"Security & safety concerns of CO_2 storage"

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British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

www.bgs.ac.uk

A network of public scientific institutes through Europe promoting integration to form **a unique European Research Laboratory on CO_2 Storage** durably engaged **to mitigate climate change and ocean acidification**

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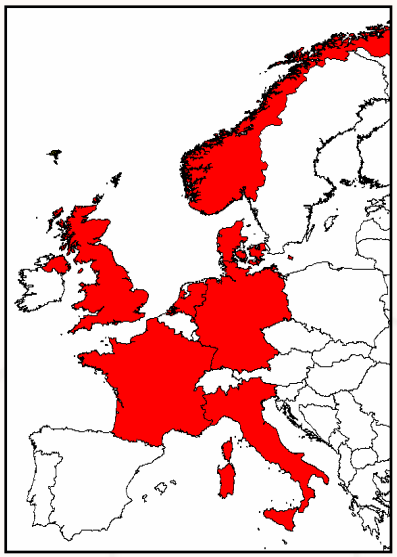

UK
Natural Environment Research Council-British Geological Survey-BGS (Co-ordinator)
Heriot-Watt University –HWU
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Kingsley Dunham Centre
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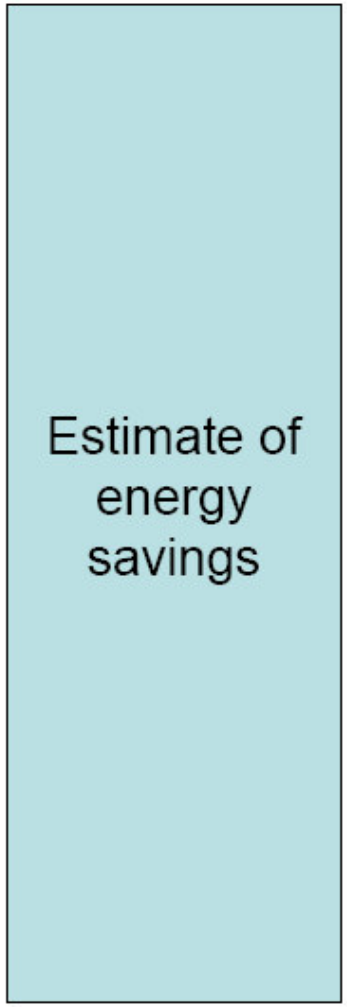
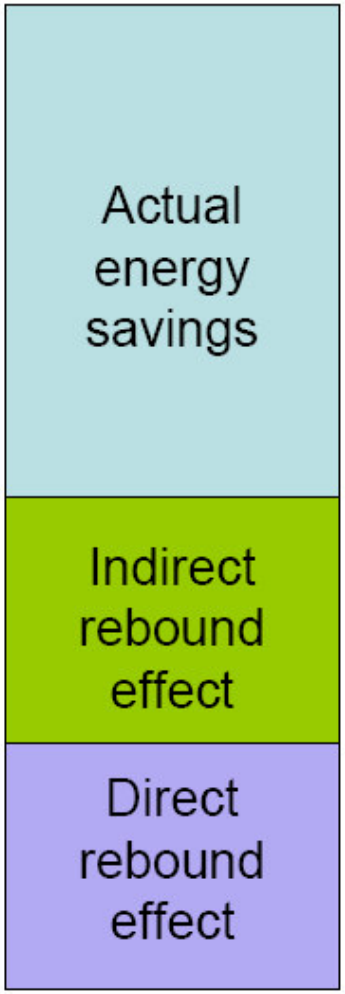
http://www.ukerc.ac.uk/Downloads/PDF/07/0710ReboundEffect/0710ReboundEffectReport.pdf





CCS is special
It is the only technology that deals directly with the problem.

