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CROSS-BORDER COLLABORATION

ESSENTIAL FOR GEOLOGICAL SUCCESS IN THE BALTIC SEA REGION

Richard Vernon

22nd April 2015

SLR CONSULTING

- Independent energy and environmental consultancy
- Over 1100 employees
- Turnover £100 million
  - Multidisciplinary advice from in-house experts on strategic and site specific issues
  - Diverse and growing client base
- Over 70 Offices in UK, Ireland, USA, Canada, Africa , Australasia and southern Africa.





SLR AND CCS

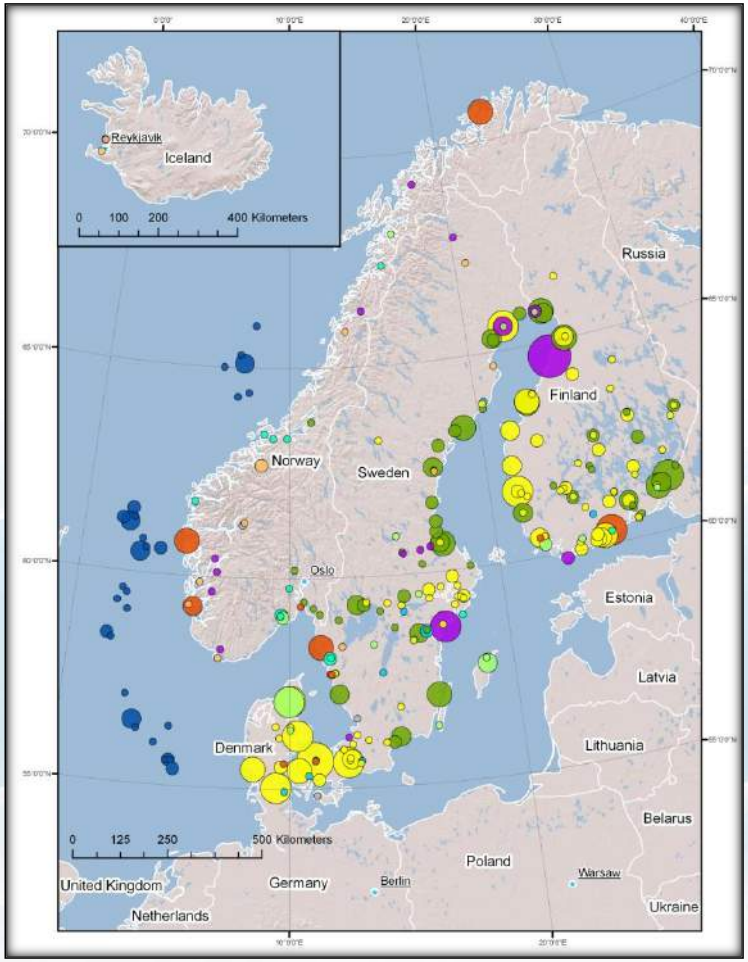
- Active CCS practice based in UK and Ireland
- Draw on technical expertise from SLR around the world
- Focus on transport and storage
- Projects around the world
  - Recent major examples in Nova Scotia, South Africa and the Baltic Sea

