEMO-ONDE 2005-2006 Test experiment (314 operational days)

ONDE = Ocean Noise Detection Experiment

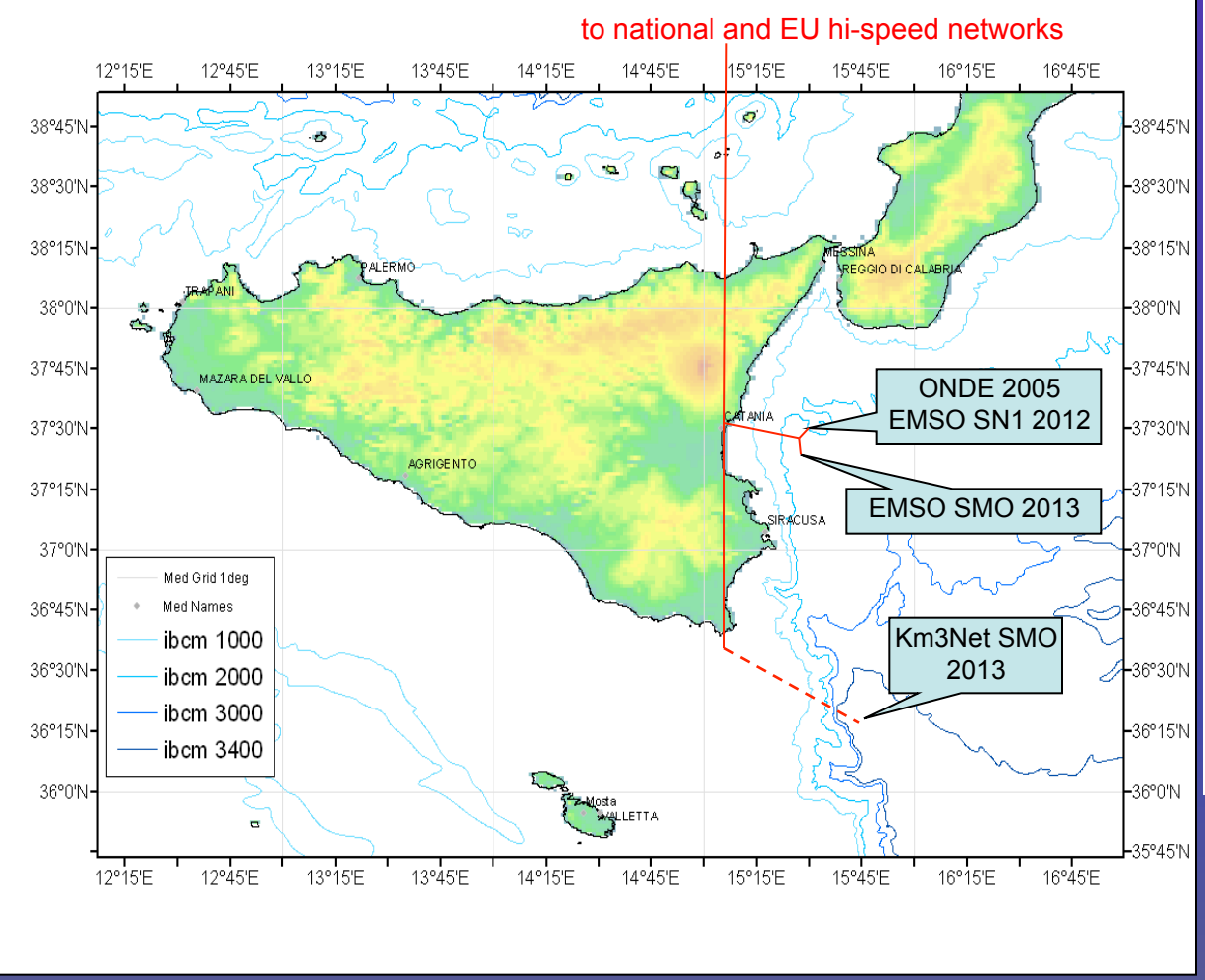
EMSO-SN1 Active from July 2012 through June 2013

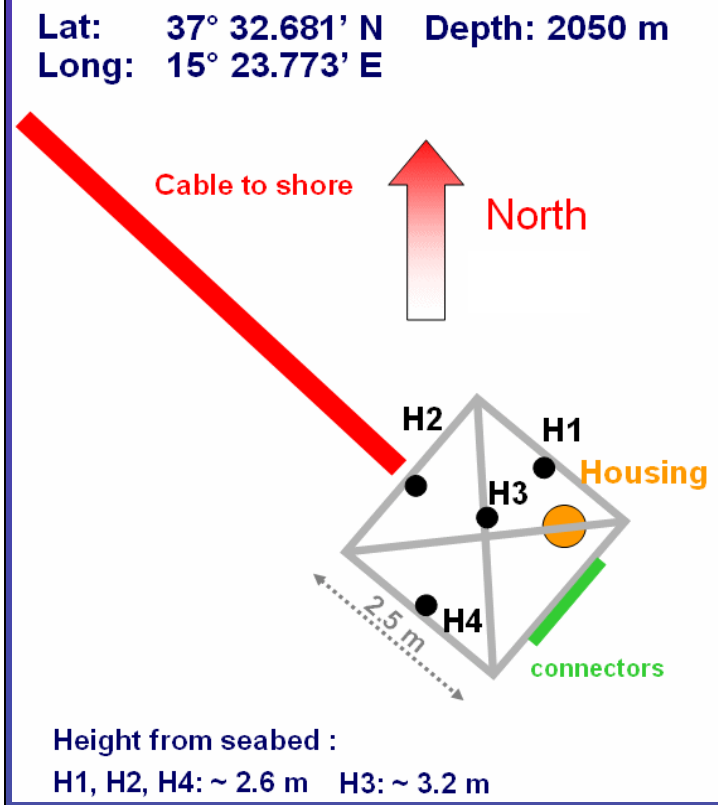
EMSO SMO (ONDE 2) Active from July 2013

Km3Net SMO Tower Capo Passero Active from March 23 2013

EMSO – European Multidisciplinary Submarine Observatories

SMO – Submarine Multidisciplinary Observatory, a project granted by the Italian Ministry of Research

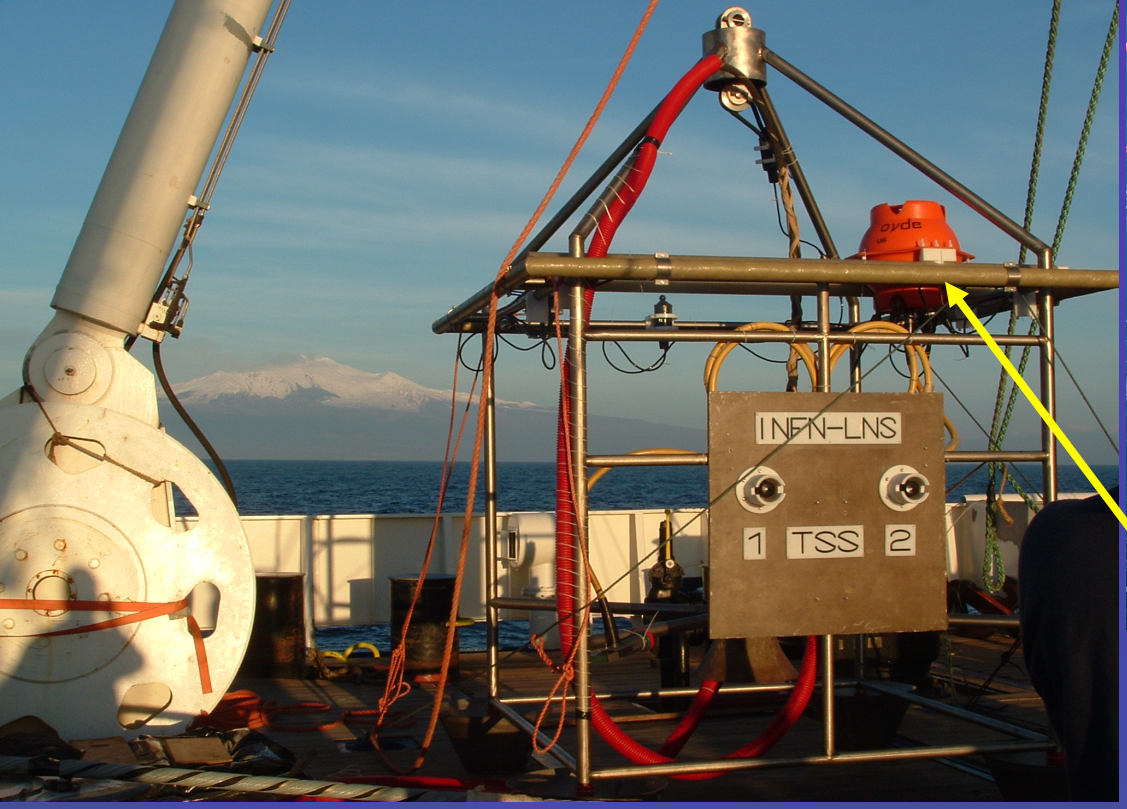




Project started in year 2000
Deployed JAN 25th, 2005
231 recording days in 2005
83 days in 2006

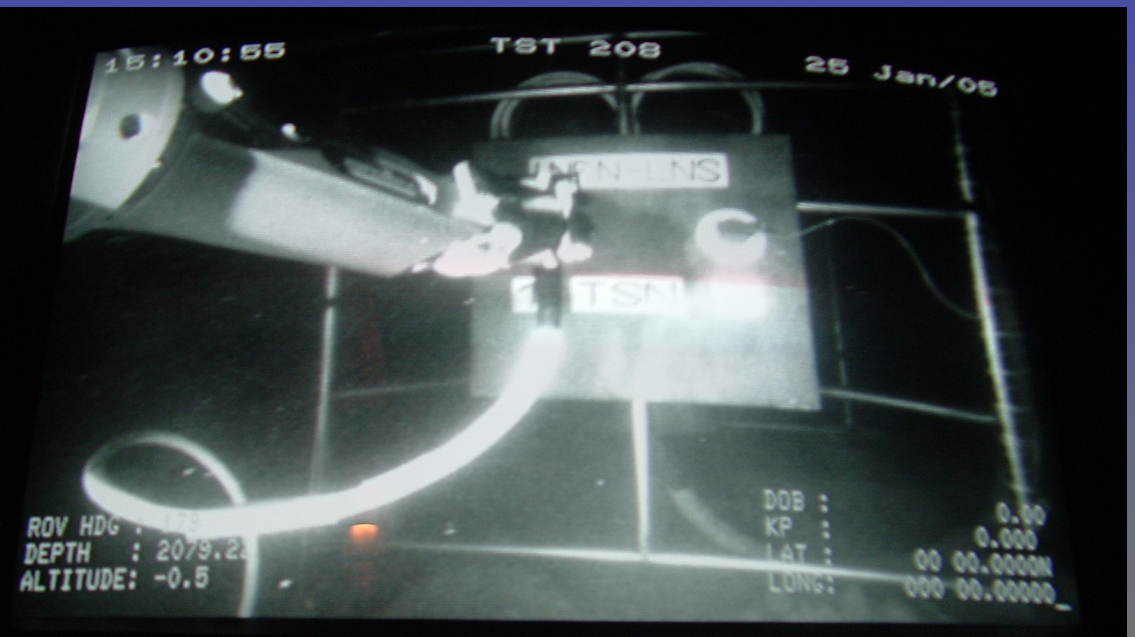
The NEMO ONDE test platform was located 21 km off Catania at 2000 m depth, connected to the LNS labs in Catania by fiber optic cable to provide real-time data transmission of four hydrophones sampled at 96kHz, 24 bits.

The experiment was primarily aimed at studying the undersea noise related different types of sources (biological, geophisycal, anthropic) that may interfere with neutrino detection.