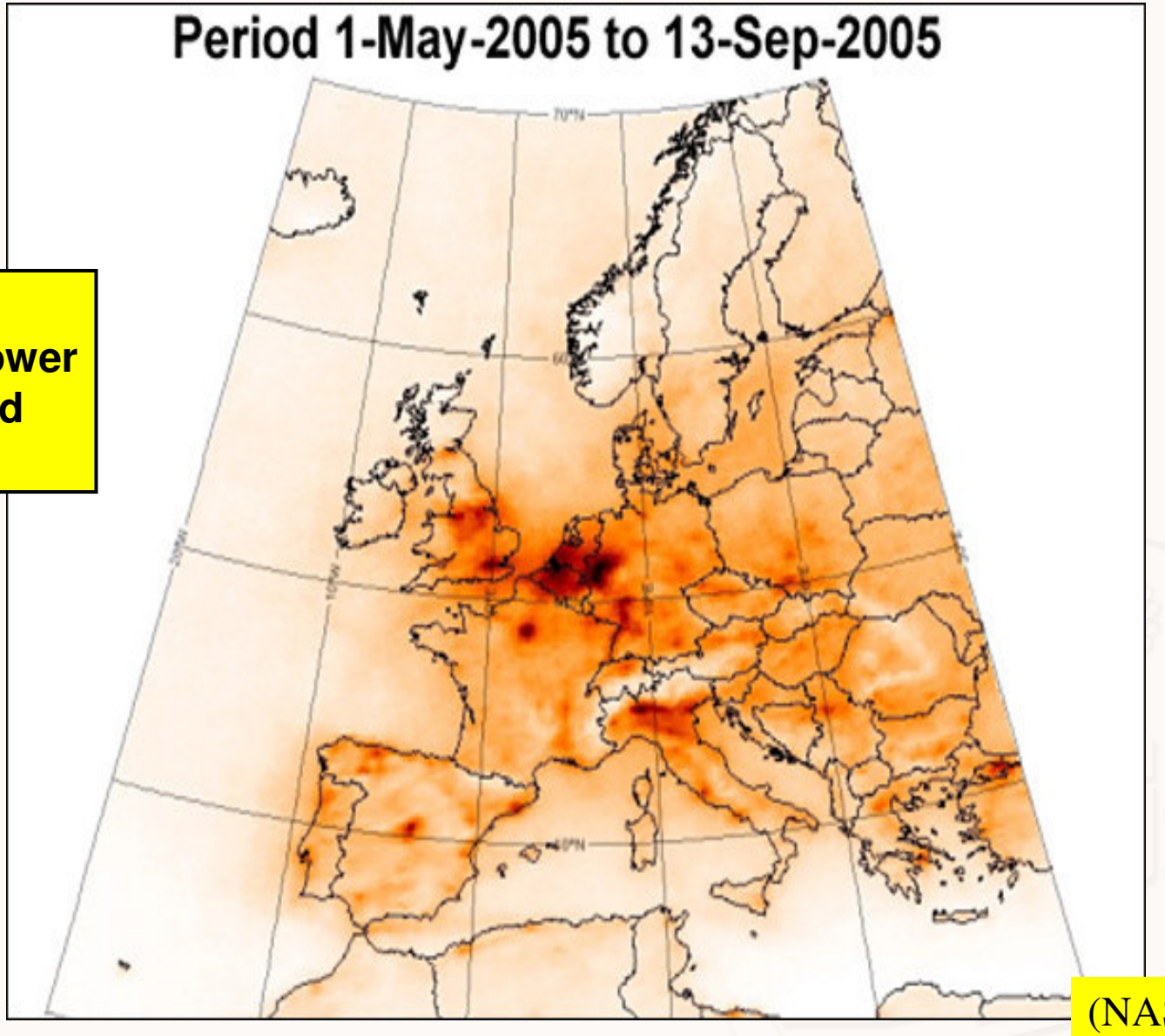
Indirect methods of reducing emissions, whilst fossil fuels are widely available, have major uncertainties and unintended consequences

Economy-wide rebound effect

UKERC

Comment: There is already widespread policy support for non-CCS methods which have risk of high levels of "leakage"

Fossil fuel (NOx) emissions in the lower atmosphere imaged from space



(NASA)

How much CO_2 are we currently leaking into the sky from fossil fuels?