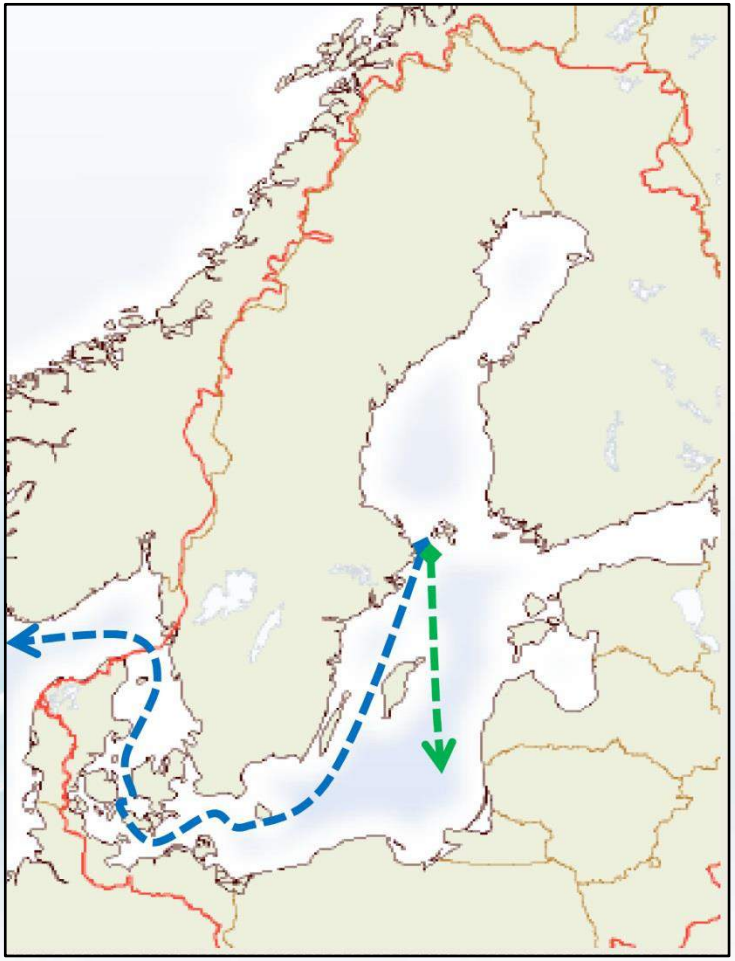
THE BASTOR PROJECT

- BASTOR I funded by Finland
  - CLEAN Programme managed by VTT, with financial support from Fortum Oyj, Helsingin Energia, Neste Oil Oyj, Ruukki Metals Oy, and Tekes – the Finnish Funding Agency for Technology and Innovation

- BASTOR II funded by Sweden
  - Swedish Energy Agency and GCCSI managed by Elforsk, with financial support from SSAB, Jernkontoret, Svenska Petroleum Exploration, Cementa, Nordkalk, SMA Mineral, Minfo, Vattenfall, Fortum and Preem

THE CONTEXT

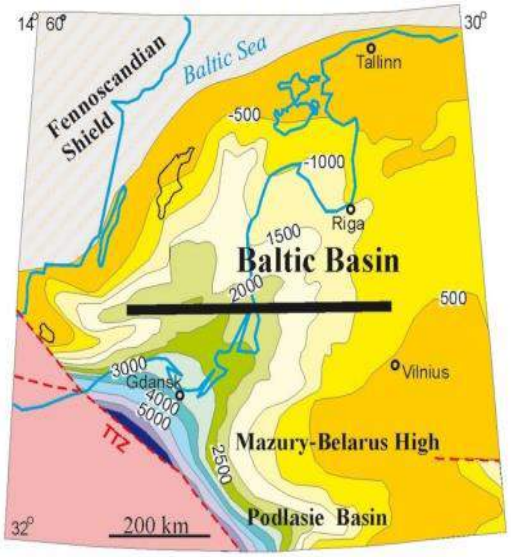

Reykjavik
Iceland
0 100 200 400 Kilometers
Russia
Finland
Norway
Sweden
Oslo
Estonia
Latvia
Lithuania
Denmark
Belarus
0 125 250 500 Kilometers
Poland
Warsaw
United Kingdom
Germany
Berlin
Netherlands
Ukraine



