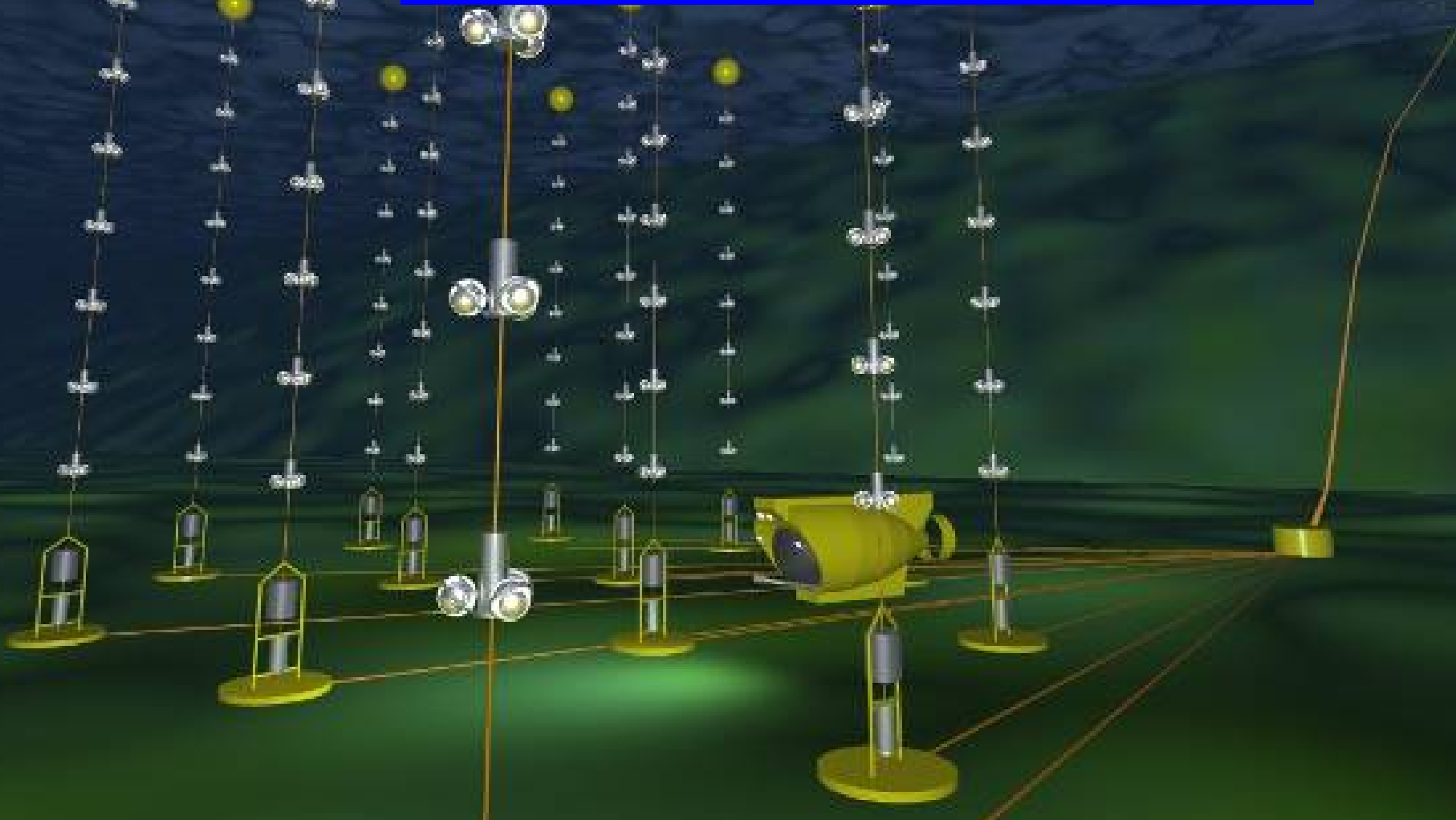


Les telescopes a neutrino comme laboratoires sous-marins

P. Coyle, CPPMarseille
Journee Astro, 7/9/07



Physics with Neutrino telescopes

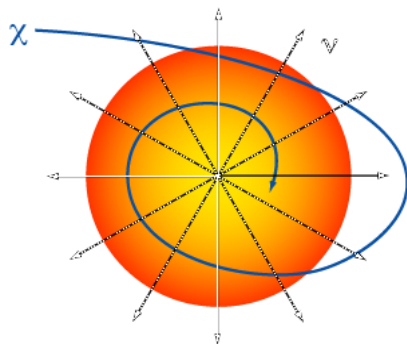
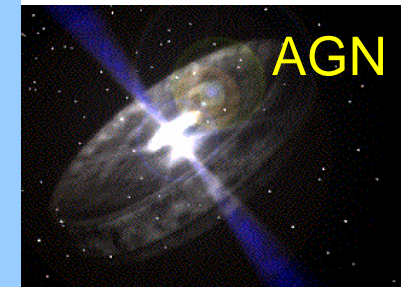
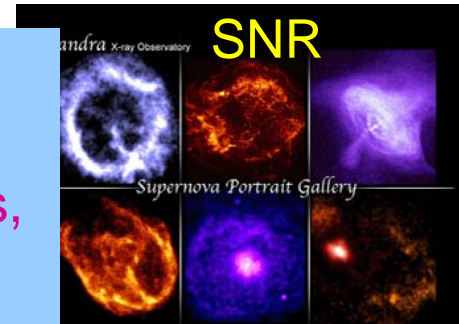


- **High energy neutrino astrophysics:**
Active Galactic Nuclei, μ -quasars
Gamma Ray Bursts, SN Remnants,
Galactic Centre,,...

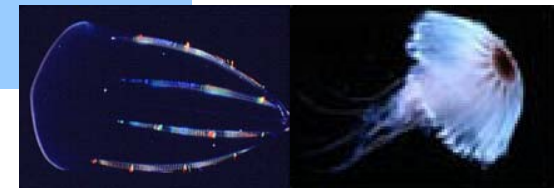
- Origin of cosmic rays
- Acceleration mechanisms
(hadronic vs leptonic)

- **Search for New Physics:**
WIMPs annihilations (sun, GC),
magnetic Monopoles...

- **Interdisciplinary Deep Sea Studies:**
oceanography, sea biology,
seismology...

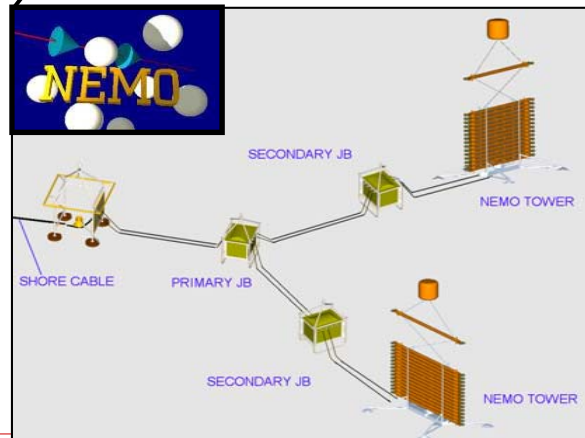
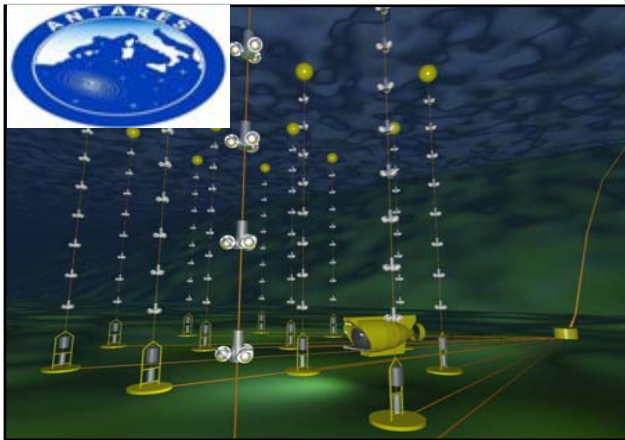
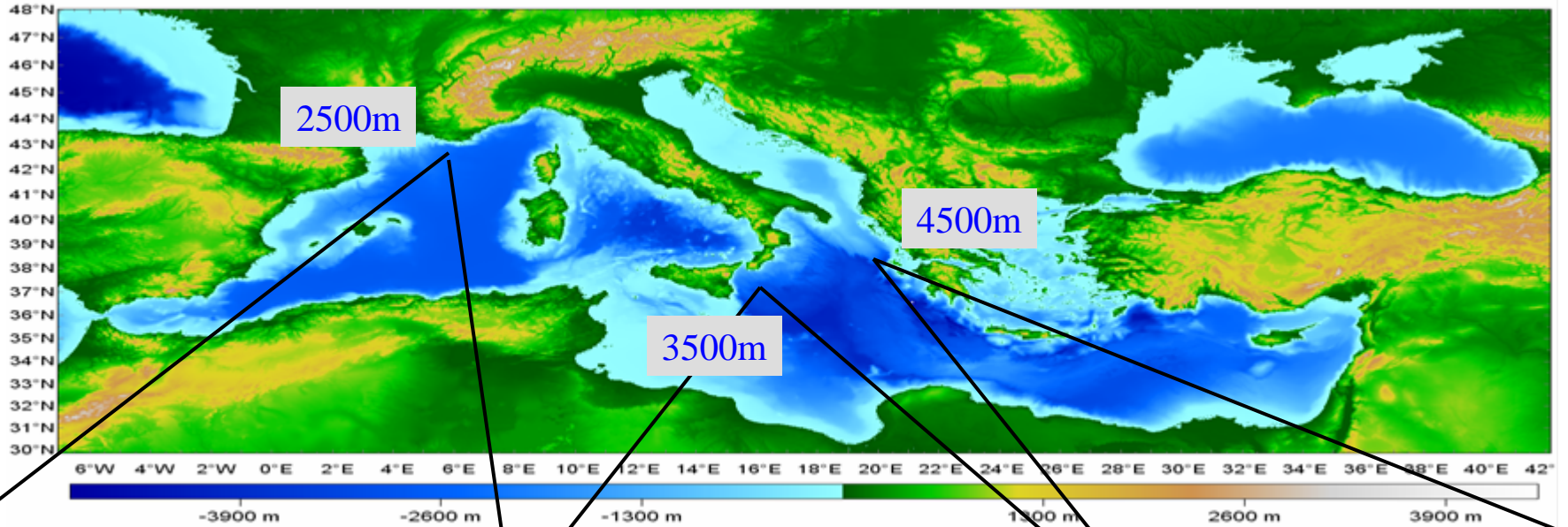