Acoustic module

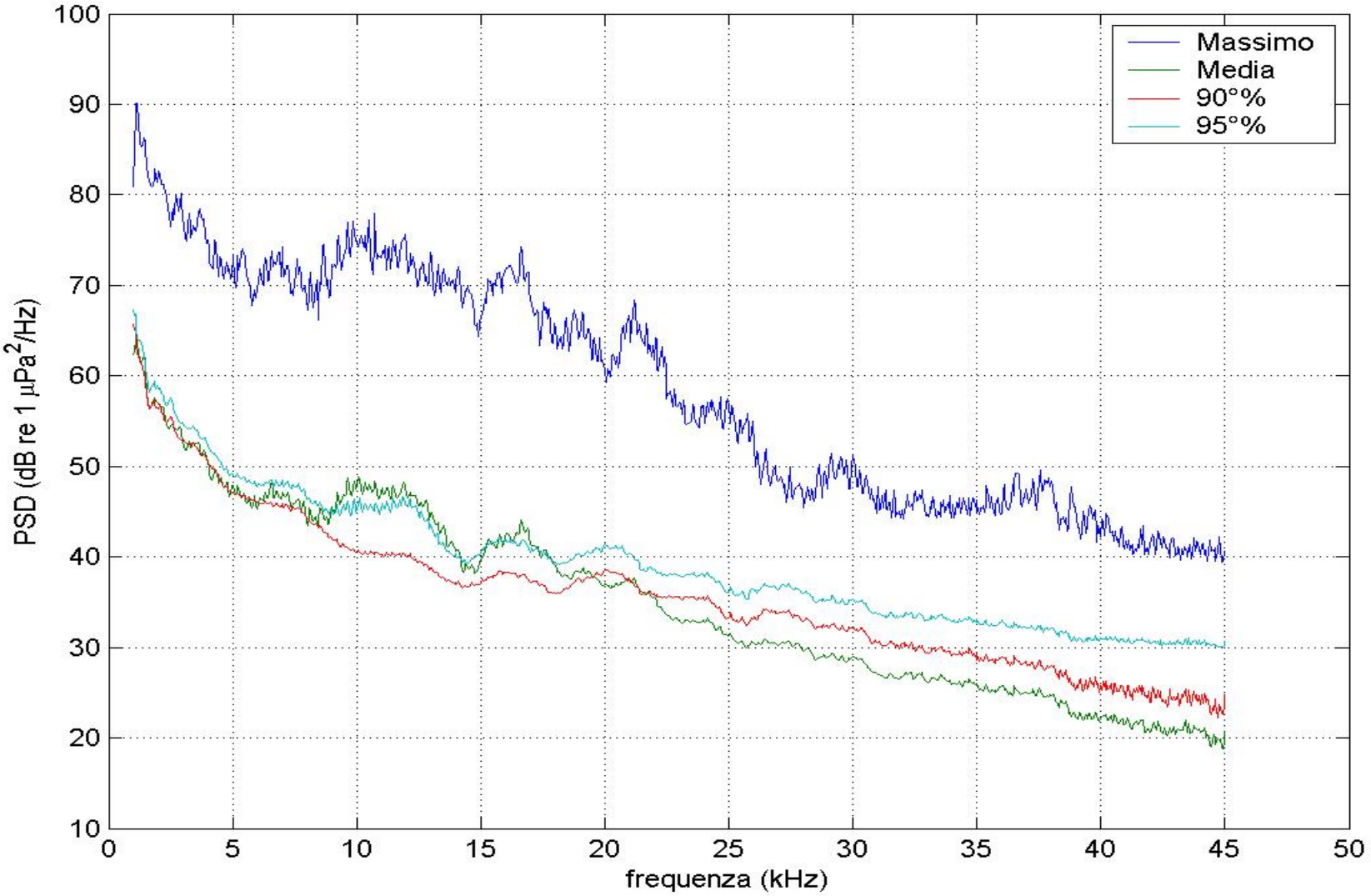
Hydrophones



Connectors for the cable to shore.

Once deployed on the sea floor at 2000m depth, the ONDE frame was connected to the optical cable by a ROV (Remotely Operated Vehicle)

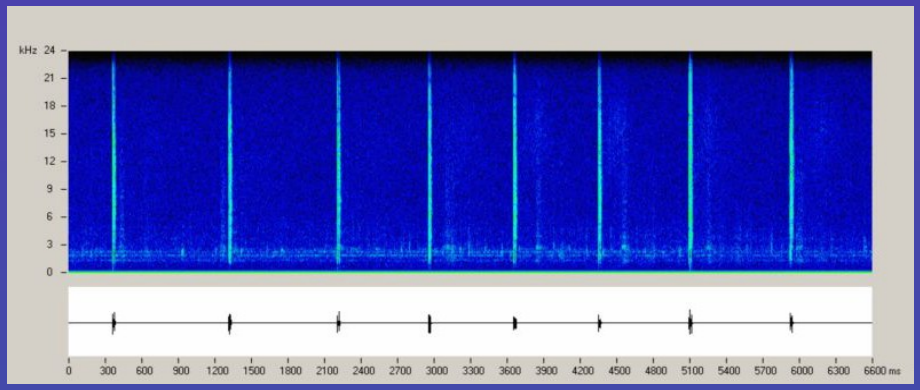
ONDE transmitted 2TB/month of acoustic data (4 hydro @ 96kHz)



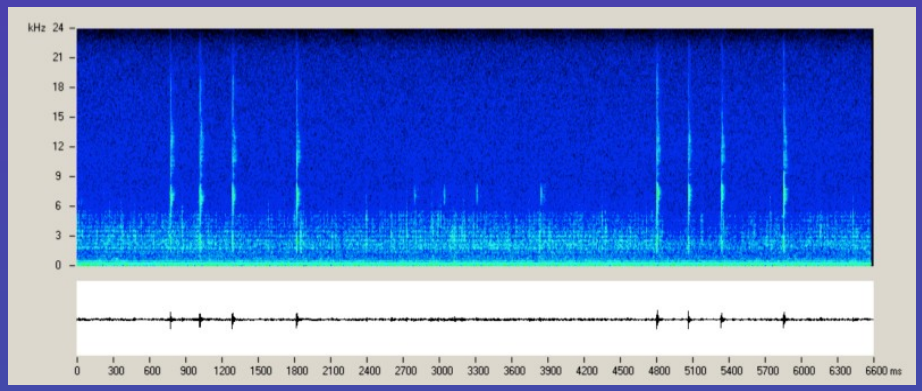
PSD spectra µPa2/Hz on hydrophone H3, day 14.11.2006 at 23:30:
Average, Max, 90° & 95° percentiles.
The Max profile is strongly influenced by the presence of sperm whales.

Sperm whale recordings

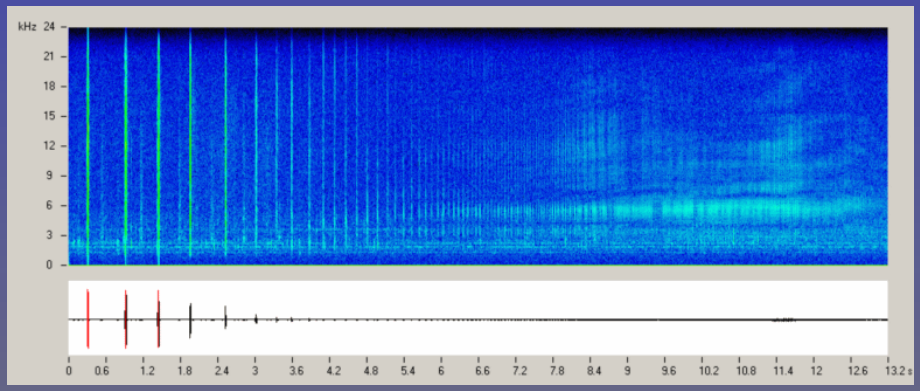
Technical and budget constraints imposed to limit the recording to 5 minutes every hour. This schedule was considered suitable for sampling ocean noise and to study the presence of sperm whales.