- Anthropogenic emissions ~30Gt
- Volcanic emissions ~0.3Gt

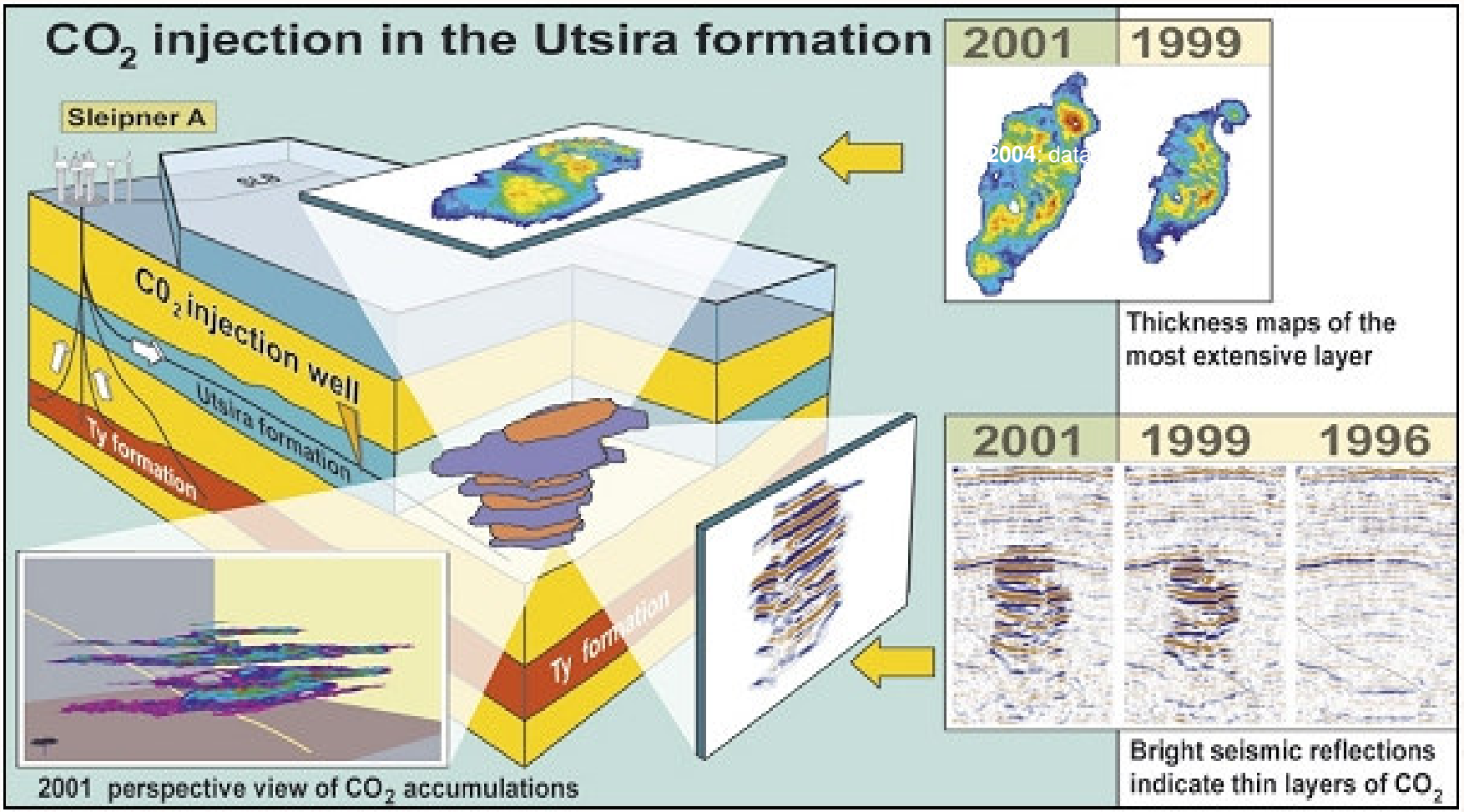
- Volcanic emissions are ~1% of anthropogenic ones
- Anthropogenic emissions are rising at more than 2.5%/annum (~750Mt/annum)

http://www.bgs.ac.uk/programmes/landres/segs/downloads/VolcanicContributions.pdf

Nature's North Sea CO_2 storage projects

- Brae field >30% CO_2
- Miller Field @ 20% CO_2
- K12b 13% CO_2
- Sleipner 9% CO_2

CO_2 has been retained for millions of years in these fields



CO_2 is safely stored by Statoil

Courtesy of Statoil & SACS/CO2 Store

BEST PRACTICE FOR THE STORAGE OF CO_2 IN SALINE AQUIFERS

Observations and guidelines from the SACS and CO2STORE projects

Edited and compiled by:

Andy Chadwick, Rob Arts, Christian Bernstone, Franz May, Sylvain Thibeau & Peter Zweigel

http://www.co2store.org/TEK/FOT/SVG03178.nsf/Attachments/CO2STORE_Best_Practice_Manual_2007_revision_1.pdf/

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There is a broad array of tools/methods for monitoring storage in all scenarios