Neutralino
Annihilation



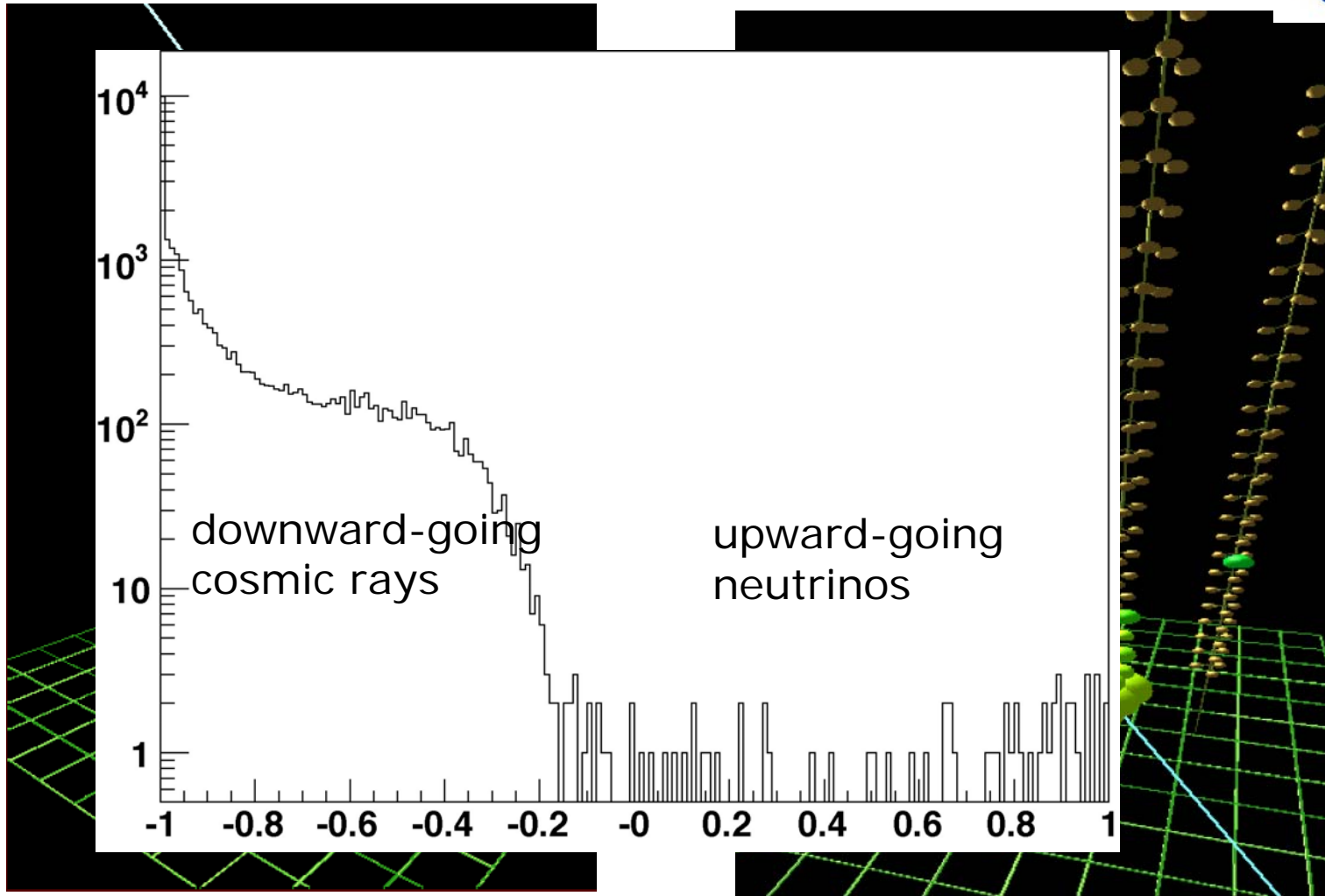
Bioluminescent Organisms

Three Mediterranean Projects





Antares - First Neutrinos with 5 lines





NEMO Phase-1: Test Site Catania

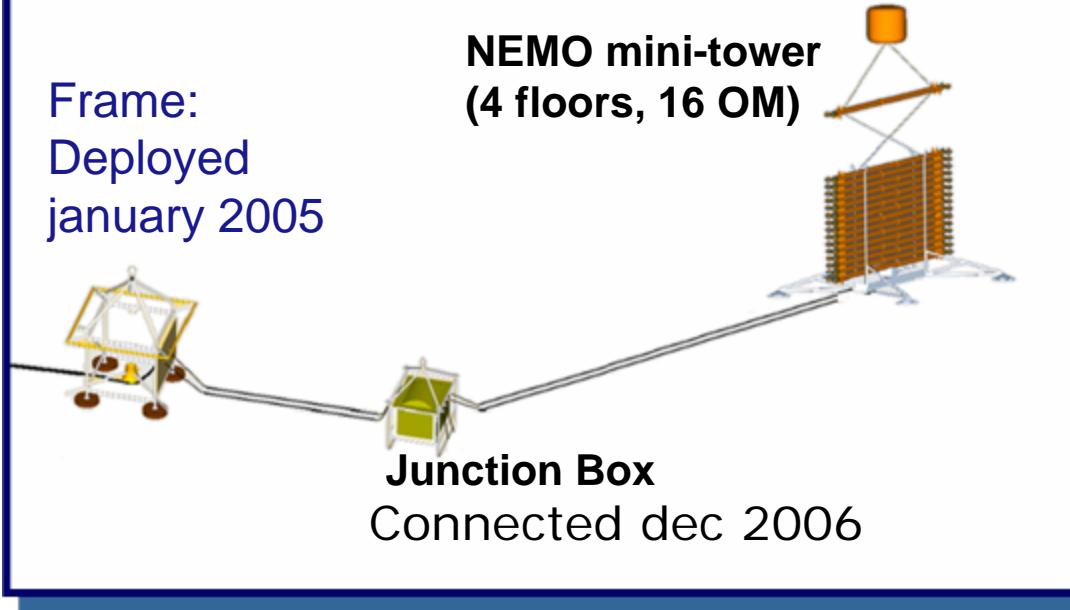
Underwater test site: 25km E of Catania, 2000m

Shore laboratory port of Catania



Frame:
Deployed
january 2005

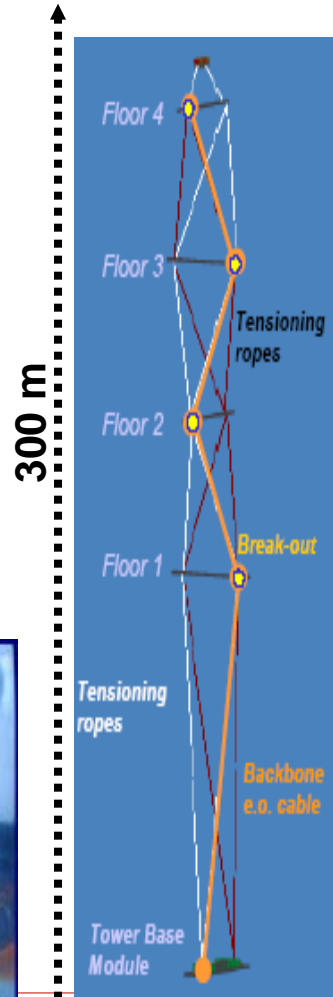
NEMO mini-tower
(4 floors, 16 OM)



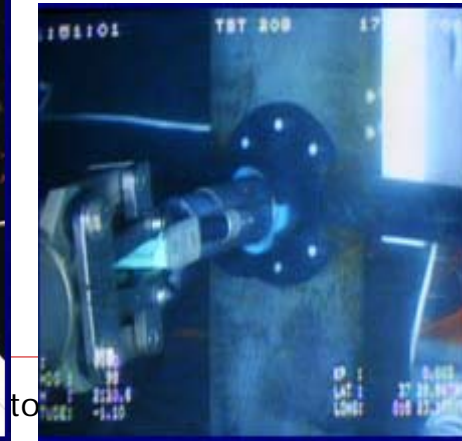
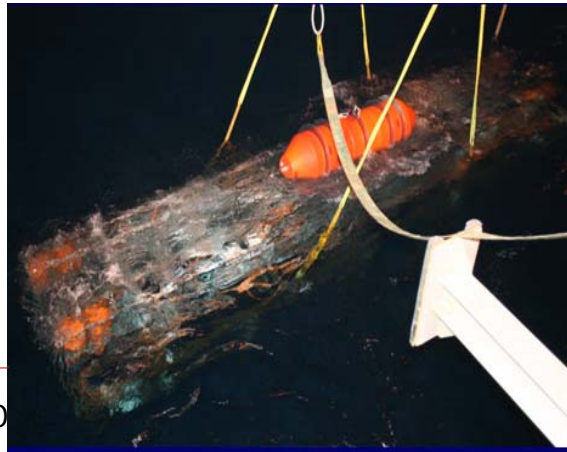
Junction Box
Connected dec 2006