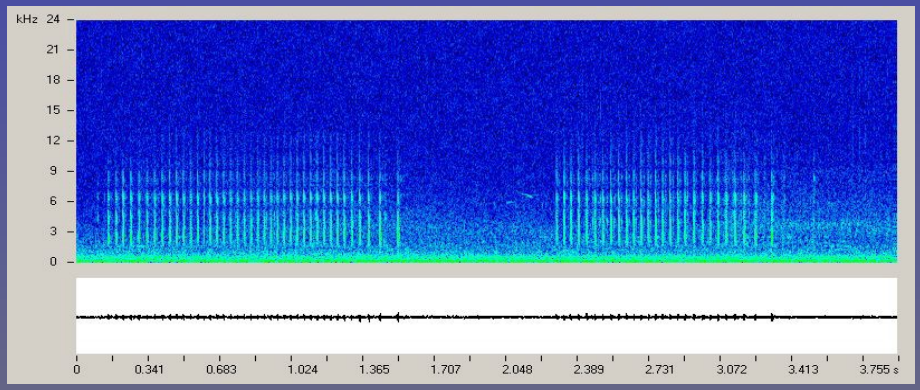
Regular clicks



Codas, mainly 3+1, 2+1



Echolocation runs

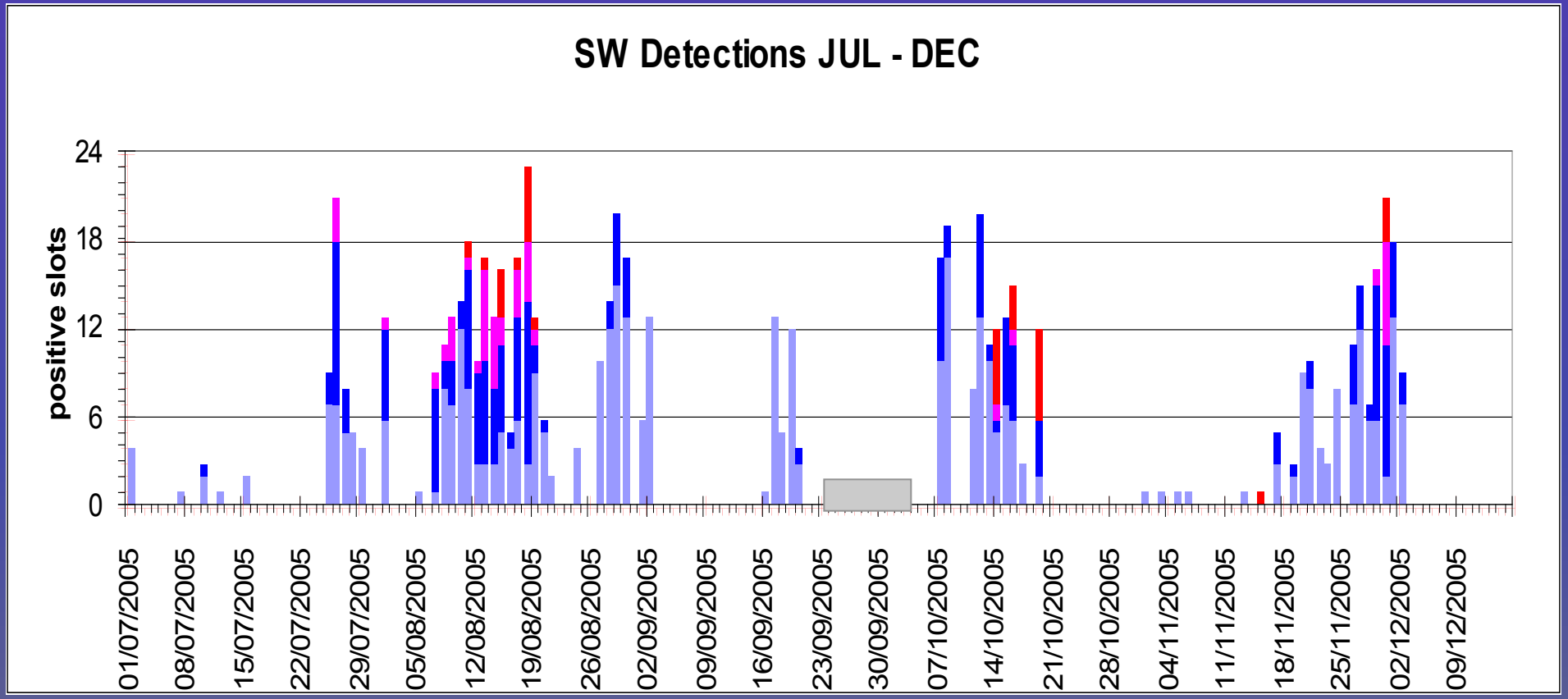


Chirrups

The neutrino and the whale

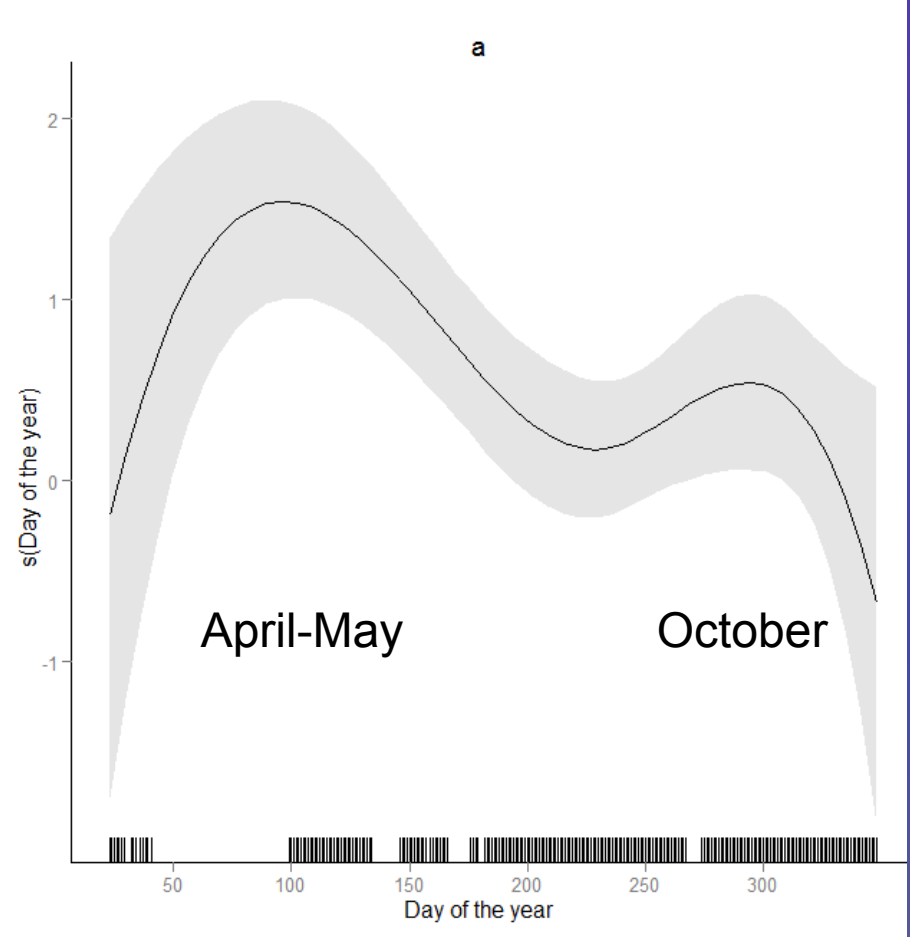
Years	Days with samples	Samples #	At least 1 animal	Positive contacts %	Days % with at least 1 animal
2005	231	5 147	1 186	23%	51%
2006	83	2 212	506	23%	35%
Total	314	7 359	1 692	23%	

Daily & seasonal presence of sperm whales in the detection range



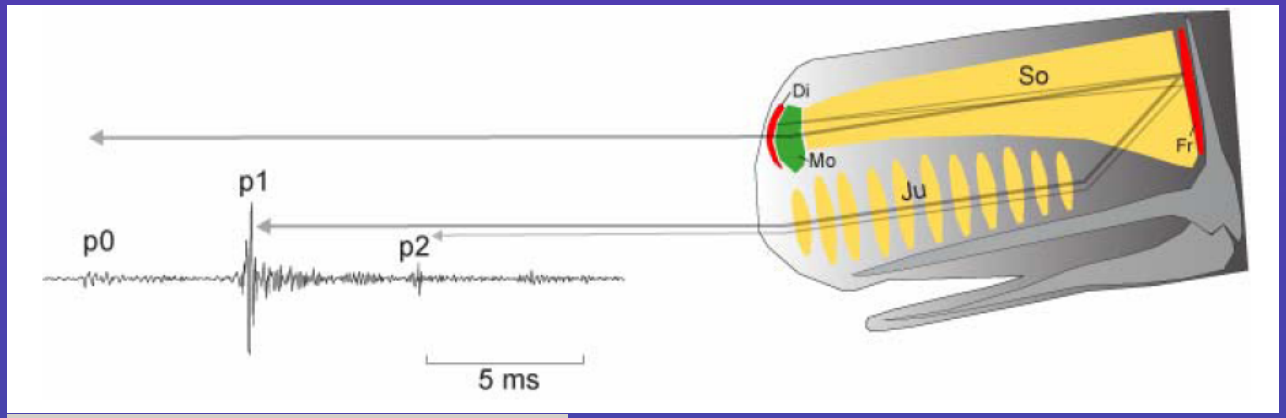
- 1 animal detected
- 2 animals detected
- 3 animals detected
- 3 or more animals detected

Ground truth for testing sperm whales' automatic detectors.



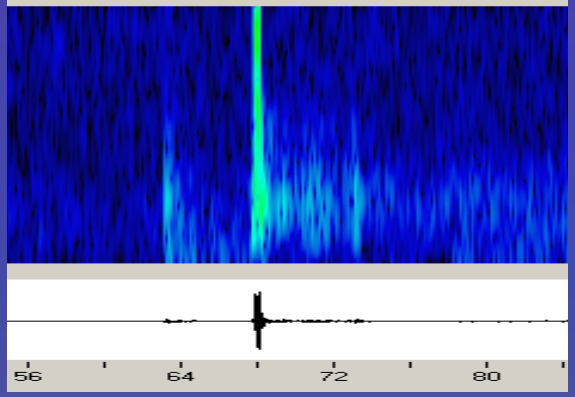
Sperm whale Presence Peaks in Spring and Autumn

In these periods groups are larger

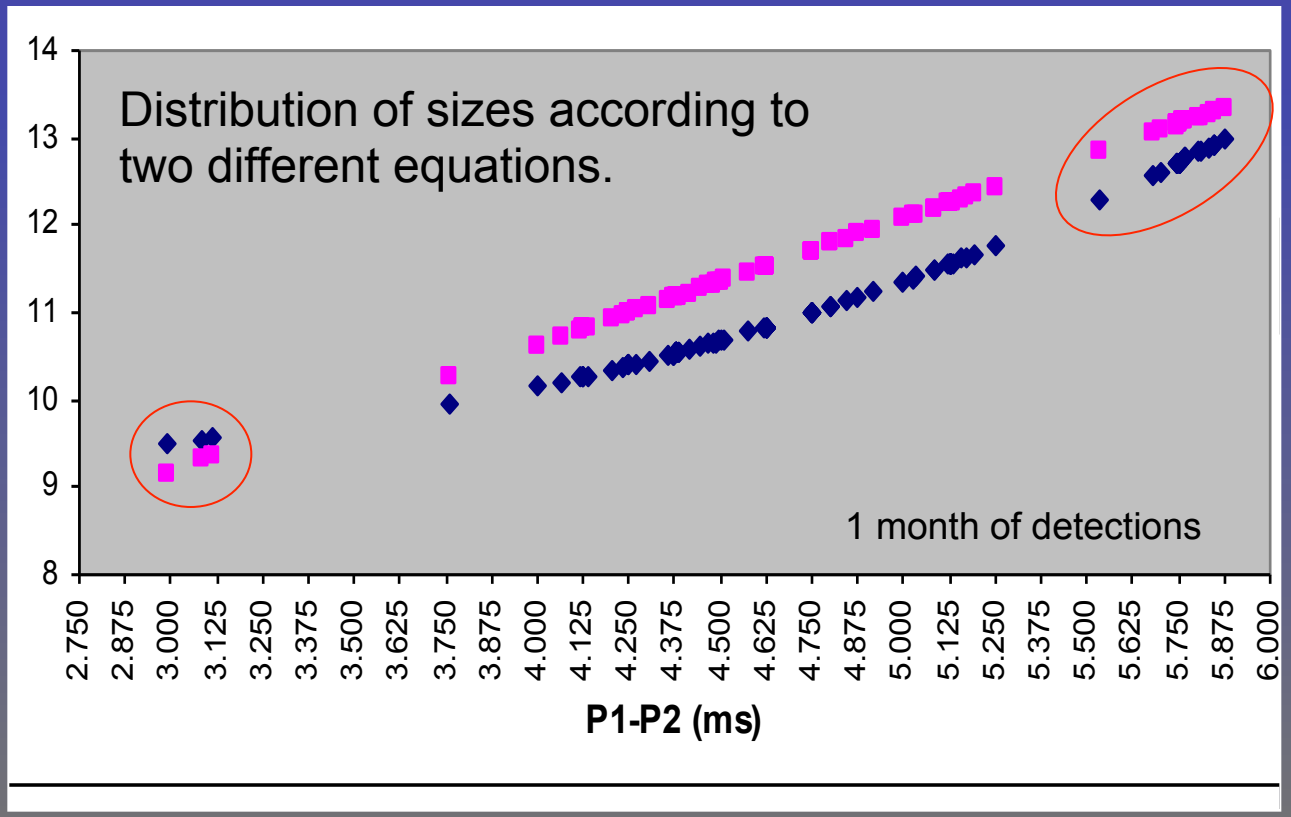


IPI measures

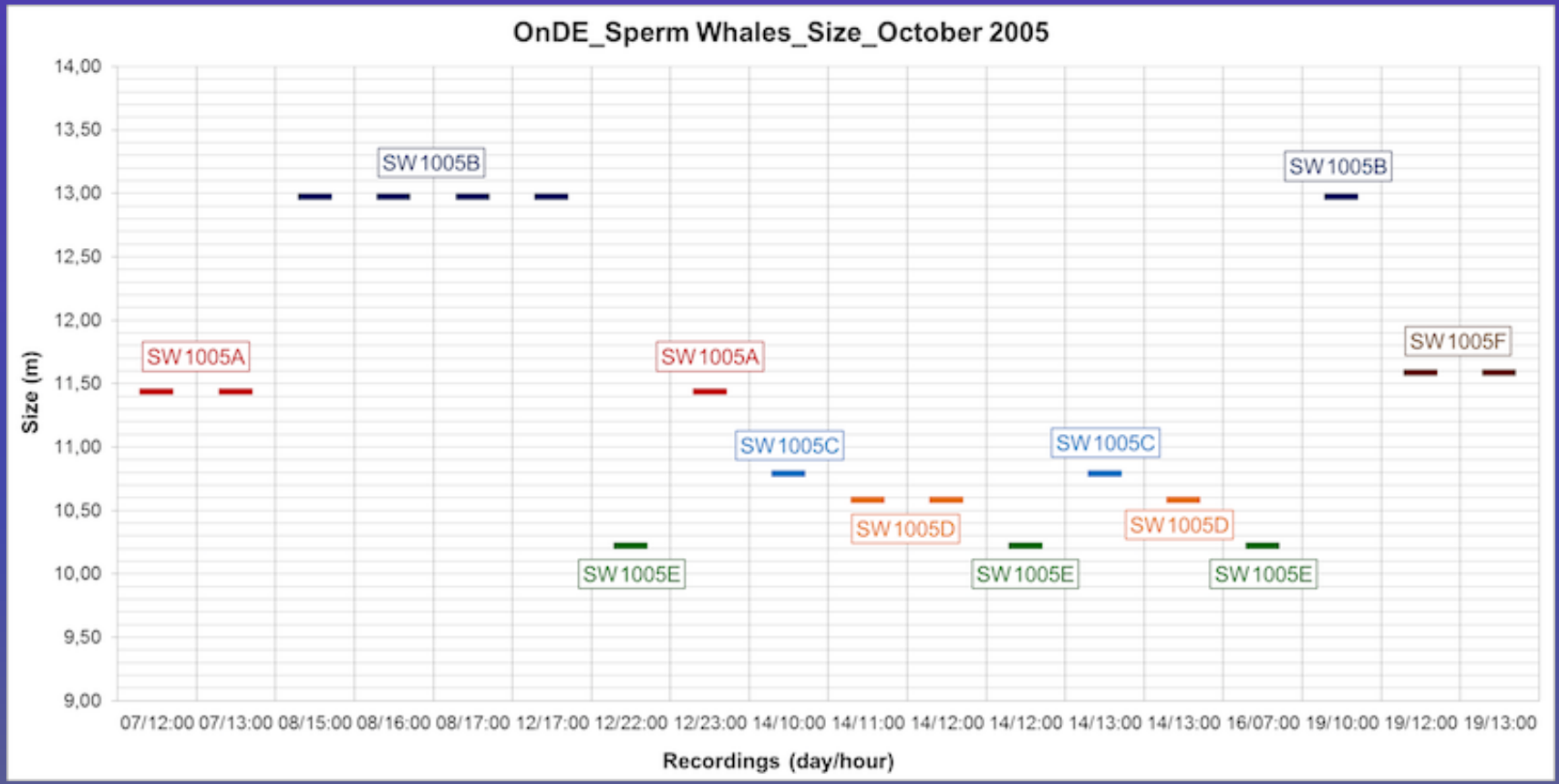
to assess sperm whales' sizes



Manual IPI measures have been taken to separate p0-p1 and p1-p2 intervals



New methods to make measures easier and more accurate are being developed and tested by F.Caruso (talk) and by the H.Glotin team (Univ. Toulon, F).