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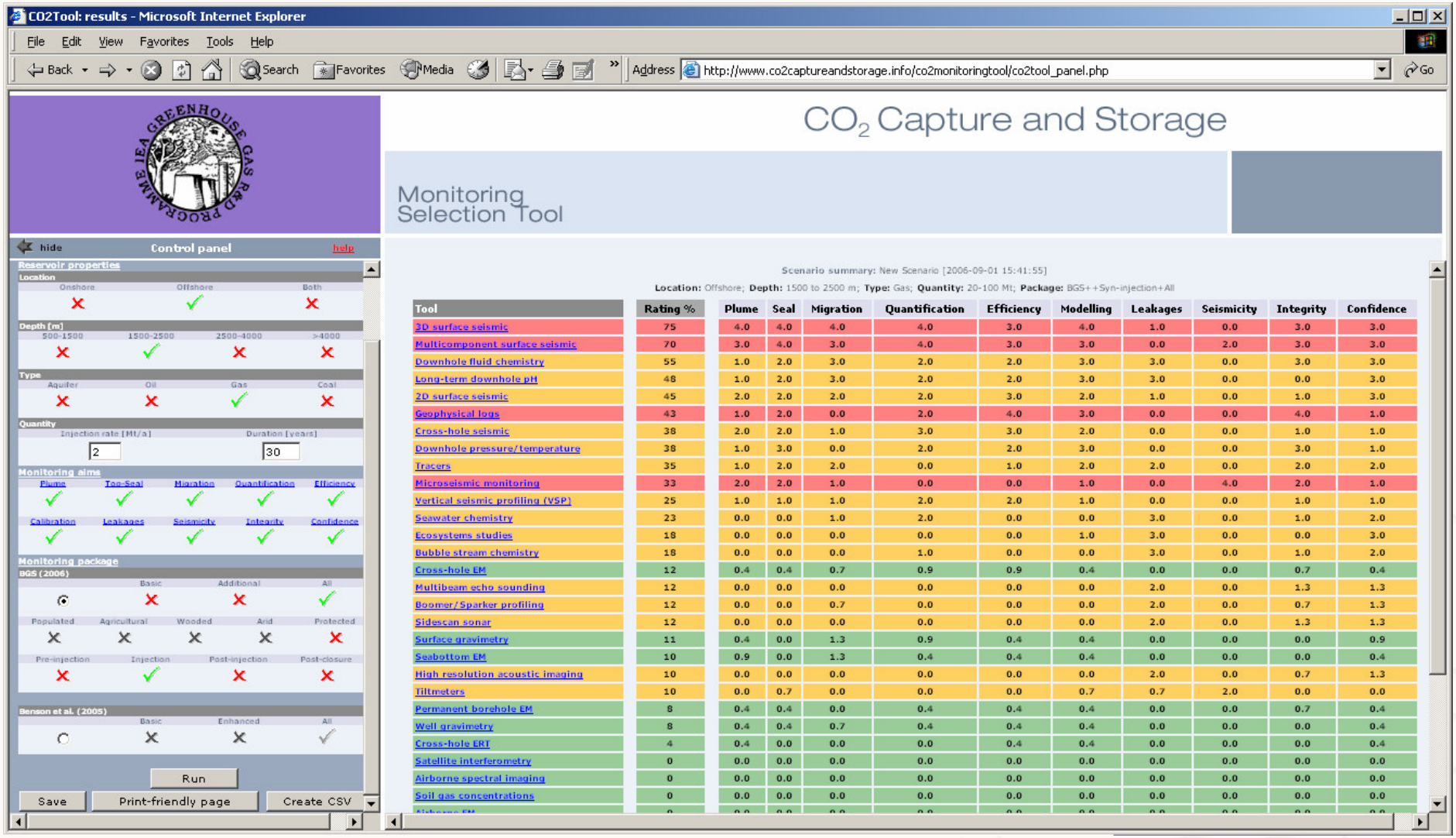