junction box

Mini-Tower
unfurled

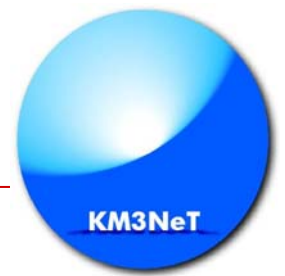


0.9.0



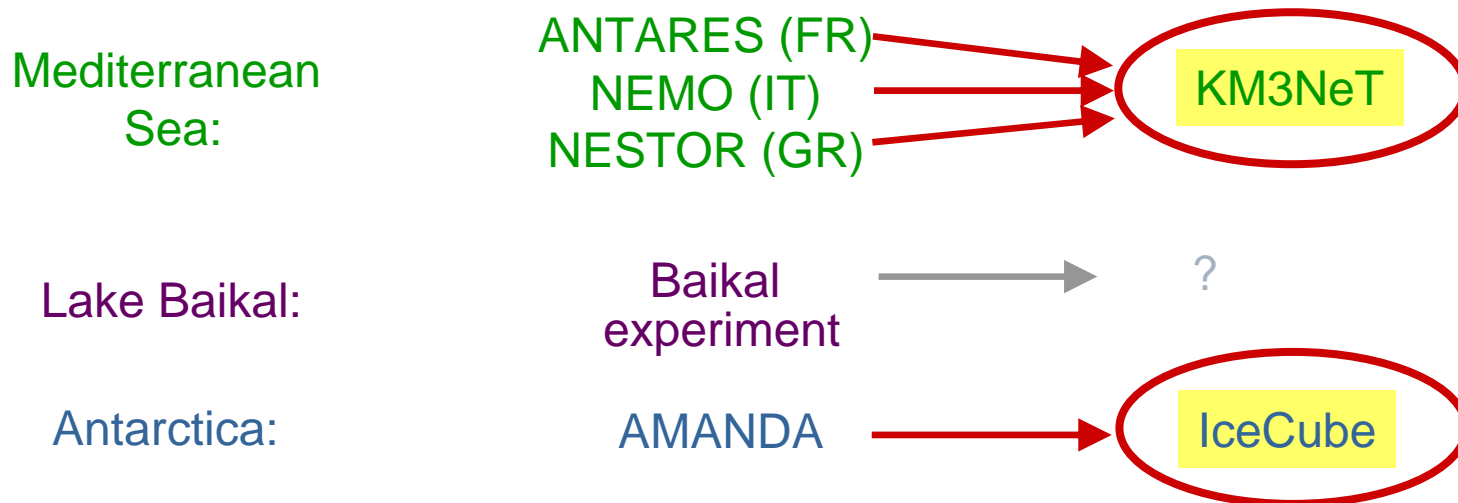
to

KM3NeT Objectives



■ Observe high-energy cosmic neutrinos

- Opens new window to the most violent processes in the universe
- Key objective of astroparticle physics
- Convergence towards two major neutrino telescopes covering the full sky:



■ Provide infrastructure for long-term deep-sea measurements

- Highly interesting for marine biologists, geologists and geophysicists, environmental scientists, oceanographers,
- Strong links to the **European Multidisciplinary Seafloor Observatory (EMSO)**



- 3-year FP6 Design Study,
 - Feb. 2006 – Jan. 2009
 - 9 M€ from EU, overall budget ~20 M€
 - Conceptual Design Report (fall 2007)
 - Technical Design Report (early 2009)

- 3-year FP7 Preparatory Phase,
(restricted to ESFRI list of opportunities)
 - Feb. 2008 – Jan. 2011
 - 5 M€ from EU
 - Legal, governance, site issues
 - Construction of prototype, preparation for production

KM3NeT-DS Participants



<u>Cyprus:</u>	Univ. Cyprus
<u>France:</u>	CEA/Saclay, CNRS/IN2P3 (CPP Marseille, IPHC Strasbourg, APC Paris-7), Univ. Mulhouse/GRPHE, IFREMER
<u>Germany:</u>	Univ. Erlangen, Univ. Kiel
<u>Greece:</u>	HCMR, Hellenic Open Univ., NCSR Demokritos, NOA/Nestor, Univ. Athens
<u>Italy:</u>	CNR/ISMAR, INFN (Univs. Bari, Bologna, Catania, Genova, Napoli, Pisa, Roma-1, LNS Catania, LNF Frascati), INGV, Tecnomare SpA
<u>Netherlands:</u>	NIKHEF/FOM (incl. Univ. Amsterdam, Univ. Utrecht, KVI Groningen)
<u>Spain:</u>	IFIC/CSIC Valencia, Univ. Valencia, UP Valencia
<u>UK:</u>	Univ. Aberdeen, Univ. Leeds, Univ. Liverpool, Univ. Sheffield
<u>(Ireland:</u>	Dublin (Aharonian))

Particle/Astroparticle institutes (30) – Sea science/technology institutes (7) – Coordinator

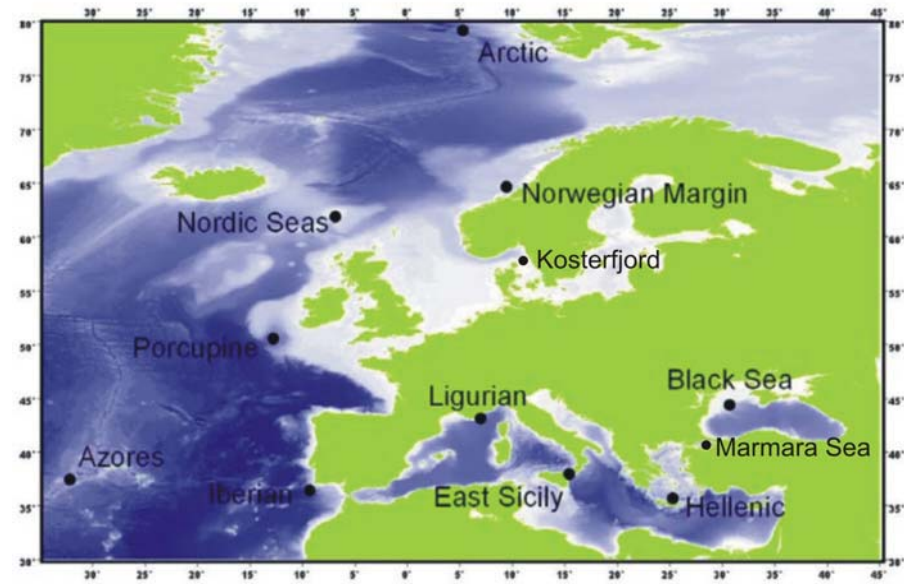


ESONET-NOE/EMSO-PP OBJECTIVES

The goal of the ESONET NOE is the **lasting integration** of European research on deep sea multidisciplinary observatories.

Its objective is to produce a practical plan for long term monitoring of the ocean margin environment around Europe as part of GMES with capability in: geophysics, geotechnics, chemistry, biochemistry, oceanography, biology and fisheries.

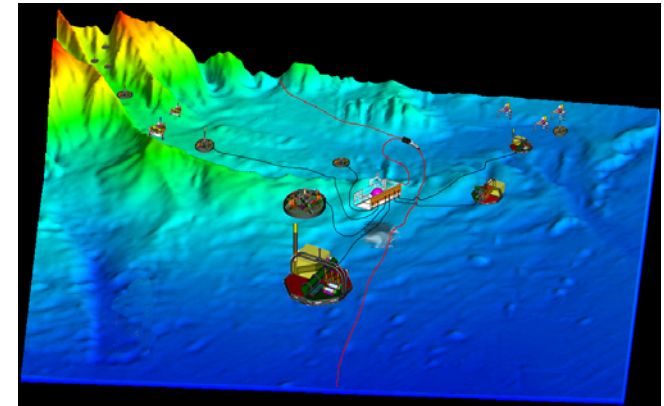
ESONET CA recommended to install long term observatories on 11 sites around Europe.