Size of sperm whales recorded on 2005 - October 7 to 19 (Growcott equation).

Short talk by F.Caruso et al.

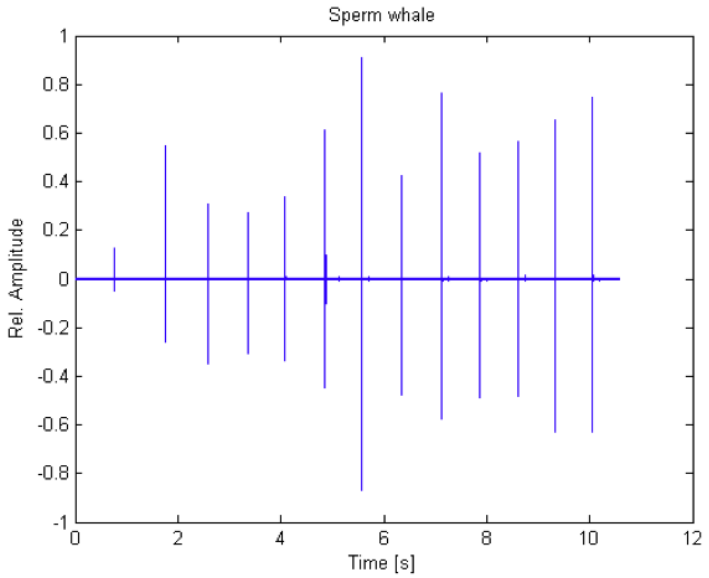


Figure 2.5 Sperm whale click train

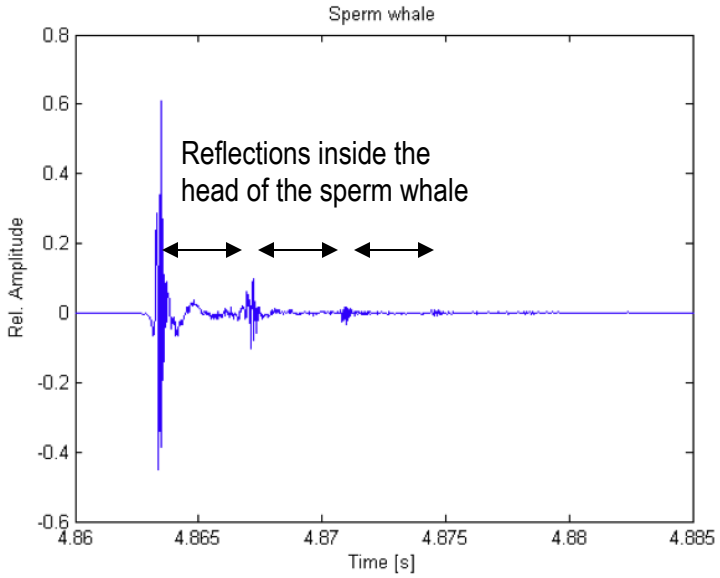
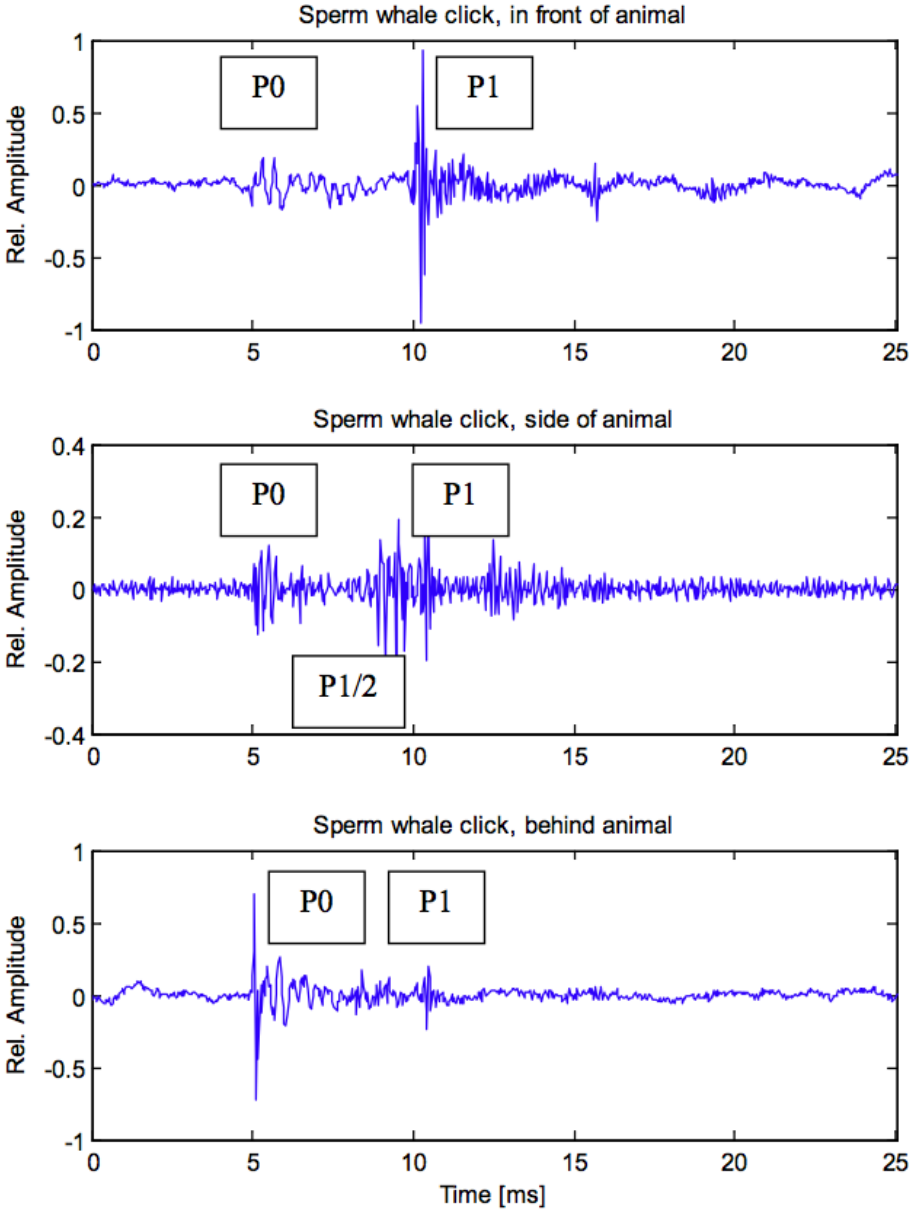
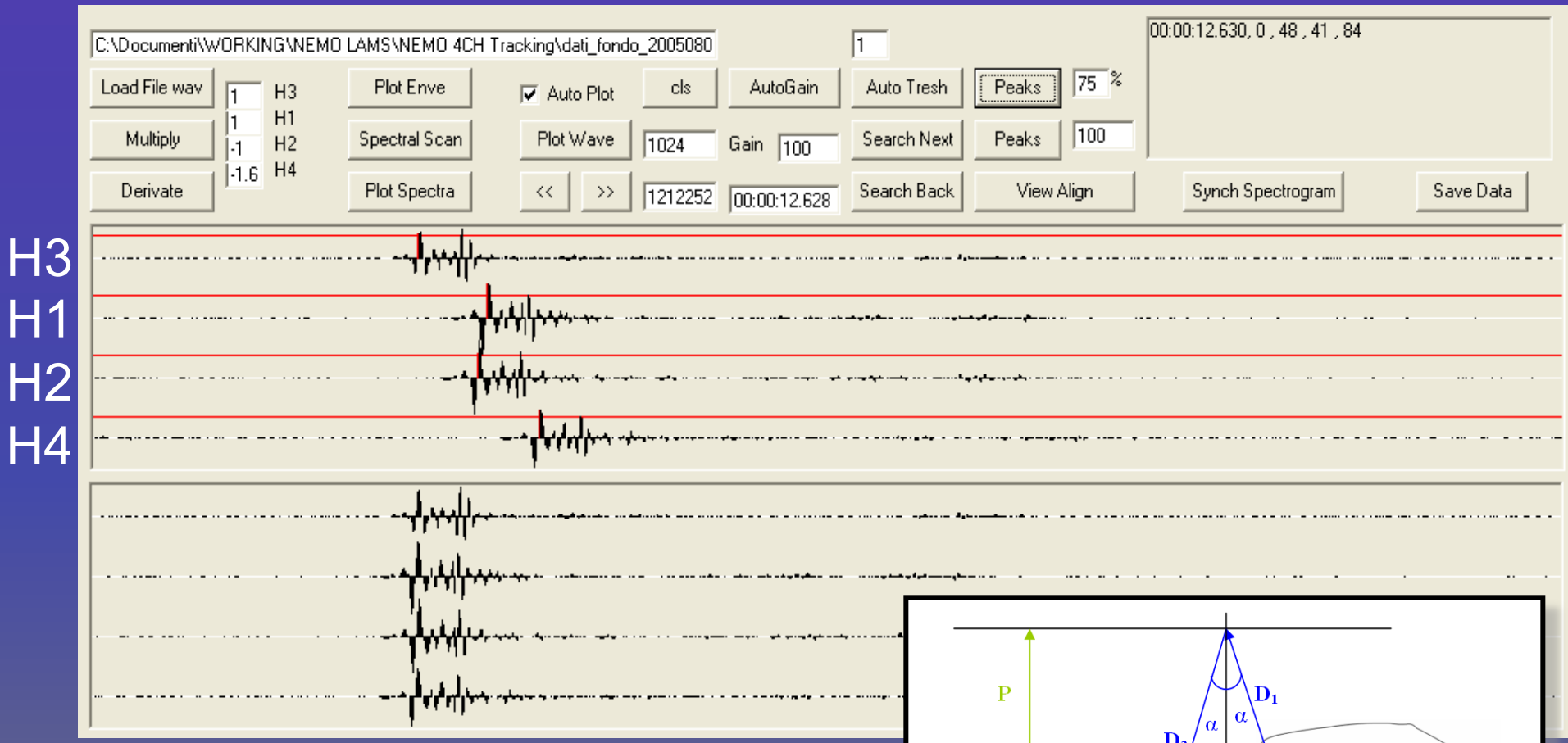


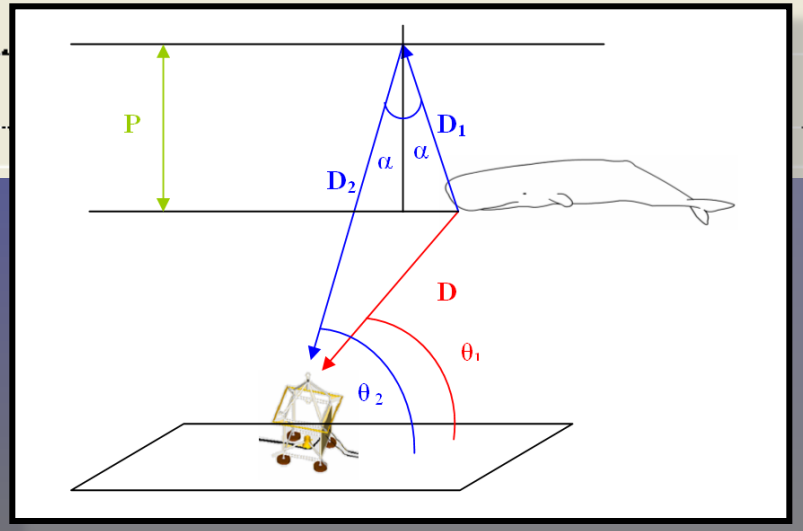
Figure 2.6 Details of a sperm whale click. Zoom into Figure 2.5



Detailed analysis of signal details to assess sperm whale sizes by discriminating the pulses.