Tool	Rating %	Plume	Seal	Migration	Quantification	Efficiency	Modelling	Leakages	Seismicity	Integrity	Confidence
3D surface seismic	75	4.0	4.0	4.0	4.0	3.0	4.0	1.0	0.0	3.0	3.0
Multicomponent surface seismic	70	3.0	4.0	3.0	4.0	3.0	3.0	0.0	2.0	3.0	3.0
Downhole fluid chemistry	55	1.0	2.0	3.0	2.0	2.0	3.0	3.0	0.0	3.0	3.0
Long-term downhole pH	48	1.0	2.0	3.0	2.0	2.0	3.0	3.0	0.0	0.0	3.0
2D surface seismic	45	2.0	2.0	2.0	2.0	3.0	2.0	1.0	0.0	1.0	3.0
Geophysical logs	43	1.0	2.0	0.0	2.0	4.0	3.0	0.0	0.0	4.0	1.0
Cross-hole seismic	38	2.0	2.0	1.0	3.0	3.0	2.0	0.0	0.0	1.0	1.0
Downhole pressure/temperature	38	1.0	3.0	0.0	2.0	2.0	3.0	0.0	0.0	3.0	1.0
Tracers	35	1.0	2.0	2.0	0.0	1.0	2.0	2.0	0.0	2.0	2.0
Microseismic monitoring	33	2.0	2.0	1.0	0.0	0.0	1.0	0.0	4.0	2.0	1.0
Vertical seismic profiling (VSP)	25	1.0	1.0	1.0	2.0	2.0	1.0	0.0	0.0	1.0	1.0
Seawater chemistry	23	0.0	0.0	1.0	2.0	0.0	0.0	3.0	0.0	1.0	2.0
Ecosystems studies	18	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.0	0.0	3.0
Bubble stream chemistry	18	0.0	0.0	0.0	1.0	0.0	0.0	3.0	0.0	1.0	2.0
Cross-hole EM	12	0.4	0.4	0.7	0.9	0.9	0.4	0.0	0.0	0.7	0.4
Multibeam echo sounding	12	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.3	1.3
Boomer/Sparker profiling	12	0.0	0.0	0.7	0.0	0.0	0.0	2.0	0.0	0.7	1.3
Sidescan sonar	12	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.3	1.3
Surface gravimetry	11	0.4	0.0	1.3	0.9	0.4	0.4	0.0	0.0	0.0	0.9
Seabottom EM	10	0.9	0.0	1.3	0.4	0.4	0.4	0.0	0.0	0.0	0.4
High resolution acoustic imaging	10	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.7	1.3
Tiltmeters	10	0.0	0.7	0.0	0.0	0.0	0.7	0.7	2.0	0.0	0.0
Permanent borehole EM	8	0.4	0.4	0.0	0.4	0.4	0.4	0.0	0.0	0.7	0.4
Well gravimetry	8	0.4	0.4	0.7	0.4	0.4	0.4	0.0	0.0	0.0	0.4
Cross-hole ERT	4	0.4	0.0	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.4
Satellite interferometry	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Airborne spectral imaging	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil gas concentrations	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