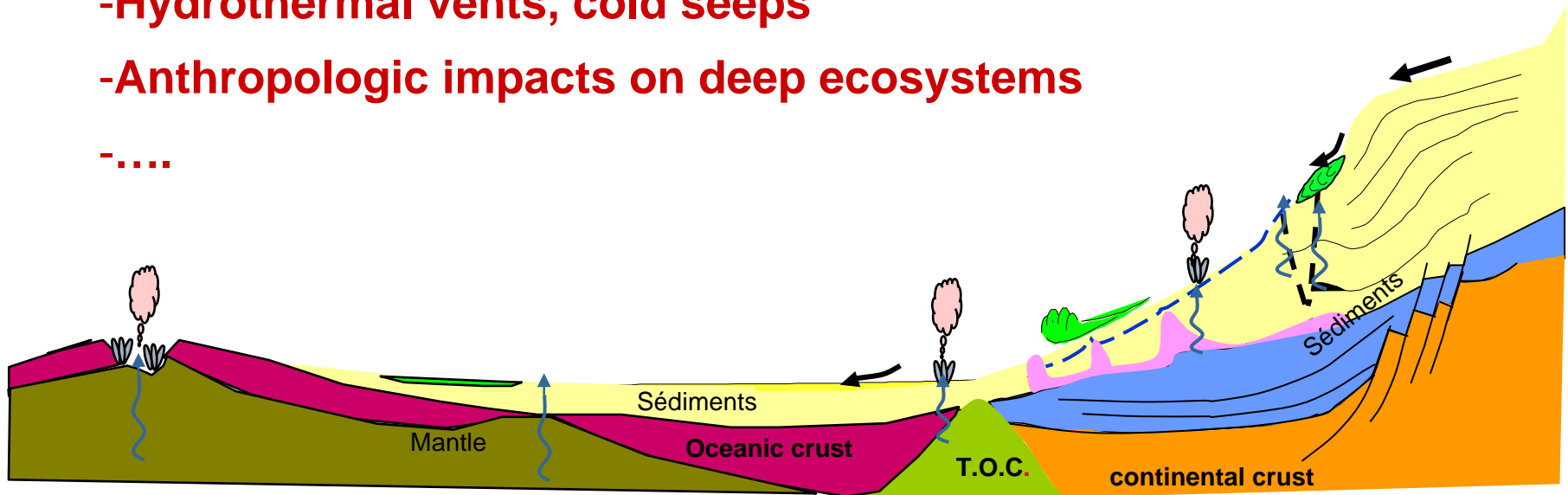
EMSO SCIENCE



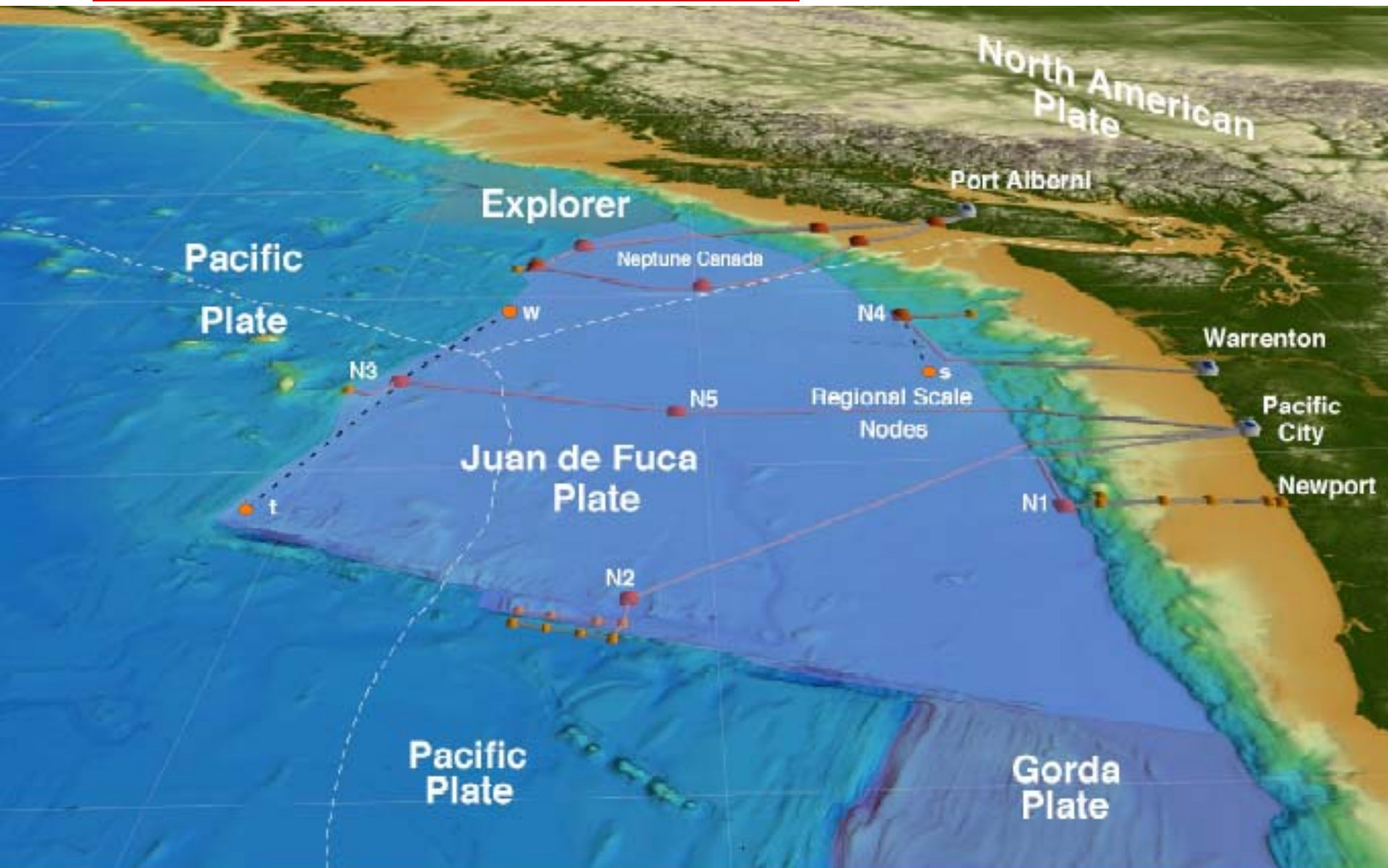
- Earthquakes
- Submarine slides, turbidity currents
- Tsunamis
- Benthic storms
- Bio-diversity changes
- Pollutions
- Hydrothermal vents, cold seeps
- Anthropologic impacts on deep ecosystems
-



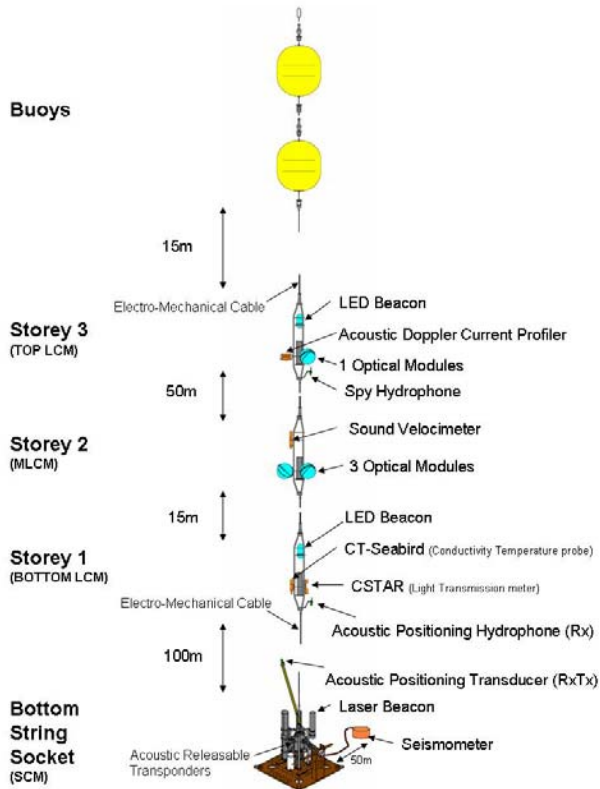
presently studied through conventional oceanographic campaigns.



USA PROJECT-NEPTUNE



ANTARES: activities interdisciplinary



-Surveillance of environmental parameters for their effect on the detector

↕
interaction

-Understanding of marine environment for associated sciences:

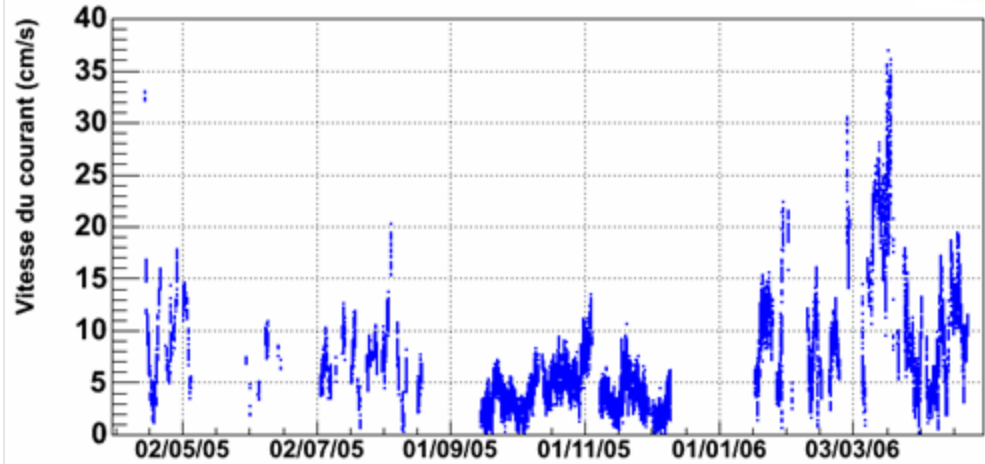
- Sismology
- Océanographie
- Bioluminescence
-