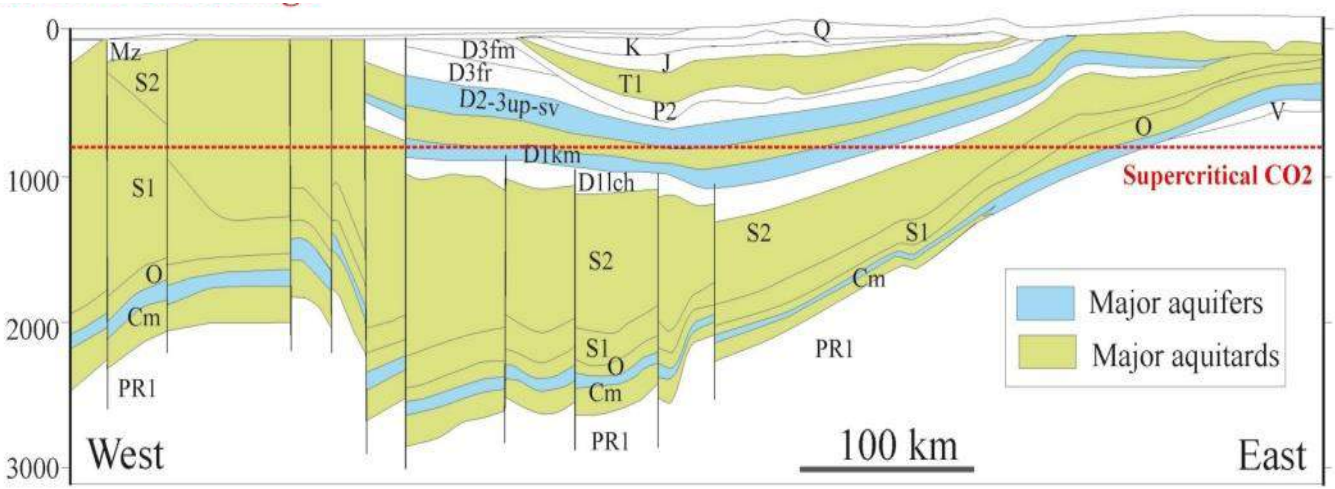
THE STUDY AREA

- The study area is defined as previously mapped Palaeozoic sedimentary basins in the Baltic Sea Area
- Cambrian reservoirs deeper than 800m below seabed are the best storage sites
- Some potential in depleted oil and gas fields
- Saline aquifers in border monoclines have significant storage capacity