Click detection and tracking – to be automated

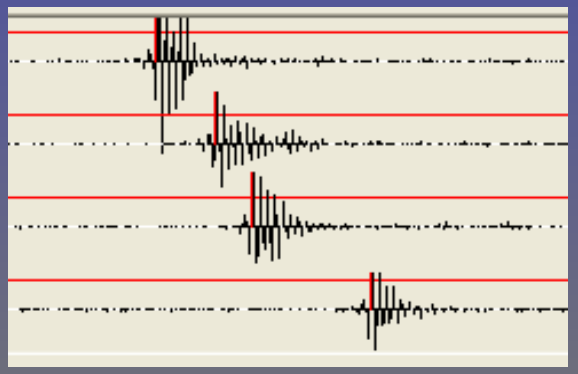




TDOA (Time Difference Of Arrival) of sperm whale clicks; on bottom panel clicks are time aligned according to their TDOAs. Real-time FFT-based selective cross correlation to be implemented soon.

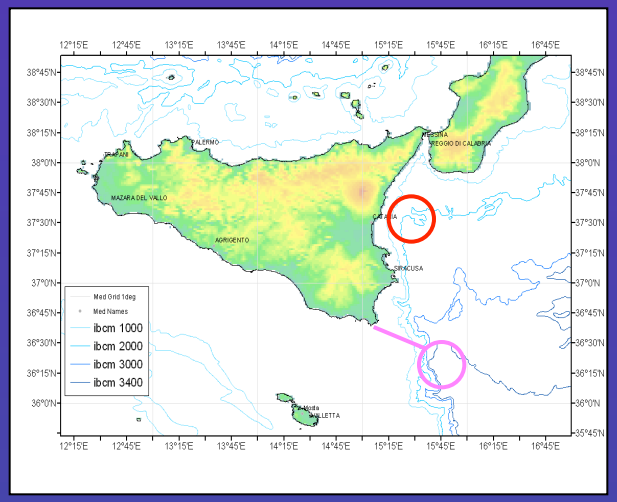
Detection of elusive/rare species such as Cuvier's beaked

Two channels spectrographic display of a series of clicks spaced 400-480ms, 300µs long, emitted by a pair of Cuvier's beaked whales, a key species in current research projects on the impact of noise on marine mammals.



EMSO / SMO / Km3Net

cabled observatories



- CATANIA Test Site EMSO

SN1 EMSO 2012
4 wideband hydrophones sampled at 96 kHz
1 low frequency hydrophone sampled at 1kHz
1 seismic sensor sampled at 100Hz
+ other oceanographic equipment

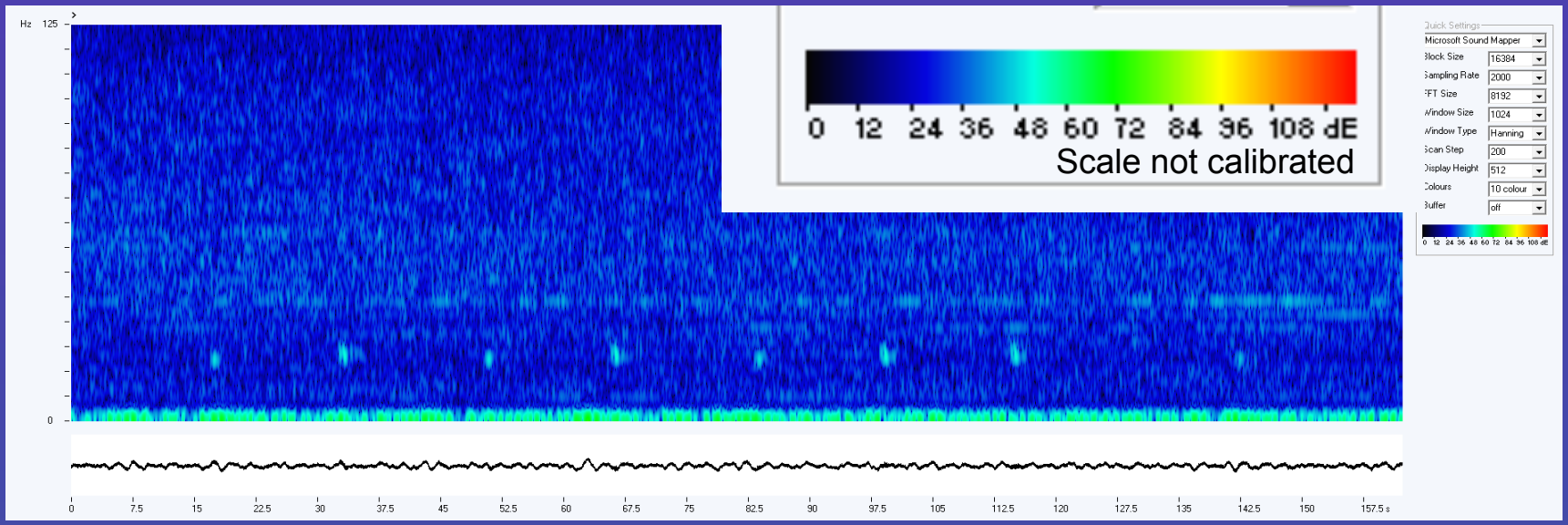
EMSO SMO 2013
4 wideband hydrophones sampled at 192 kHz

- Capo Passero Test Site

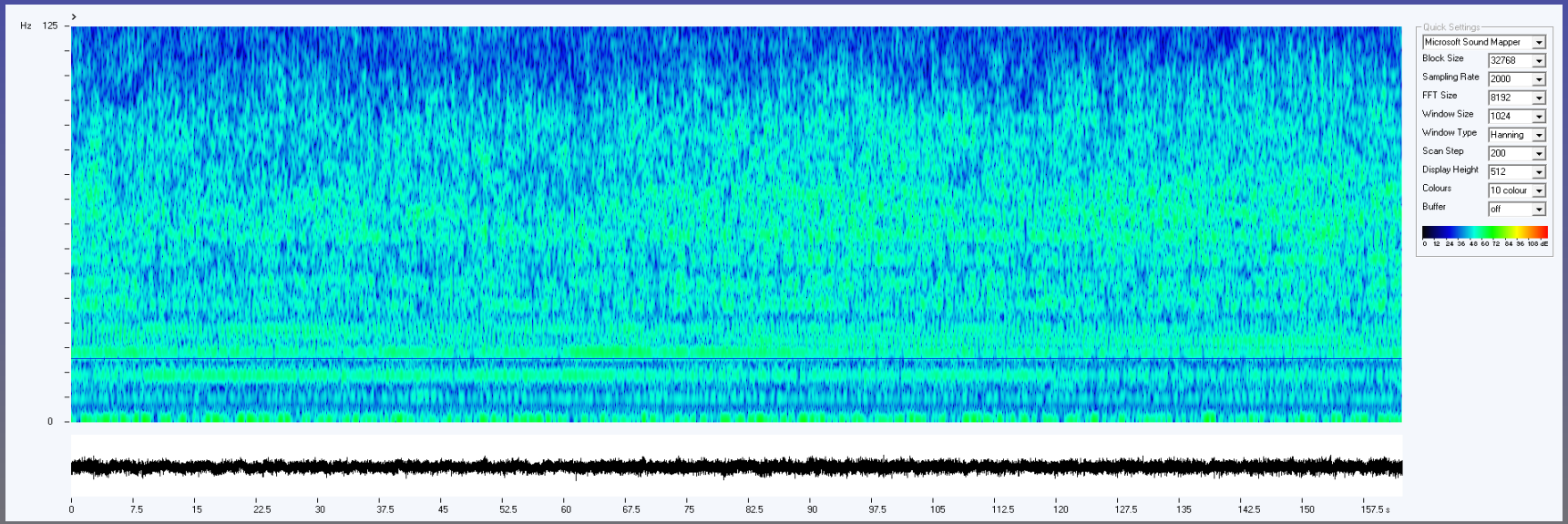
Km3Net ITA SMO tower 2013
wideband hydrophones sampled at 192 kHz
+ acoustic positioning emitters

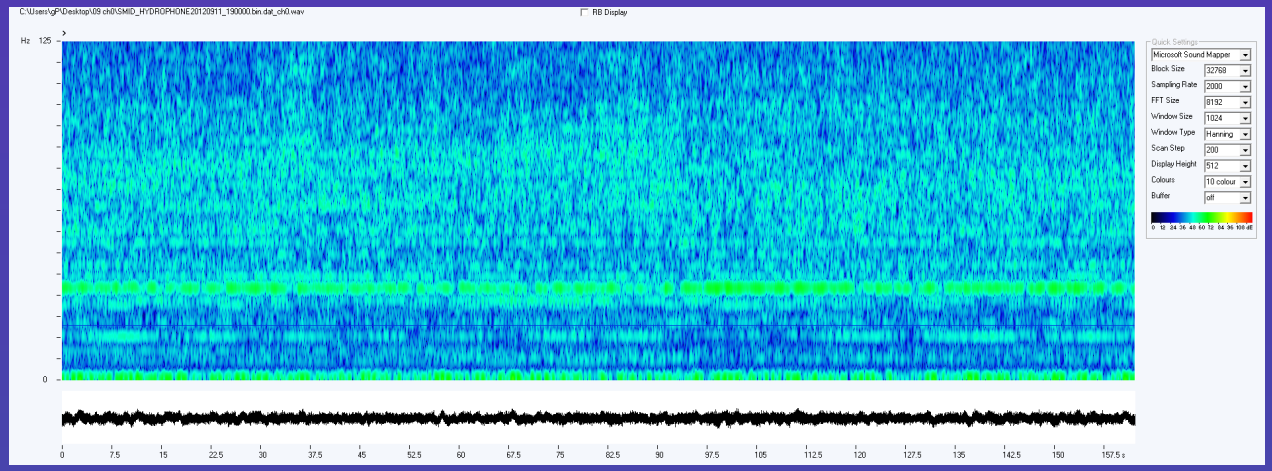
IMPACT OF SHIP NOISE
SN1 LF Hydro 1Hz-1kHz

Recording with fin whale vocalizations (top) and the noise of a passing ship (bottom) completely masking any fin whale communicative sound.



Short talk on fin whale detection by Sciacca et al.