Ligne instrumentale MILOM,
connected april 2005-march 2007

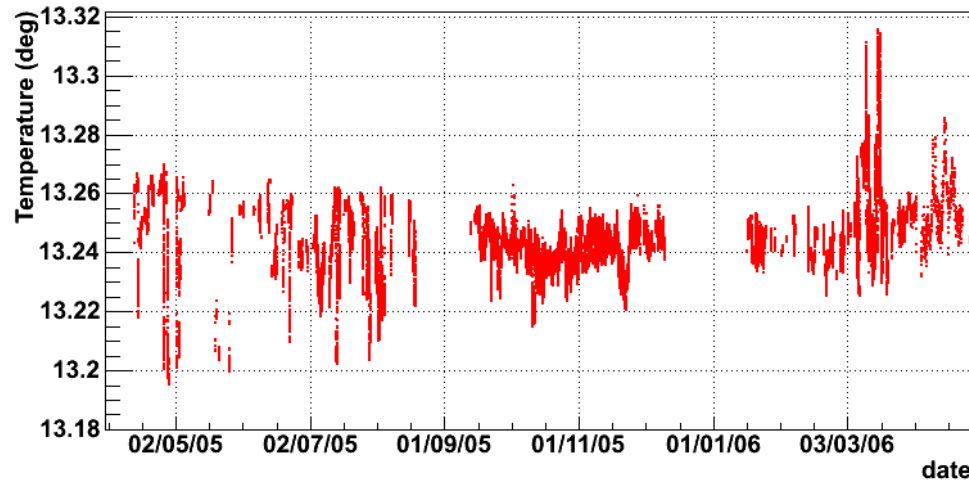
Oceanography



Acoustic Doppler current profiler



Temperature sensor

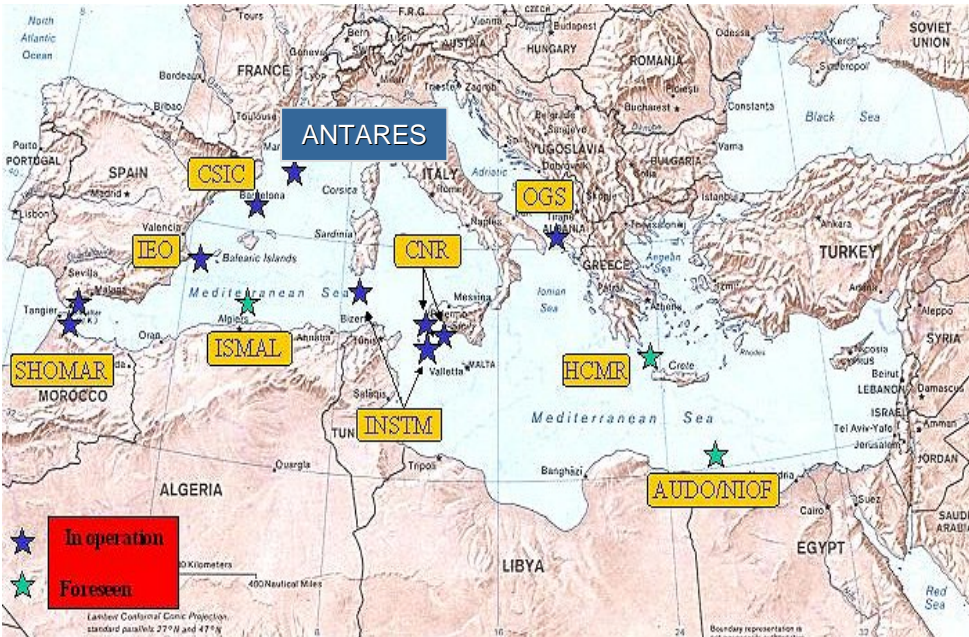


Oceanography

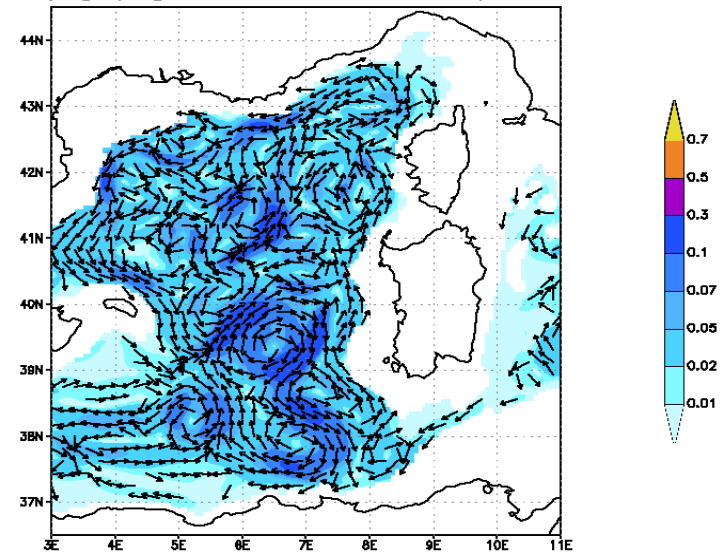


Programme Hydro-Changes du CIESM

(Commission Internationale pour l'Exploration Scientifique de la mer Méditerranée)



velocity [m/s] - date 070129 depth 1000 m

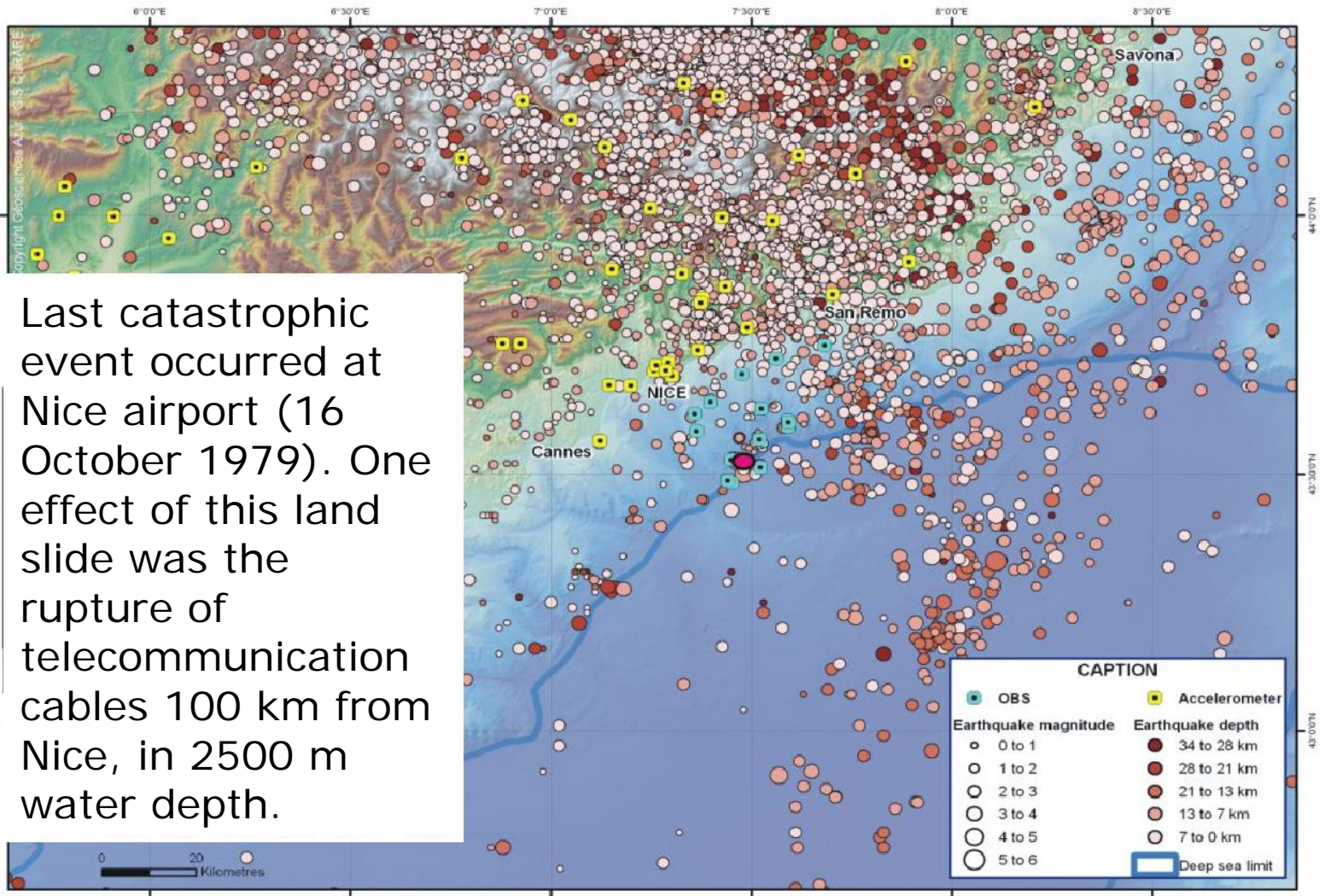


Circulation studies in the mediterranean sea

Collaboration with Centre d'Océanologie de Marseille



NICE AREA-ZONE SEISMIC



Last catastrophic event occurred at Nice airport (16 October 1979). One effect of this land slide was the rupture of telecommunication cables 100 km from Nice, in 2500 m water depth.

Seismology



In laboratory

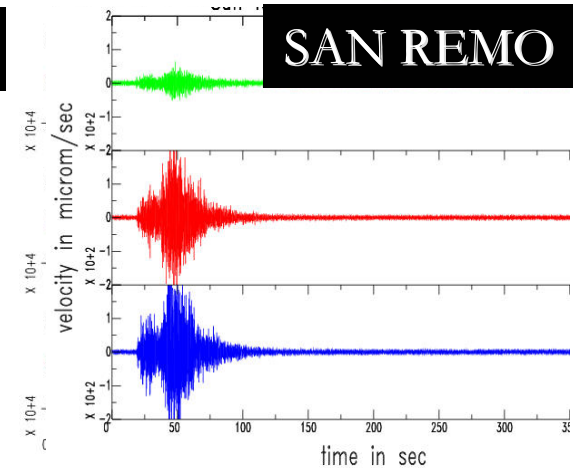
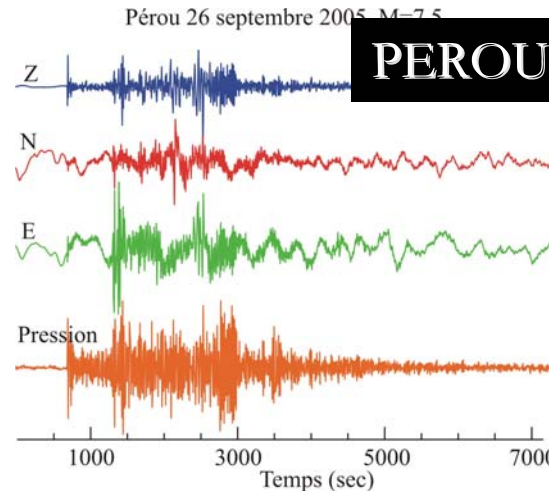


deployment



Buried at site Antares
(gain 20 dB of noise)

The seismograph ANTARES is part of seismic monitoring network, complementary to the terrestrial stations.