www.co2captureandstorage.info/co2monitoringtool/index.php

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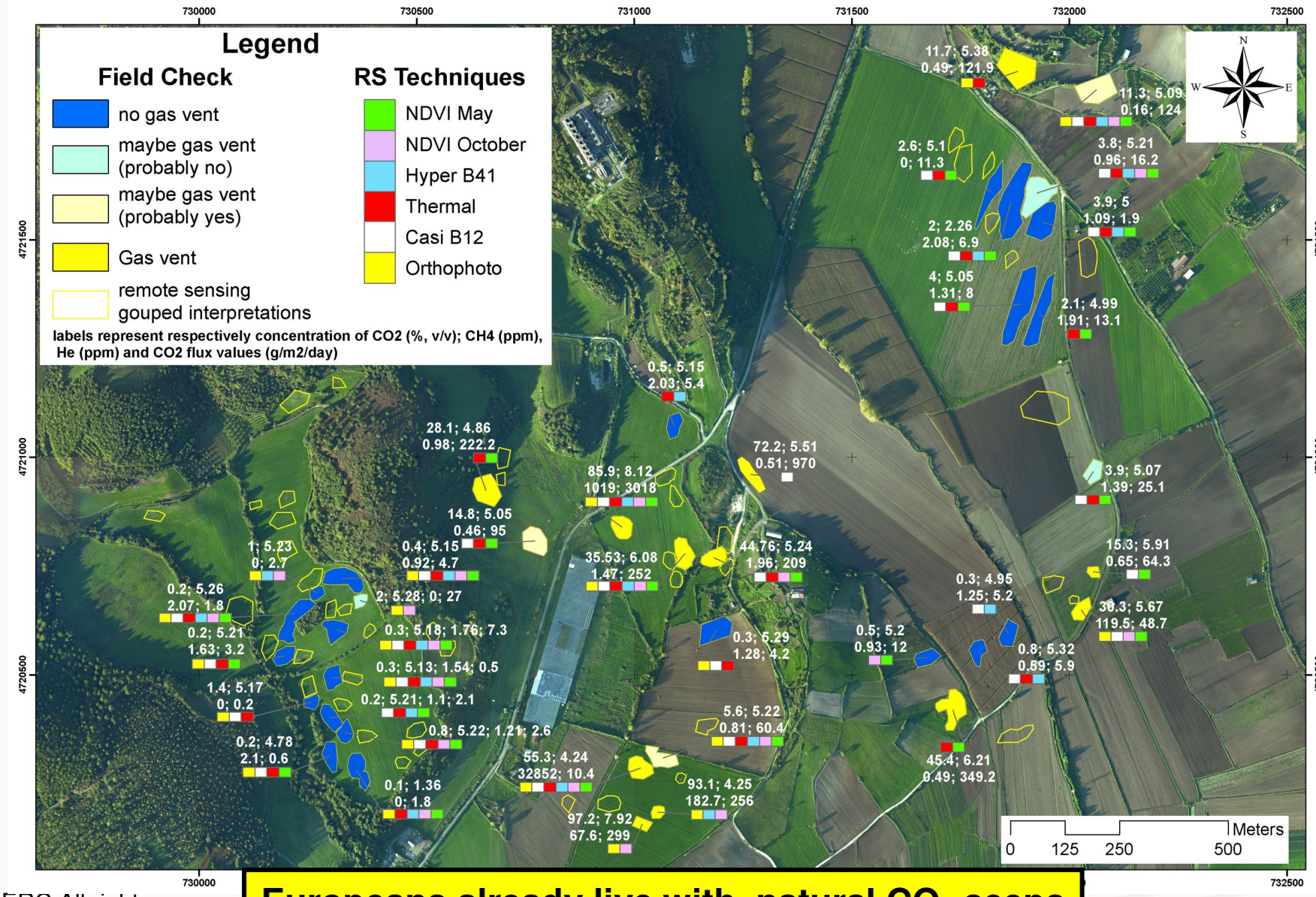
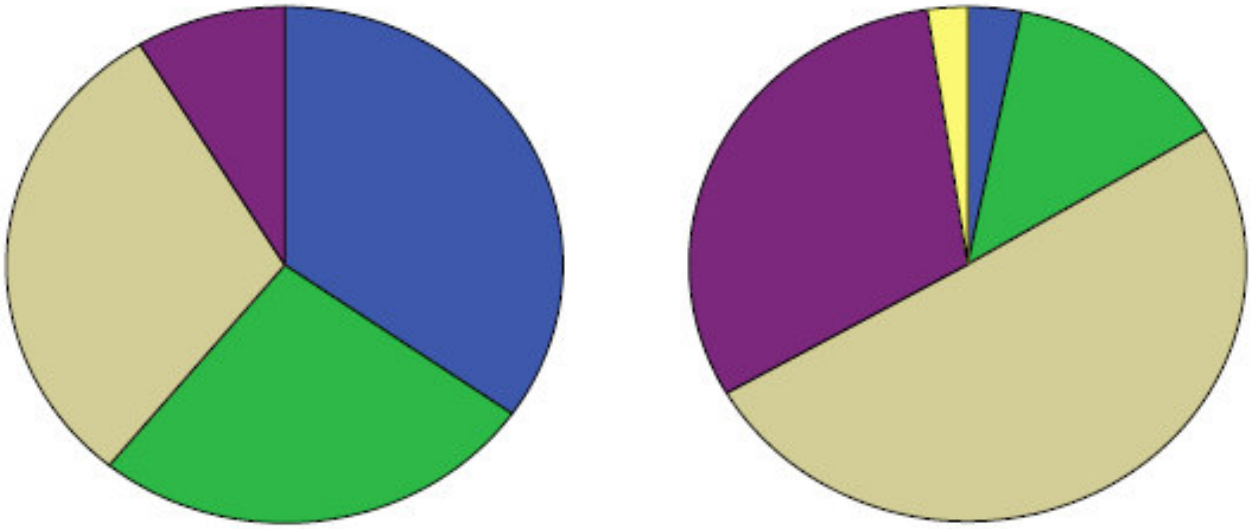


Europeans already live with natural CO_2 seeps

Perhaps this survey should have asked what global impacts would have happened without CCS?

Impacts arising from global impacts of leakage: NGOs (left), energy sector (right)

Sixth Framework Programme



Some European perceptions regarding leakage

DNV
Institute for European Environmental Policy
UNIVERSITY OF CAMBRIDGE
BAKER & MCKENZIE
Tyndall Centre for Climate Change Research
ECN

http://www.accsept.org/outputs/wp_5_2dec_2007_final.pdf

IPCC Special Report on CO_2 Capture & Storage (2005)

"Will physical leakage of stored CO_2 compromise CCS as a climate change mitigation option?

25. Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years."

http://www.ipcc.ch/

Table SPM.6. Characteristics of post-TAR stabilisation scenarios and resulting long-term equilibrium global average temperature and the sea level rise component from thermal expansion only. {Table 5.1}[a]

(IPCC 2007)

Category	CO_2 concentration at stabilization (2005 = 379 ppm) [b]	CO_2-equivalent Concentration at stabilization including GHGs and aerosols (2005 = 375 ppm) [b]	Peaking year for CO_2 emissions [a, c]	Change in global CO_2 emissions in 2050 (% of 2000 emissions) [a, c]	Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity [d, e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only [f]	Number of assessed scenarios
	ppm	ppm	Year	Percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

Meanwhile, whilst fossil fuels continue to be used CO_2 leaks to the sky at 100%
Concerns over potential leakage from storage need to be put in context!
You may ask: *what if CCS leaks?* I ask: *what will happen if we do not urgently deploy CCS?*

http://www.ipcc.ch/

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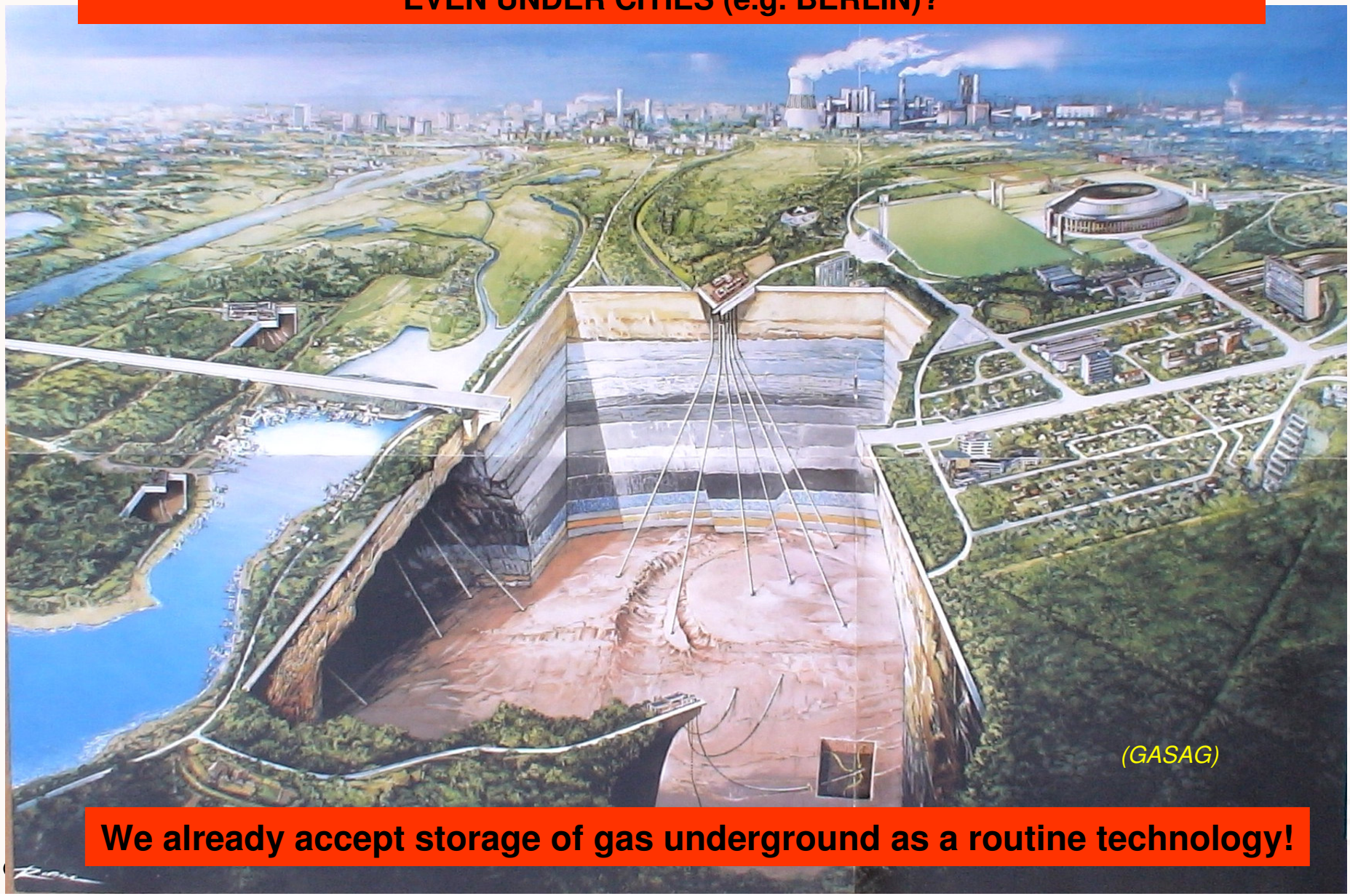
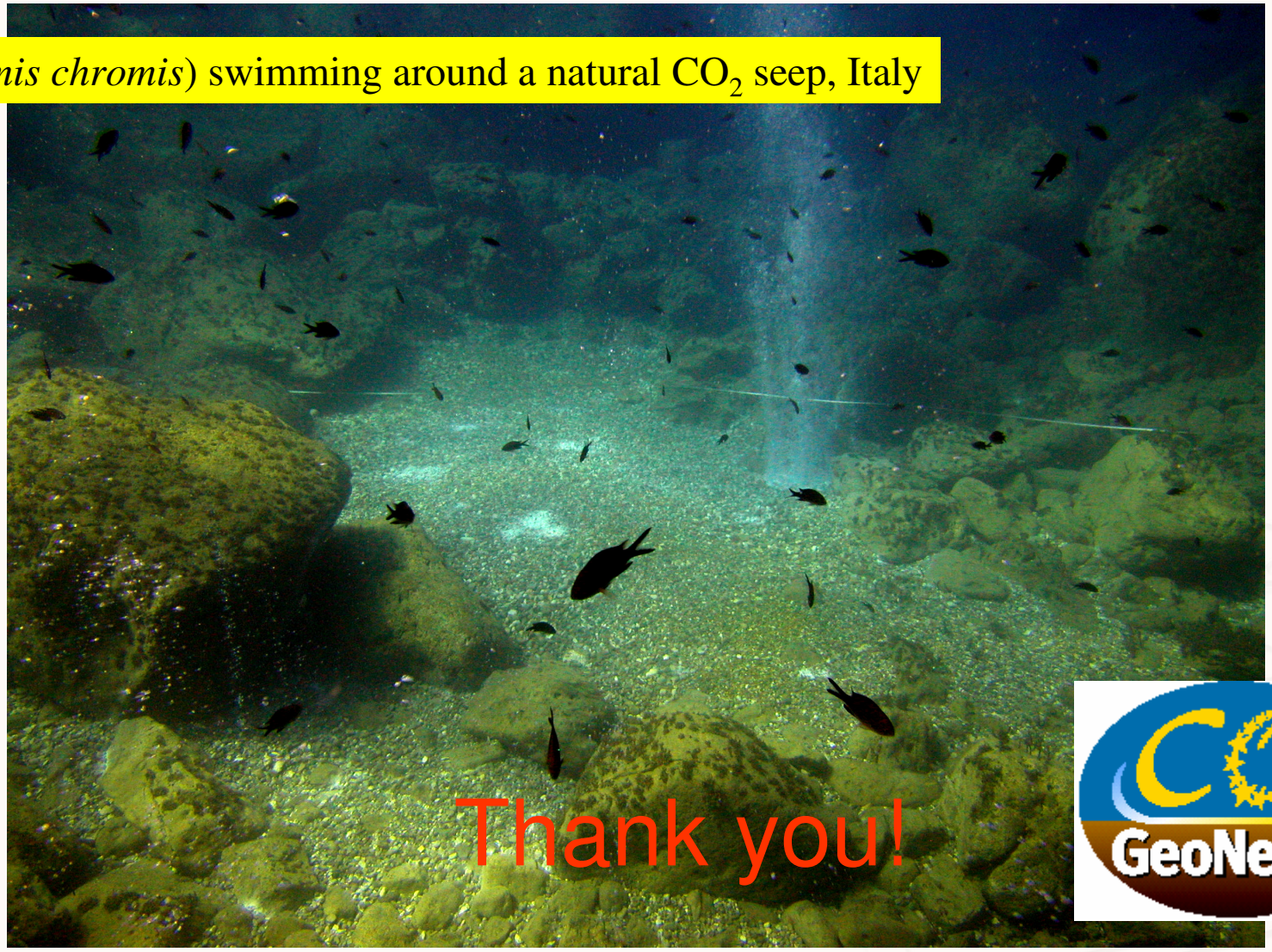
DID YOU KNOW THAT NATURAL GAS IS STORED UNDEGROUND IN EUROPE, EVEN UNDER CITIES (e.g. BERLIN)?



(GASAG)

We already accept storage of gas underground as a routine technology!

Fish (*Chromis chromis*) swimming around a natural CO_2 seep, Italy



(Giorgio Caramanna University of Rome La Sapienza)