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RB Display
Hz 125
0
Quick Settings
Microsoft Sound Mapper
Block Size 32768
Sampling Rate 2000
FFT Size 8192
Window Size 1024
Window Type Hanning
Scan Step 200
Display Height 512
Colours 10 colour
Buffer off
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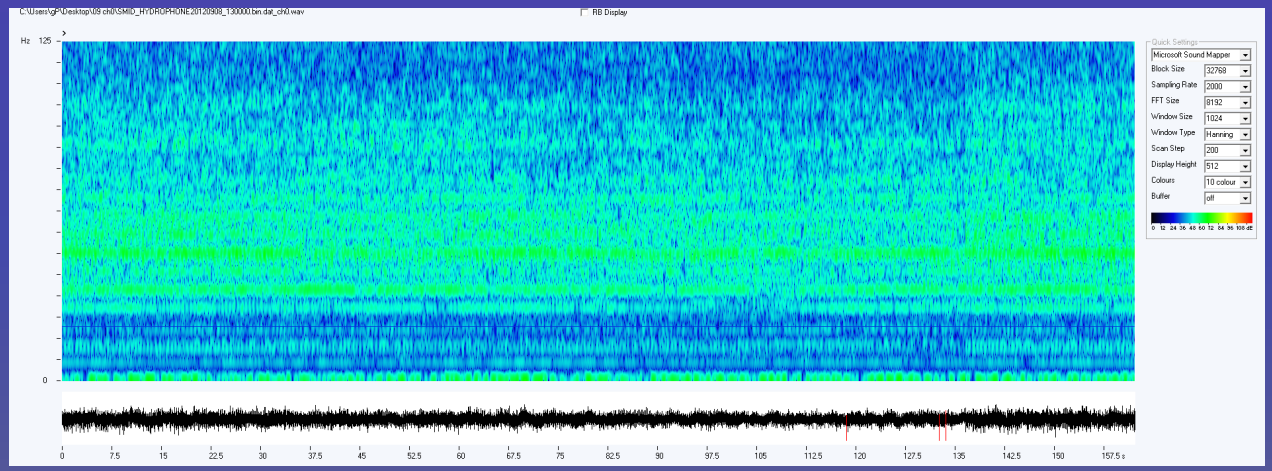
0 7.5 15 22.5 30 37.5 45 52.5 60 67.5 75 82.5 90 97.5 105 112.5 120 127.5 135 142.5 150 157.5 s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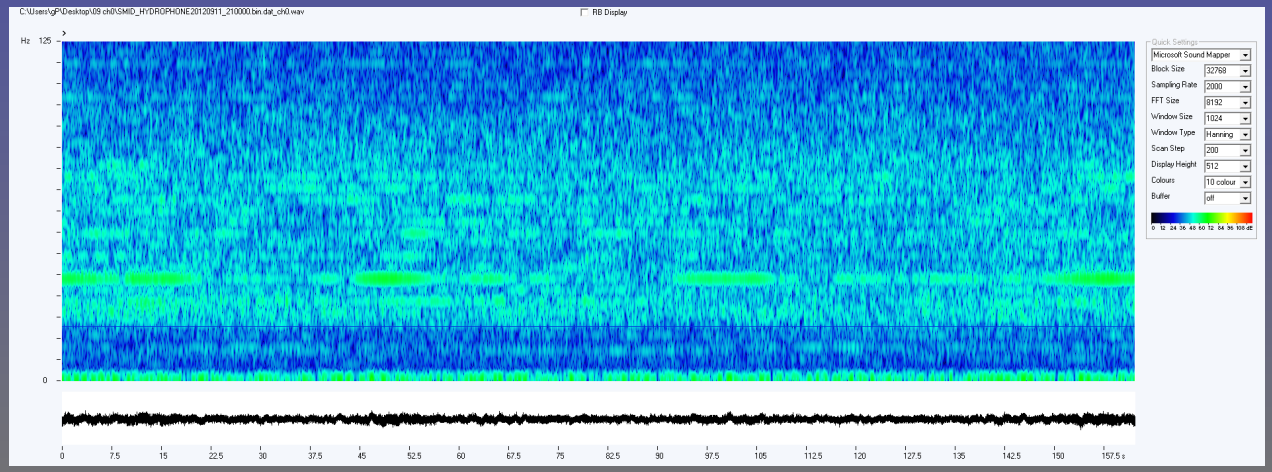
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FFT Size 8192
Window Size 1024
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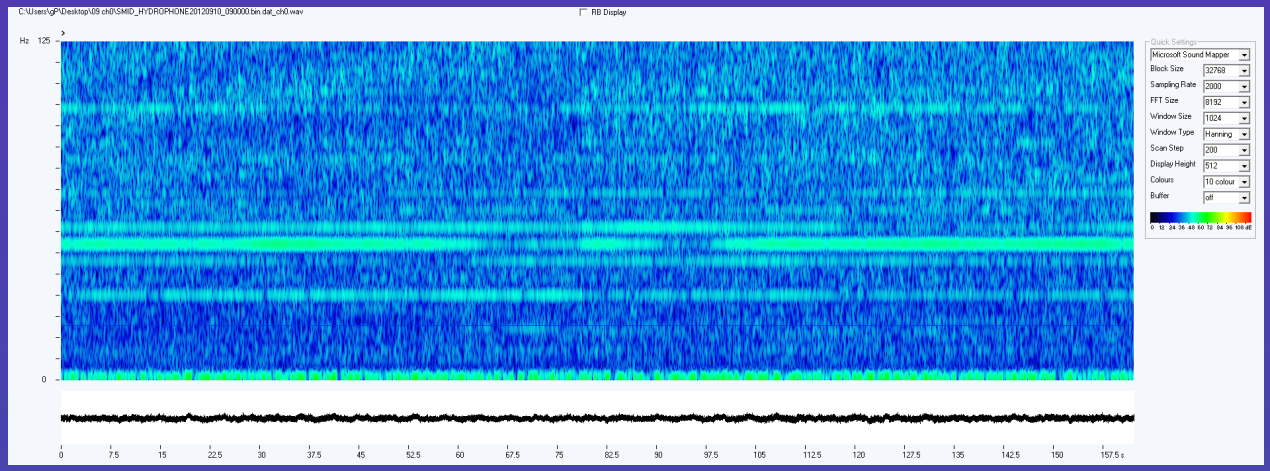
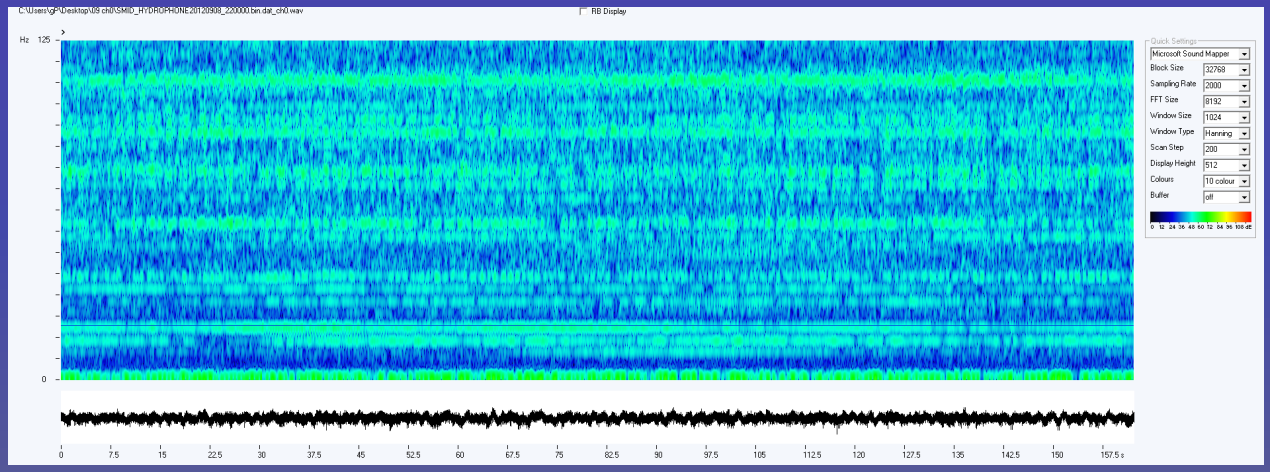
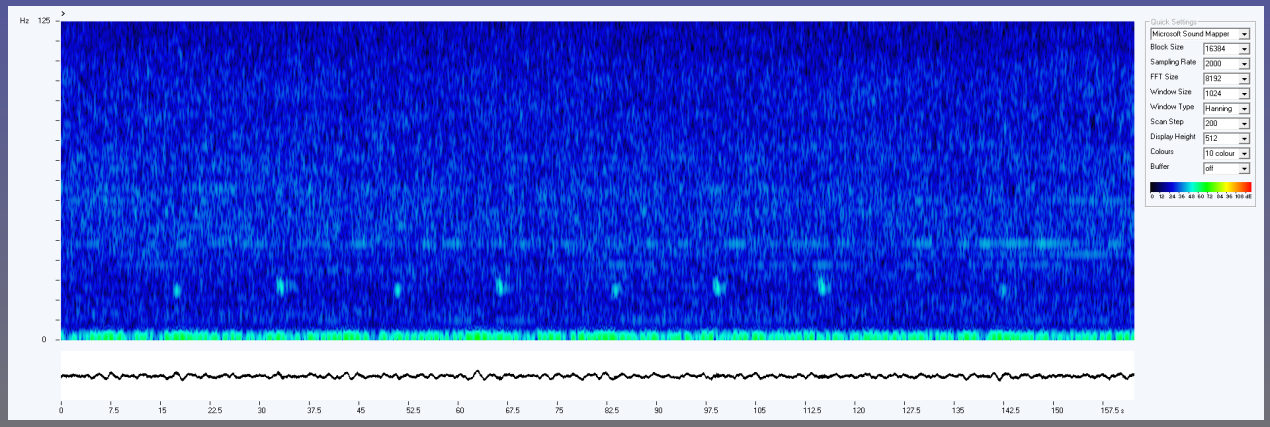
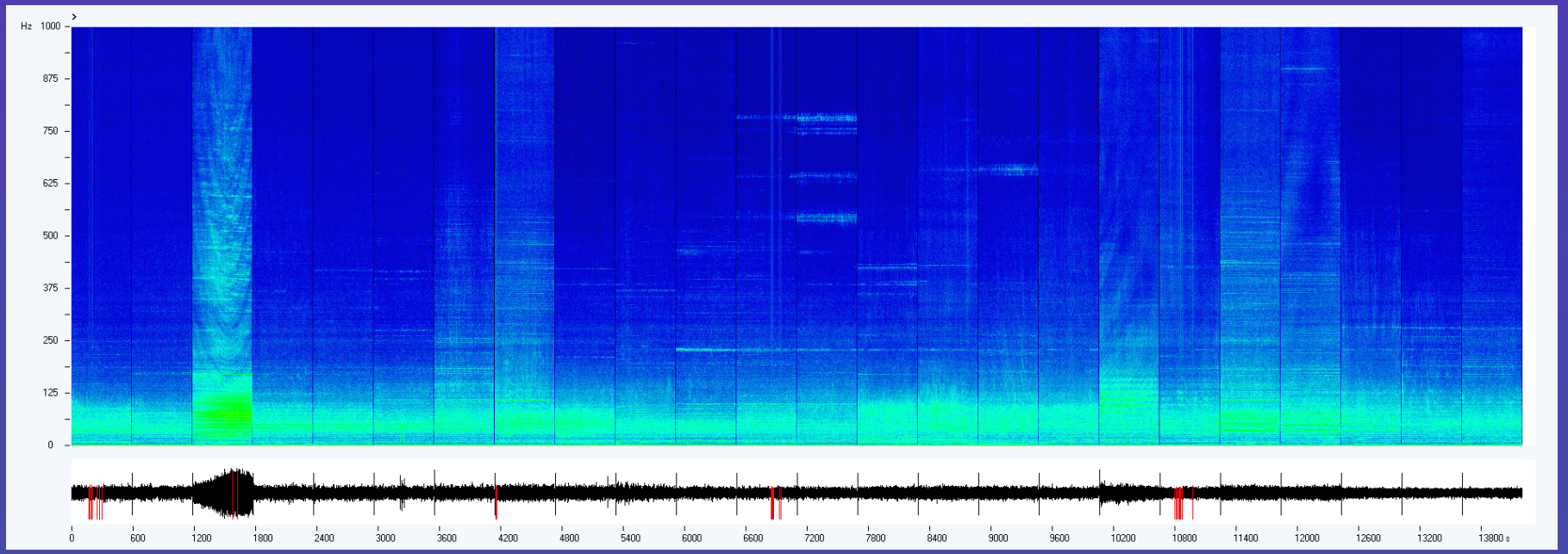






A rare quiet frame …

One day of Noise (10 minutes every hour)