Collaboration with Laboratoire Géosciences Azur



astro Paris, 10.9.07

P. Coyle: laboratoires sous marin

DEEP SEA NET



DEEP SEA NET APPLICATION

Geoscience Azur project:

Four seismometers in Ligurian Sea

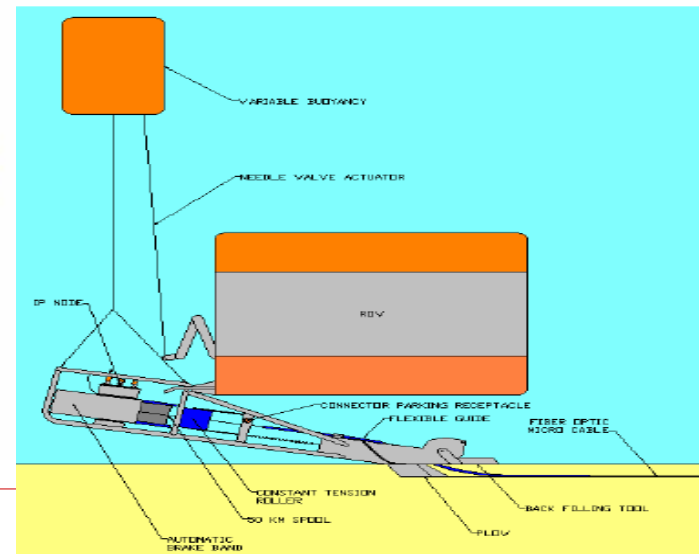
- Battery operated
- (0.3 mW power)

Location

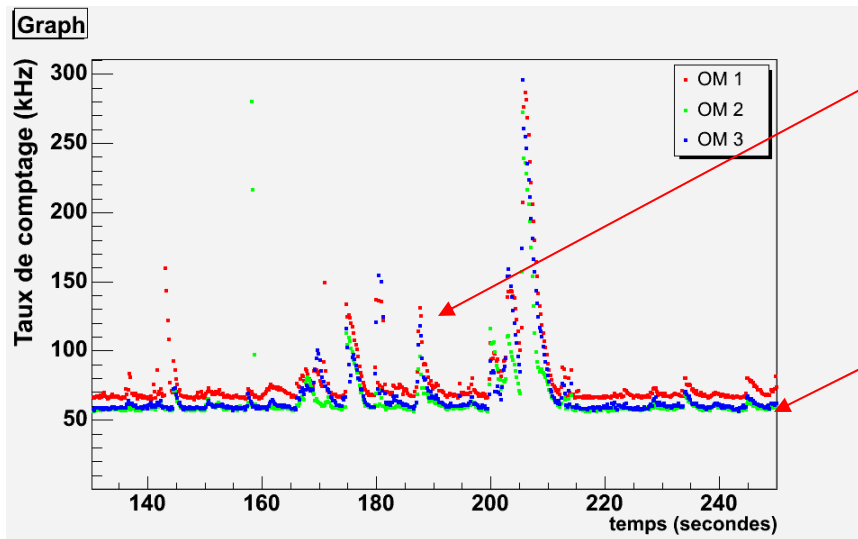
- S1: $43^{\circ}30' / 7^{\circ}30'$
- S2: $43^{\circ}35' / 7^{\circ}50'$
- S3: $43^{\circ}40' / 8^{\circ}10'$
- S4: $43^{\circ}15' / 7^{\circ}55'$

Distances from Antares JB

- JB-S1=133 km (needs 3 segments)
- S1-S2=28 km
- S2-S3=28 km
- S3-S4=51 km



Bioluminescence



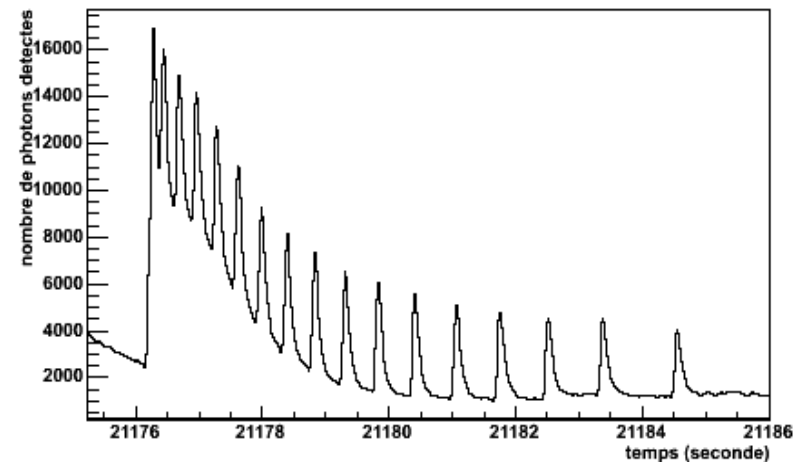
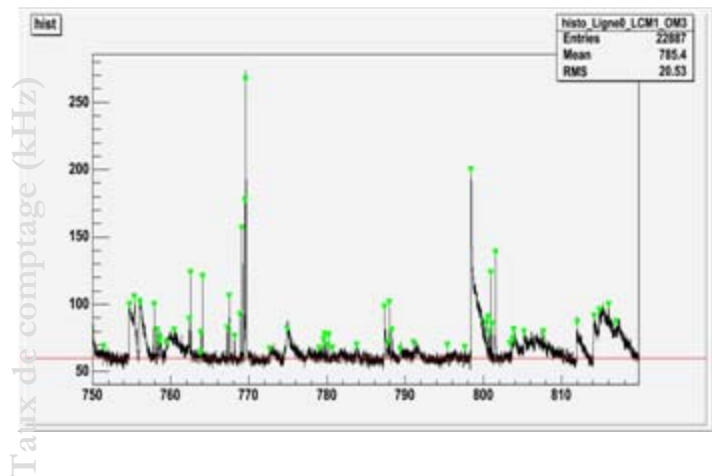
bioluminescence bursts

^{40}K (~ 40 kHz) +
luminescent bacteria

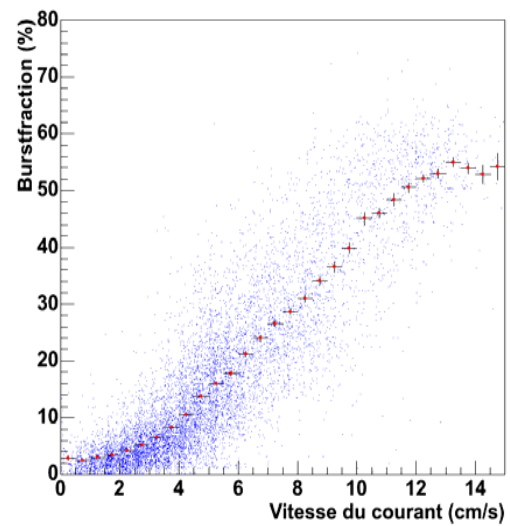
2 minutes
Counting rate on 3 PMT of same storey



Bioluminescence: Burst Activity

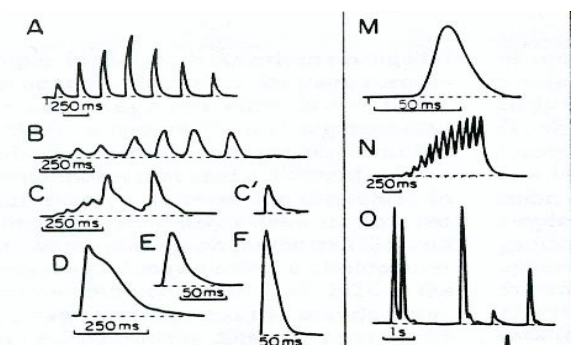


stimulated by turbulence around the structure



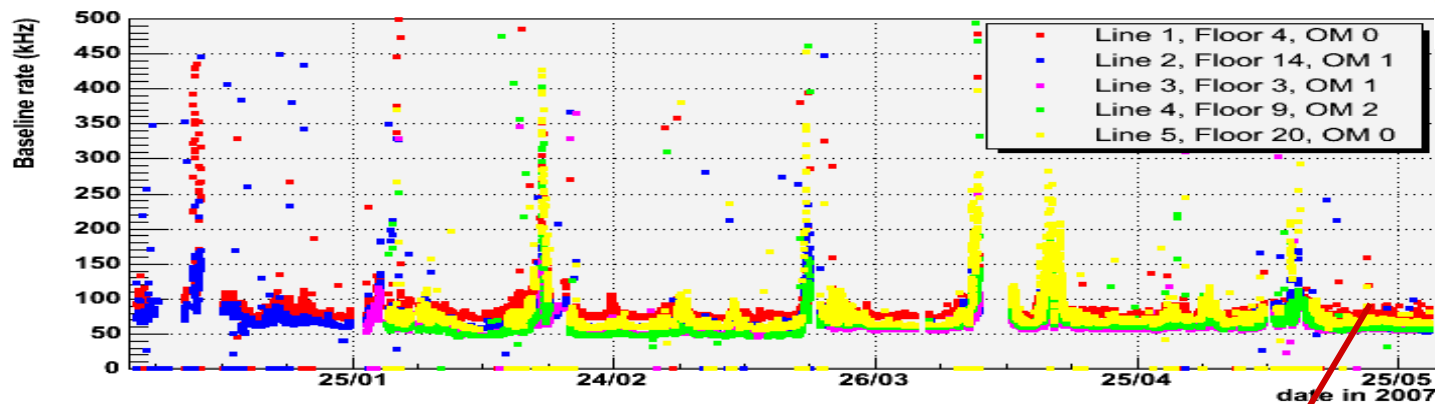
Characteristic of species involved

Temps (secondes)

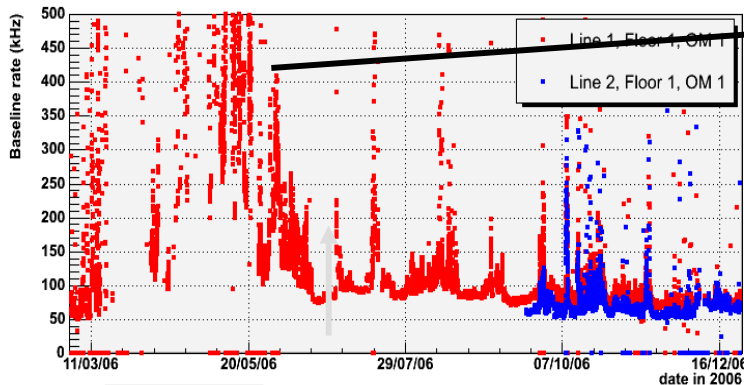




Bioluminescence: Continuous Component

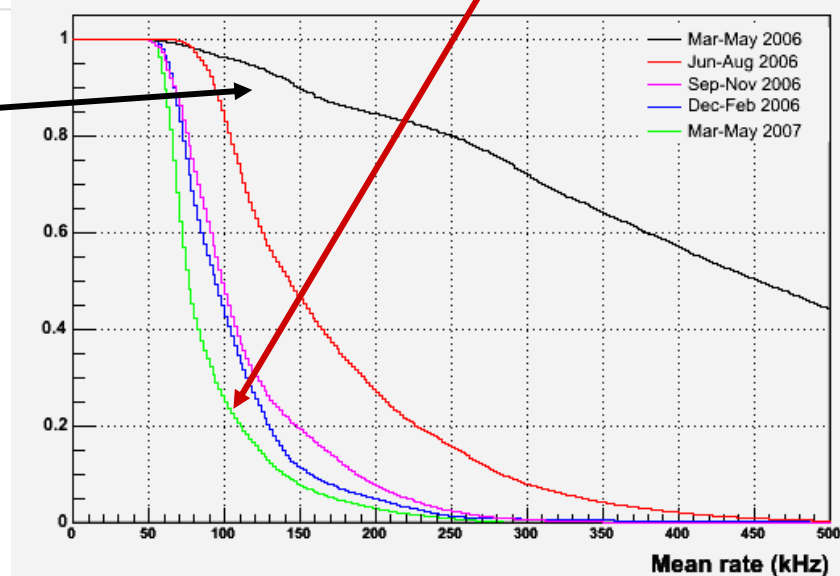


Lines 3, 4 & 5



Line 1

Line 2



Biocam on IL 07



Videosurveillance camera
for night vision



Source IR
(850 nm)