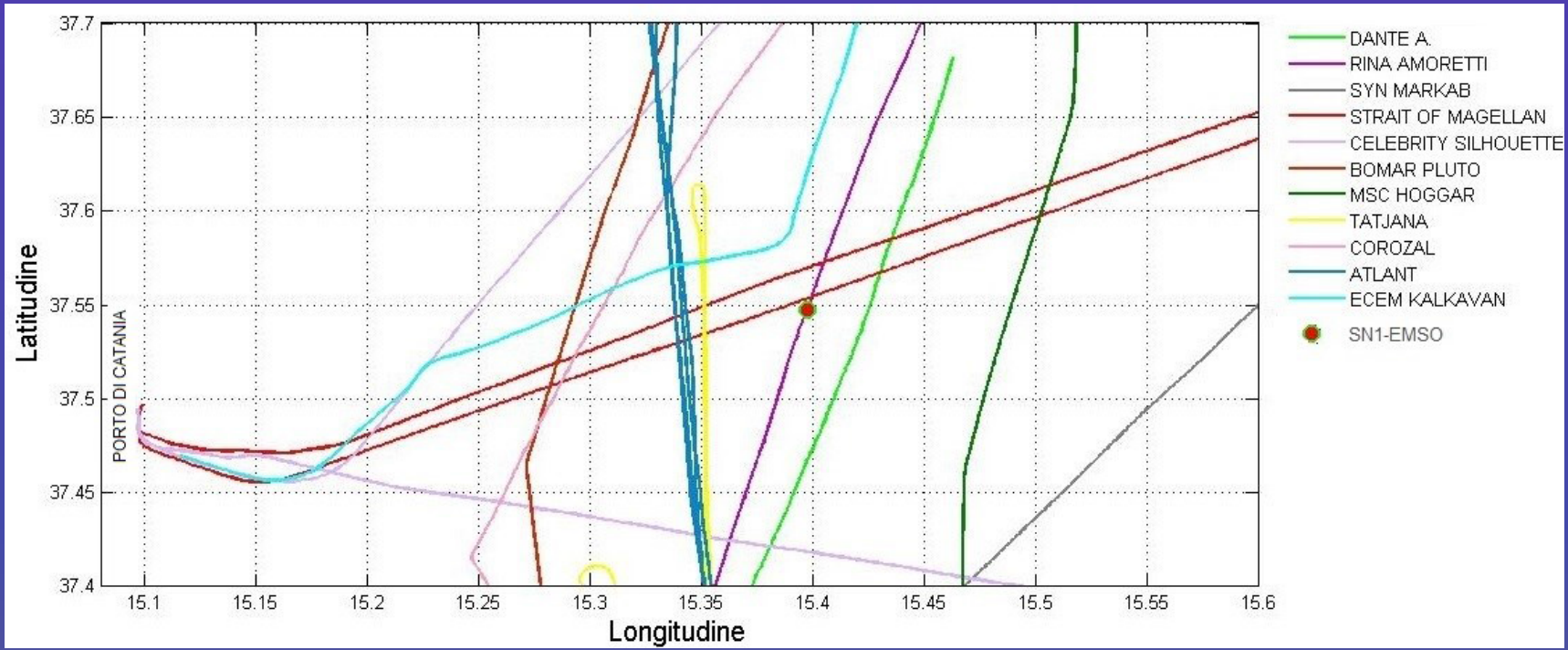


Low frequency ship noise has the potential to disrupt the fin whales' communication system by reducing to few miles their ability to communicate.

In the Gulf of Catania ship noise maintains high levels - mostly concentraded below 125 Hz - most of the time.

The difference among quietest and noisiest frames is greater than 40 dB.
This means the theoretical reduction of the communicative space from 100km to less than 1.5 km.

Ship tracking by AIS



Sample AIS tracks of commercial ships entering/leaving the Port of Catania passing close to the SN1-EMSO platform (Inserra P., Thesis, 2013)

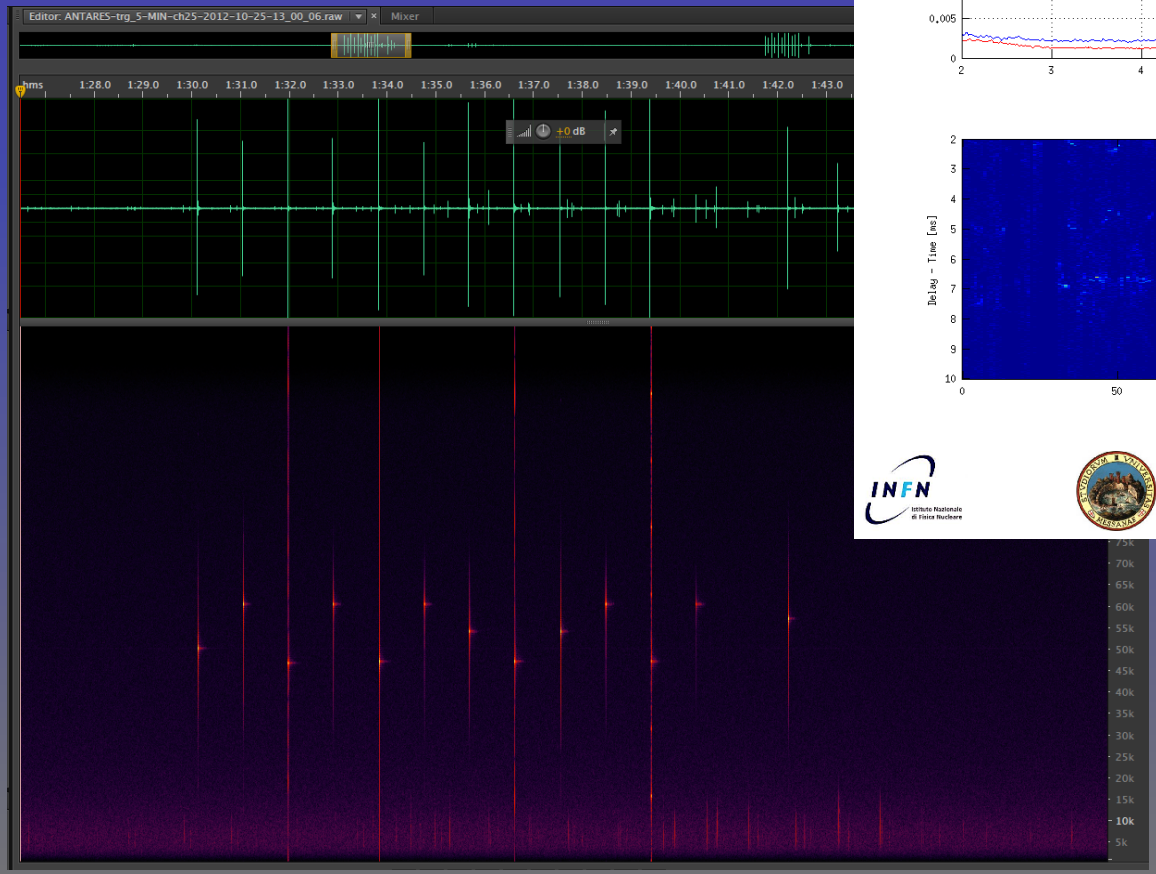
By linking measured levels witht the AIS position of transiting ships it is now possible to model the noise exposure of whales in the area and identify the most noisy ships. This allow to extrapolate the impact of ship noise on other areas.

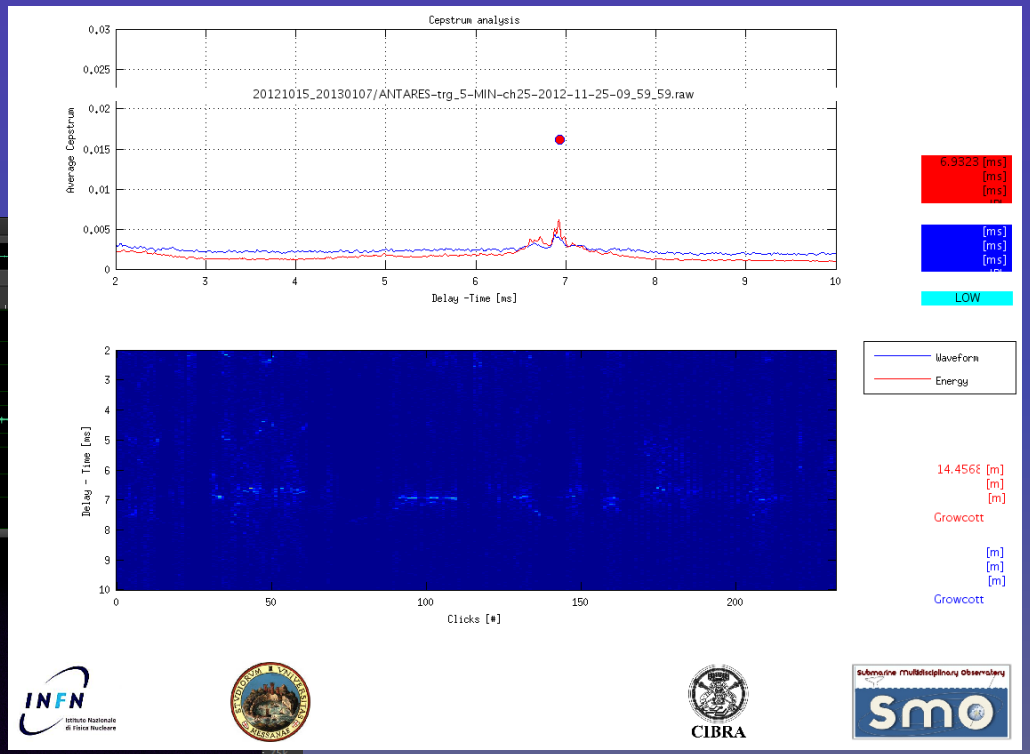
Talk by S.Pulvirenti

ANTARES - AMADEUS

Wideband data acquisition, 250 kHz sampling, data files provided by M.Andre’