➔ Visualisation of bioluminescent organisms

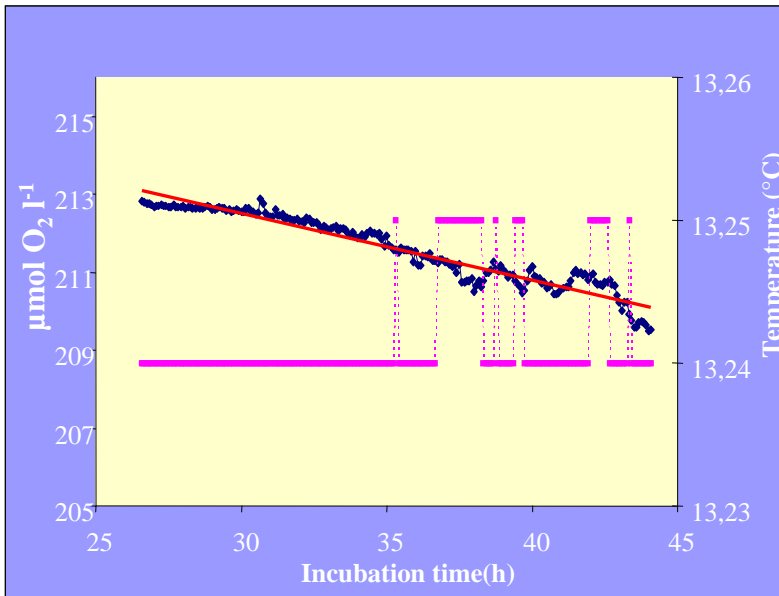
In situ Oxygen Dynamics Auto-sampler



Motors
Incubation chamber
Optode sensor



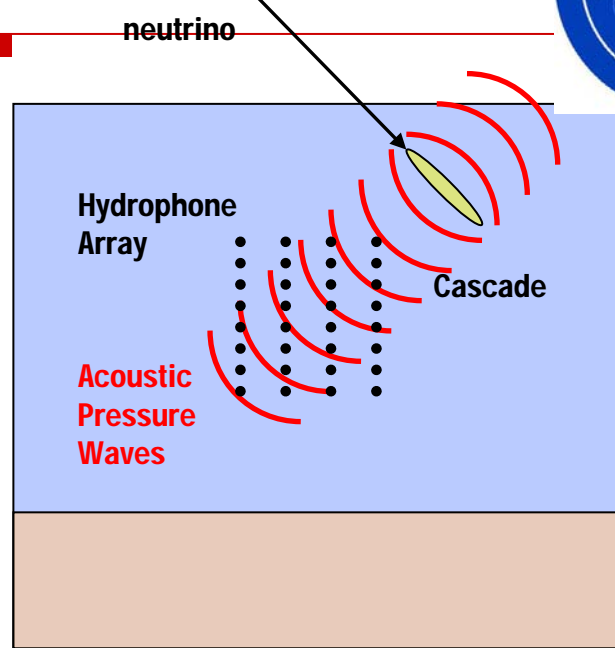
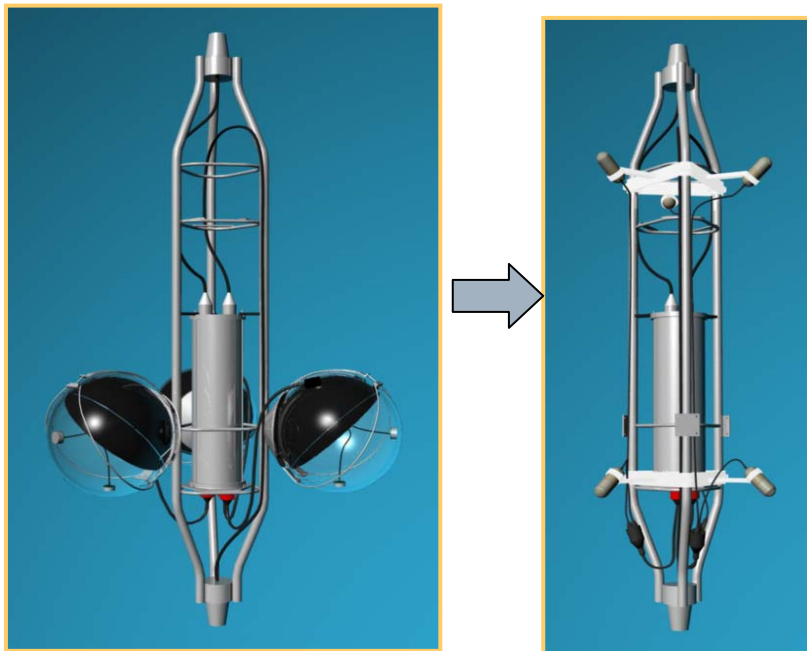
Acquisition system
'equipression'



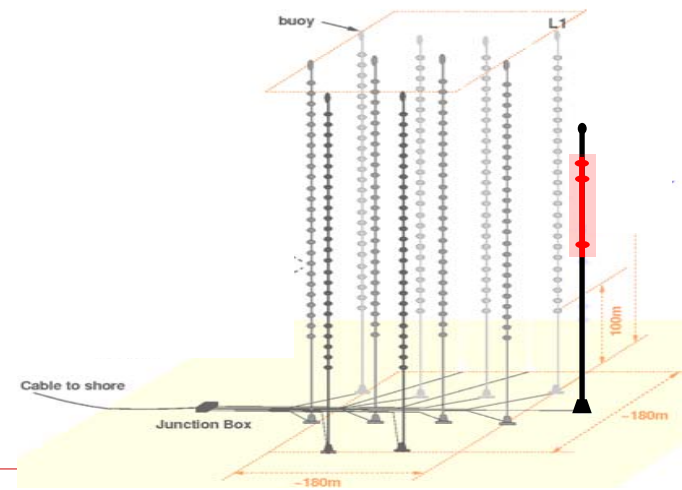
First results :
Biological O₂ consumption
estimation : $0.2 \mu\text{mol dm}^{-3} \text{ h}^{-1}$



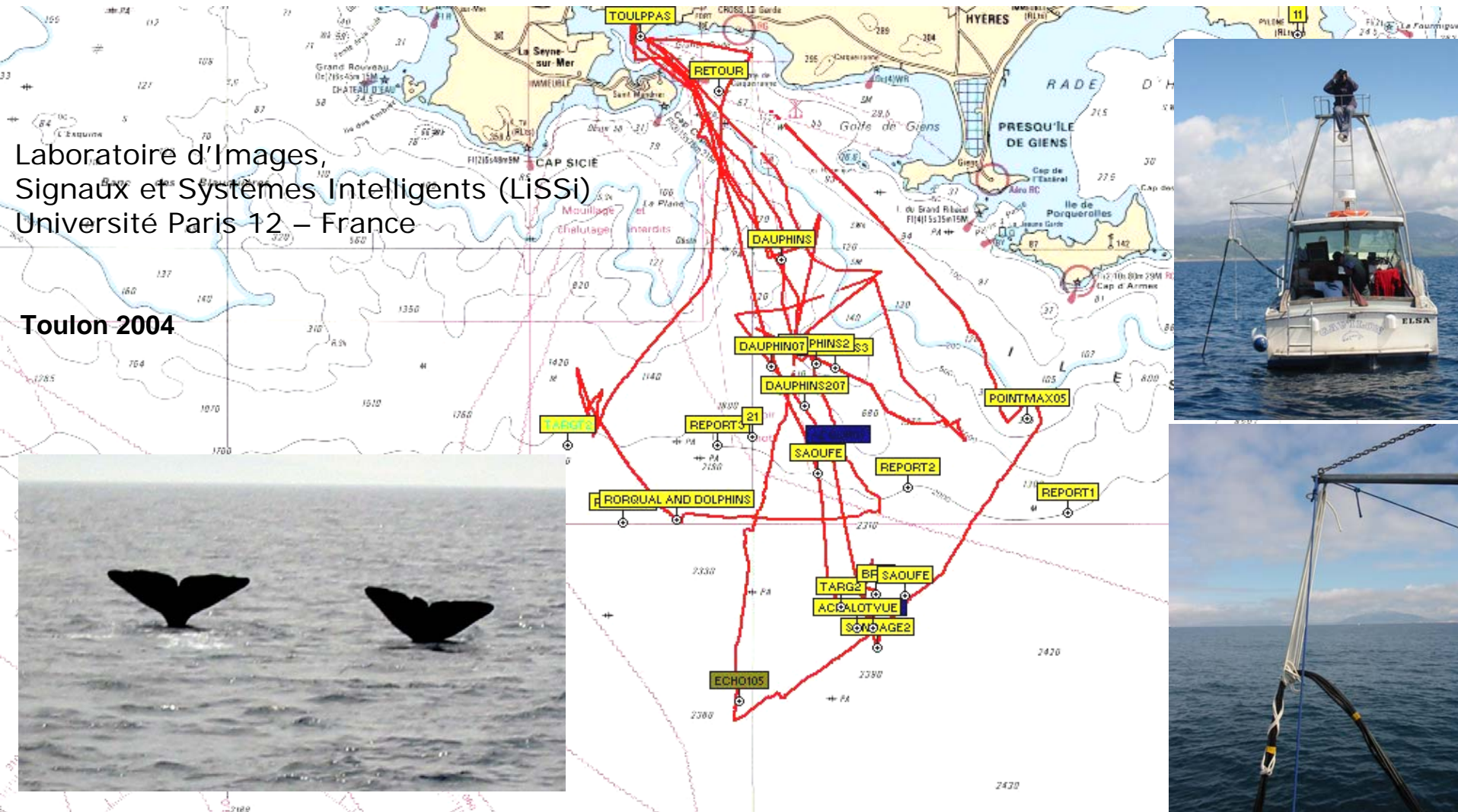
ACOUSTIC DETECTION



- “Instrumentation Line” with 3 acoustic storeys deployed in july 2007, connection dec 2007
- *Look for co-incidences at different distance scales (1m, 10m, 100m)*
- Also use existing acoustic transceivers to test 3D reconstruction