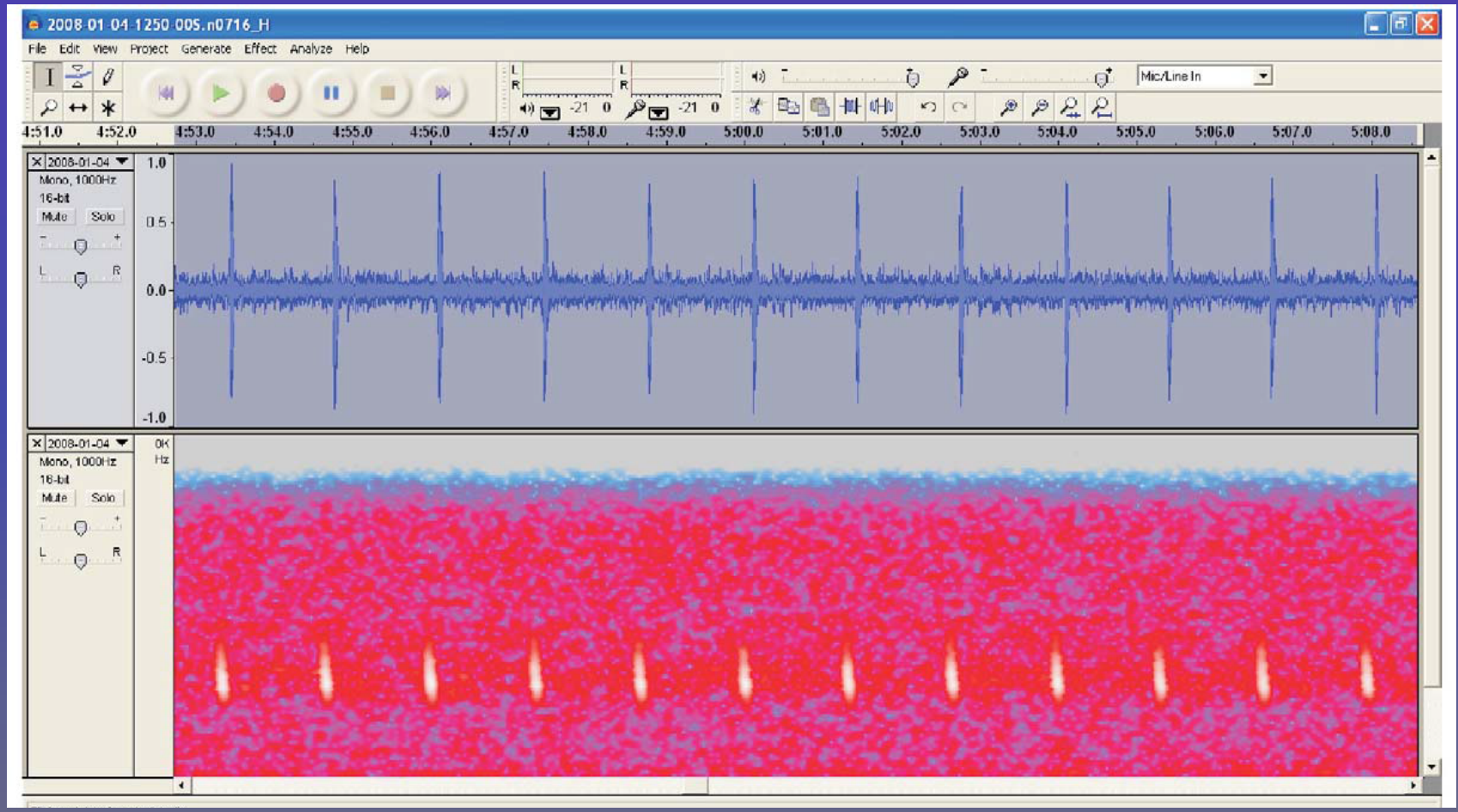
Acoustic positining pingers





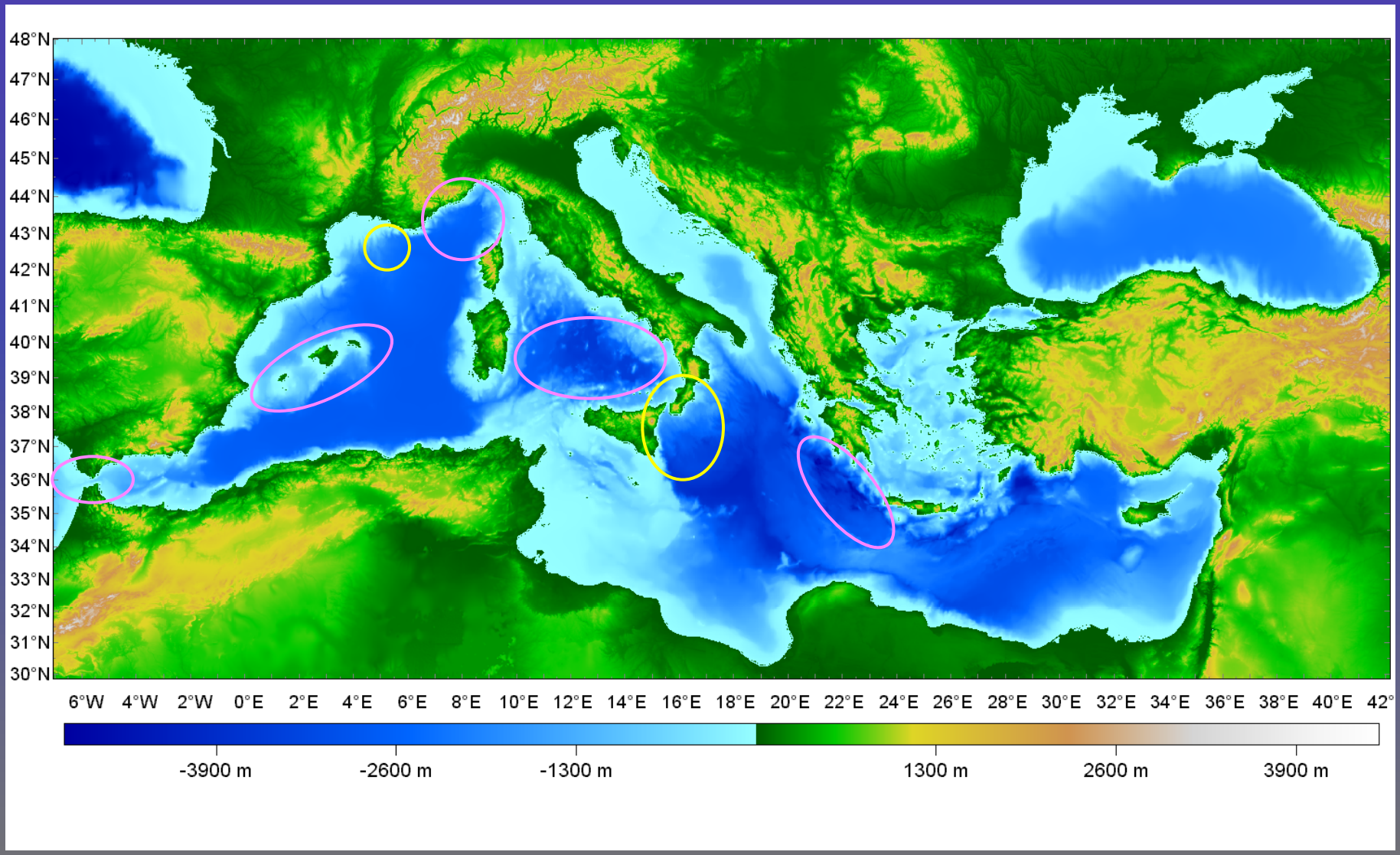
Sperm whale detection and IPI estimate by cepstrum

NEAREST – GEOSTAR Platform - Gulf of Cadiz

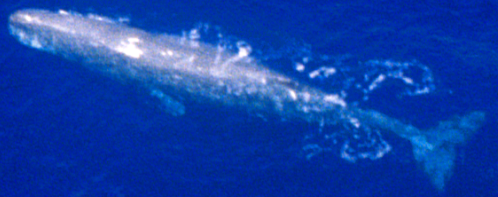


Fin whale calls detected by a seismic sensor (0-100 Hz)
Geissler & al., EGU 2009

CABIRIA, is a LIFE project submitted to EEC to study and protect sperm whales in the Ionian Sea. The project is designed to be the core of a series of interdisciplinary projects aimed at expanding monitoring efforts to other hot spots.



Field-work to be granted within CABIRIA and other projects



Validation

Photo-id

Problems
Constraints
Way ahead

Sailing boat - cruises 1991-1999	DAT tapes	"record only if there is something…"
Oceanographic ships - cruises 1999-2010	HD recording 40GB/disk in 2000 2TB/disk in 2010	"Record continuously max 4 weeks!!!" 24h/day 2 channels 96k in 2000; 4 or more channels at 192k in 2008-2010
Fixed deep platform with 4 hydrophones 2005-2006	HD recording 160GB/disk in 2005 250GB/disk in 2006	"No money for storage: record 5 minutes every hour!" 2 years continuous recording 4 channels 96k would require 48TB (2TB/month)

Sample resolution (16 bit)	1 sensor	4 sensors
48 kHz	8GB/day 240GB/month	32GB/day 960GB/month
192 kHz	32GB/day 960GB/month	128GB/day 3840GB/month
384 kHz	64GB/day 1920GB/month	256GB/day 7680GB/month

Table to show the data amount produced daily or monthly by acoustic sensors depending on sampling rate and sample resolution. Lossless data compression algorithms, well tuned for acoustic signals (e.g. FLAC), may reduce filesize to 30% of the original size. Lossy compression (e.g. MP3) may compress more but is not acceptable for scientific uses.

Storage capacity increase…, but our appetite increases as well…
And new problems arise:
"how we can manage and analyse all those TB of recordings ?"

RT Classification and Selection main issues

Selective storage based on classification criteria ?

Which type of signals to be saved ?

Cetacean sounds ? Ships ? Sonars ? Explosions ? Pingers ?

High level Sea noise ? Low level Sea noise ?

Everything ? Or just samples ?

What to do with discarded data ?

Other constraints

Electronic interferences (power lines, data tx/rx)

Pingers for positioning (overloading of acquisition chain)

Other equipments producing noise in water (currentometers)

Long term goals to be achieved within EMSO

Expand the number of acoustic sensors cabled to shore, either LF and WB, to perform:

Ocean noise statistics (natural, shipping, sonars, sparkers, etc)

Study marine mammals' population trends and correlate with external factors (climate changes, noise, ship traffic, other impacts)

Improve detection and tracking technologies for moving sound sources

Define standards and protocols for data selection and storage

Improve technologies for long term acoustic monitoring, data recording, data distribution and processing

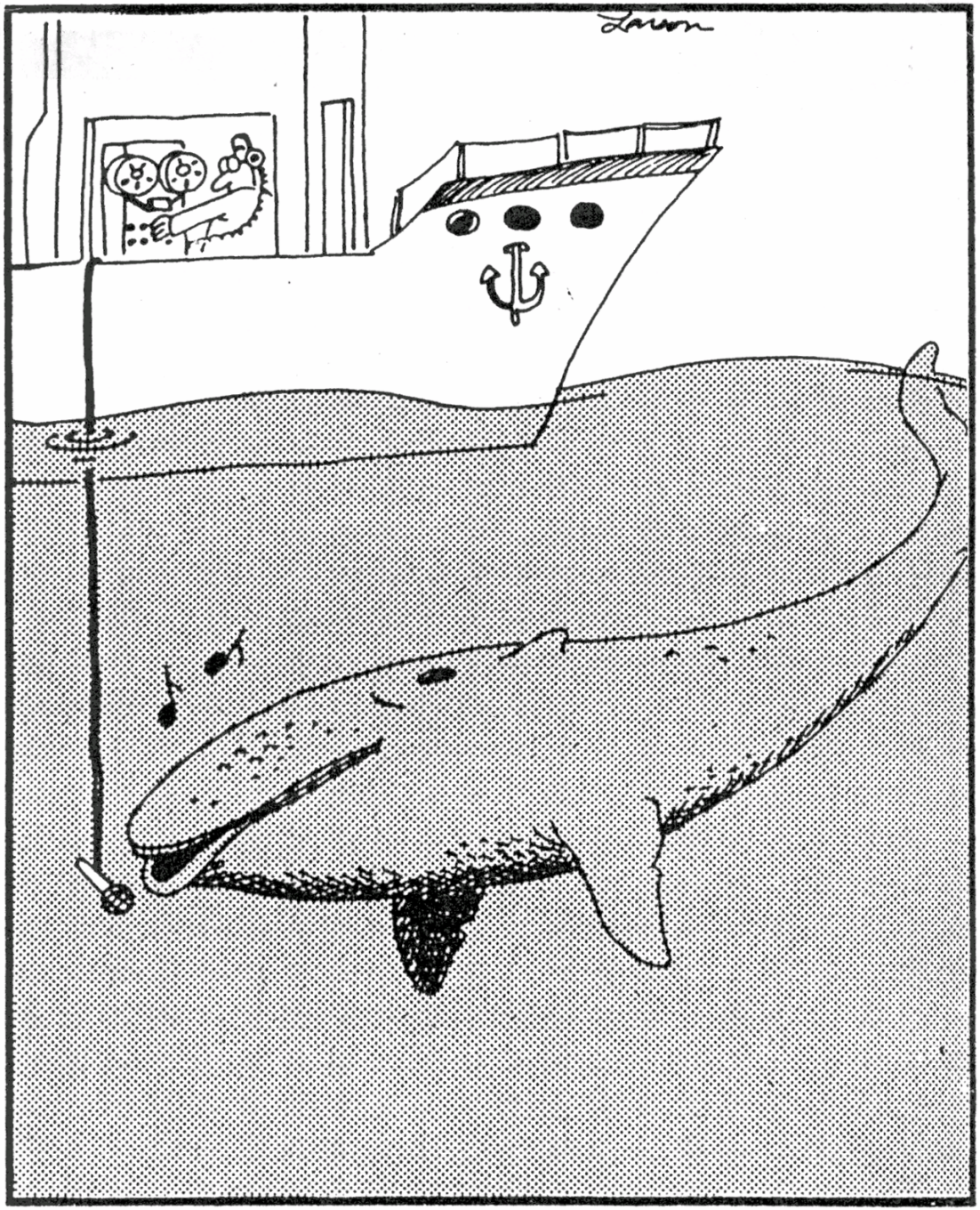
Improve technologies for acoustic data classification

Integrate and correlate multiple data (oceanographic, AIS, etc)

Goals of a synergic interdisciplinary approach

to be achieved by connecting EMSO with field research
(photo-id, surveys, radio tags, genetic samples on live and stranded animals)

- Implement the Marine Strategy Framework Directive (2008/EC/56)
  (biodiversity and noise)
- Reveal seasonal distribution of marine mammals and their movements
  (sperm whales and fin whales)
- Reveal population structure by assessing whale's size (sperm whales)
- Long term monitoring of population parameters
- Long term monitoring of local and global impacts
- Setup conservation strategies and monitoring of their effectiveness



"A Louie, Louie . . . wowoooo . . . We gotta go now . . ."

Thanks