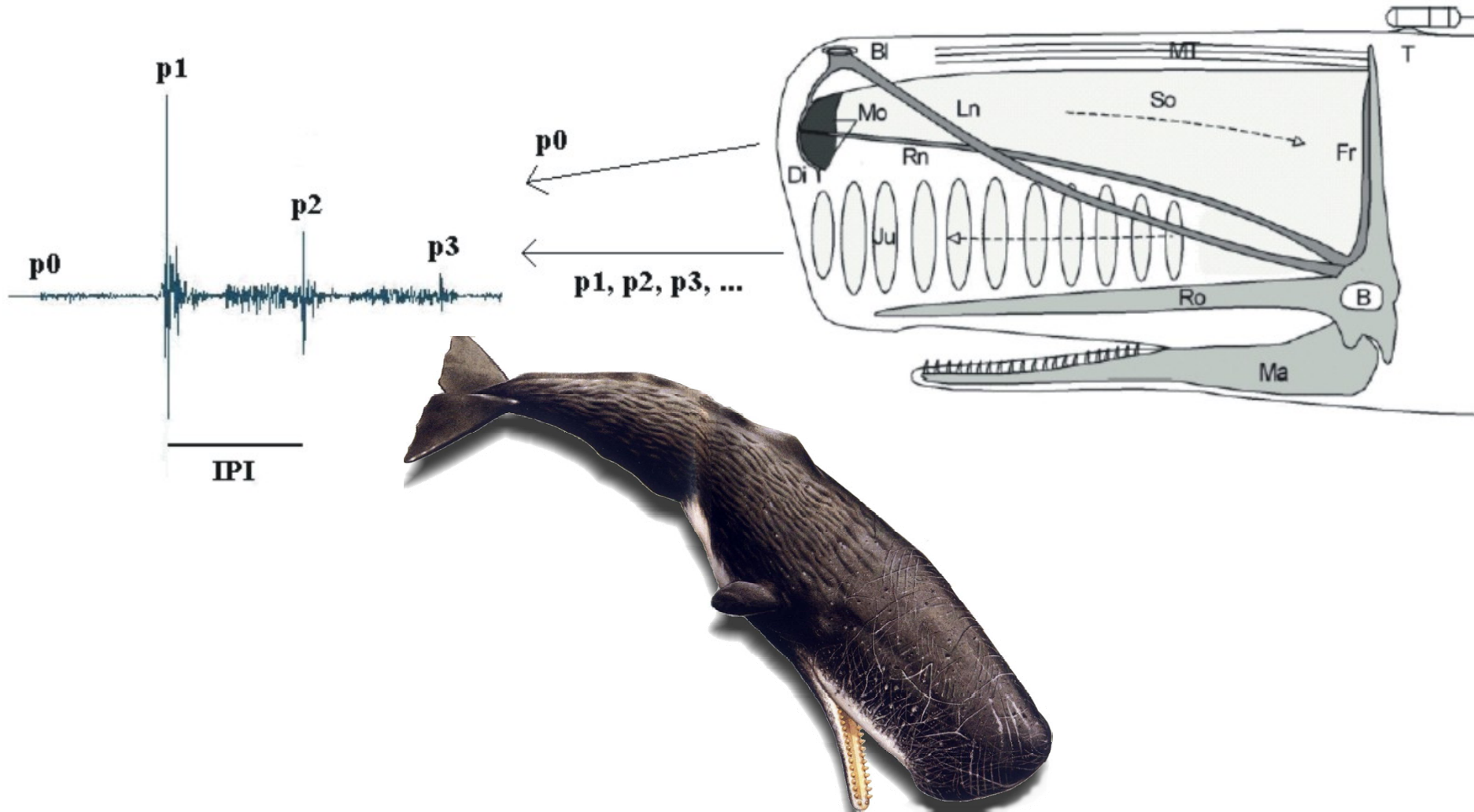
Boat Campaigns



Laboratoire d'Images,
 Signaux et Systèmes Intelligents (LISi)
 Université Paris 12 – France

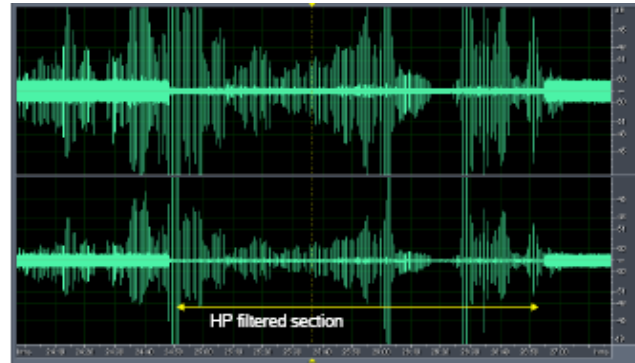
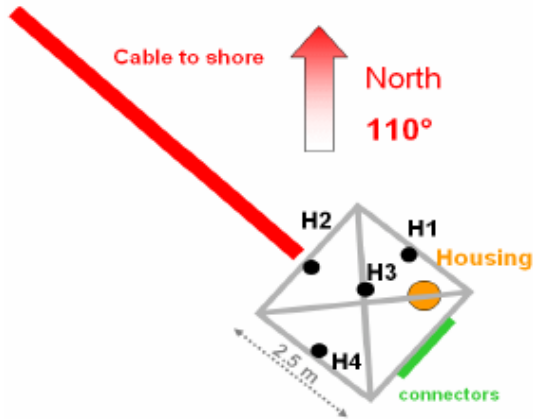
Toulon 2004

The clicks : a particular structure



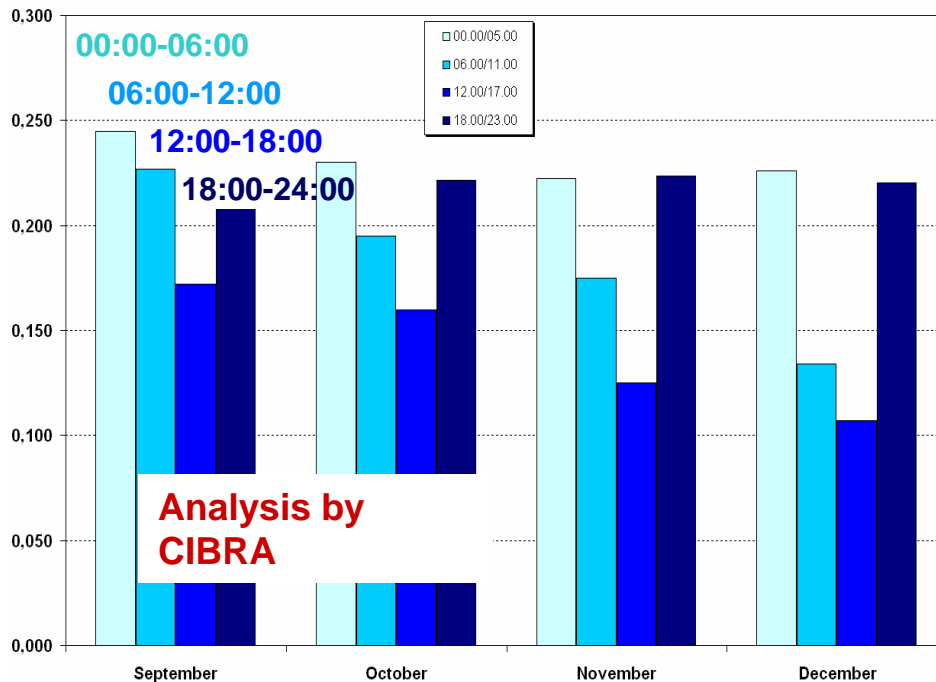


ACOUSTIC DETECTION-NEMO



By analyzing click details it is possible to assess the size and the sex of the animals. In this recording the size has been estimated 9.94-10.27 meters, matching a young male or a female (females reach about 12m, males reach 18m)

Dolphins' detection by time of day



« hundreds of sperm-whale transits per year over an area of about 1000 square kilometers --far more than have been supplied by visual sightings. Scientists are thrilled with the new tool. »

Science 2 March 2007:
Vol. 315. no. 5816, p. 1199
DOI: 10.1126/science.315.5816.1199d

OBJECTIFS SCIENTIFIQUES

L'objectif est de compléter le réseau mondial d'observatoires magnétiques utilisé pour l'étude de la dynamique du noyau, de la structure électrique profonde du manteau, la dynamique ionosphérique et magnétosphérique et de participer au programme INTERMAGNET, station au sol des satellites magnétiques.

BO/IUEM, Brest)
OARA MANDEA
PGP)
CHEL CALZAS
CHRISTINE DREZEN
LAIN DUBREULE
INSU/CNRS, Brest)

Geomagnetic station:
Full absolute geomagnetic vector
Intermagnet standard:
Baseline <5 nT/an - Angles ~30'' arc



Conclusions

- Existing neutrino telescope infrastructures are pioneering continuous and real-time observation of the deep oceans in many fields:
 - Bioluminescence
 - oceanography
 - seismology
 - acoustic detection
 - geomagnetism
- These interdisciplinary studies form an important component of future planned infrastructures