Source: after Sliaupa S., 2009

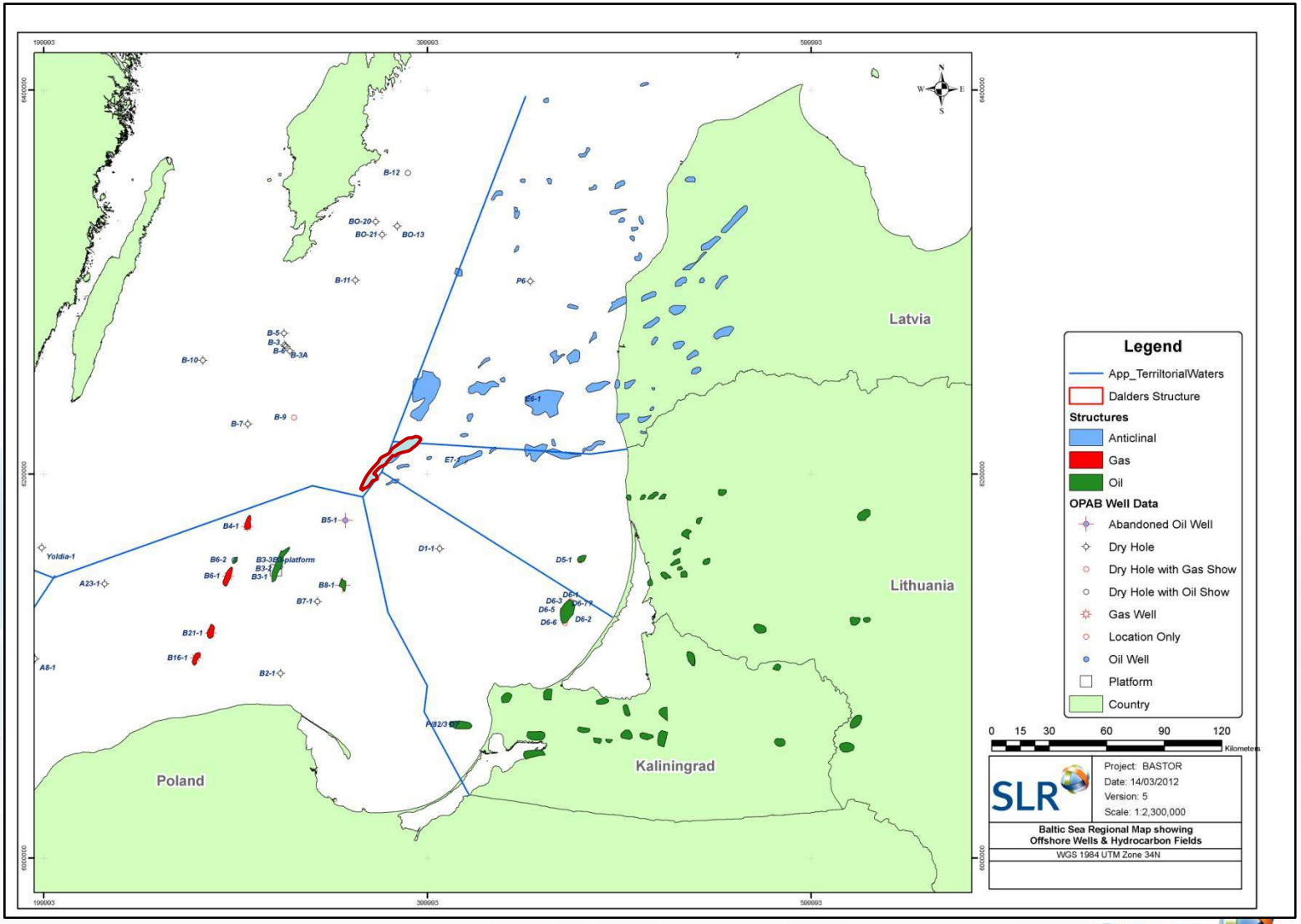


Depths of base of the Baltic Basin

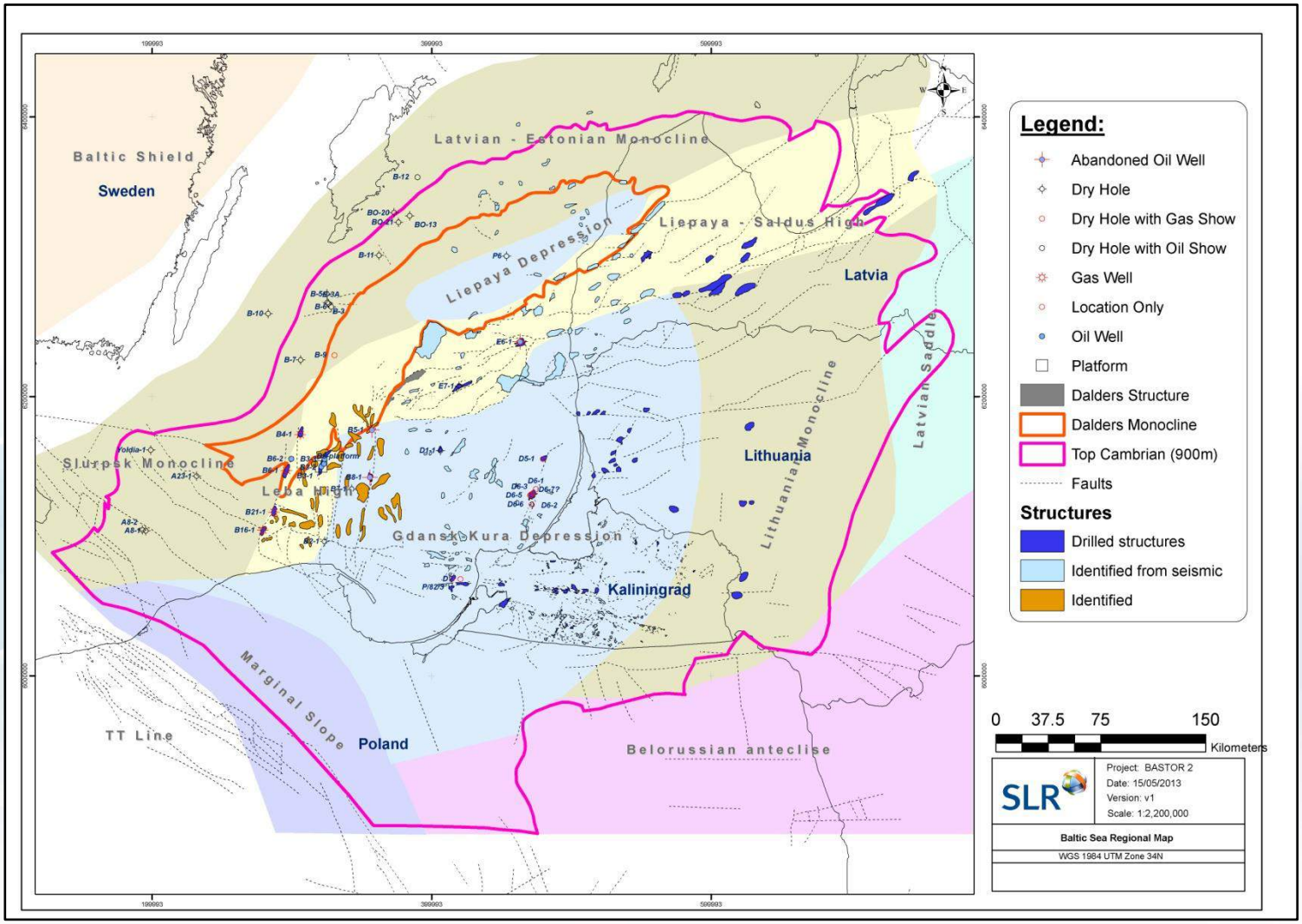


Geological cross section west-east

THE DATA BASE



REGIONAL MAP OF SEDIMENTARY BASINS WITH CO_2 STORAGE POTENTIAL



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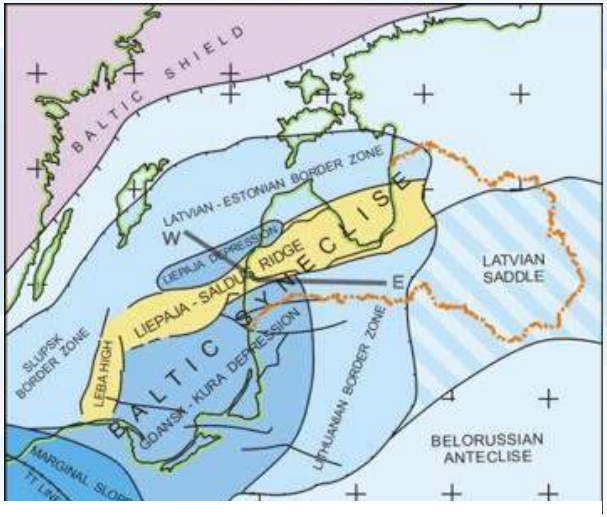
RANKING OF BALTIC SEA SUB BASINS FOR CO2 STORAGE

Rank	Basin	Characteristics	Score
1	Slupsk Border Zone	Proven reservoir/seal pair, moderate size structures, offshore, large saline aquifer, limited faulting, good accessibility, <500kms to strategic CO_2 sources	0.76
2	Gdansk-Kura Depression	Existing oil and gas production infrastructure, moderate sized structures, offshore, fair accessibility, >500kms to some strategic CO_2 sources	0.75
3	Liepaja Saldus Ridge	Proven reservoir/seal pair, moderate size structures, offshore, fair accessibility, <500kms to strategic CO_2 sources	0.75
4	Latvian Estonian Lithuanian Border Zone	Proven reservoir/seal pairs, small structures, potential saline aquifer, only small area sufficiently deep for CO_2 storage, accessible, 250kms to strategic CO_2 sources	0.71



- Four main sub basins identified and ranked in order of suitability for CO2 storage
- The border zones have potential storage capacity in saline aquifers
- Existing oil and gas fields have some storage capacity (e.g. Lotos refinery in Gdansk and B3 Field offshore Poland)

BASTOR 2 STORAGE CAPACITY

Following the ranking of the Baltic Sea sub-basins, storage capacity calculations have been completed using the GeoCapacity (2009) methodology.

Table 17 Theoretical Storage Capacity Summary

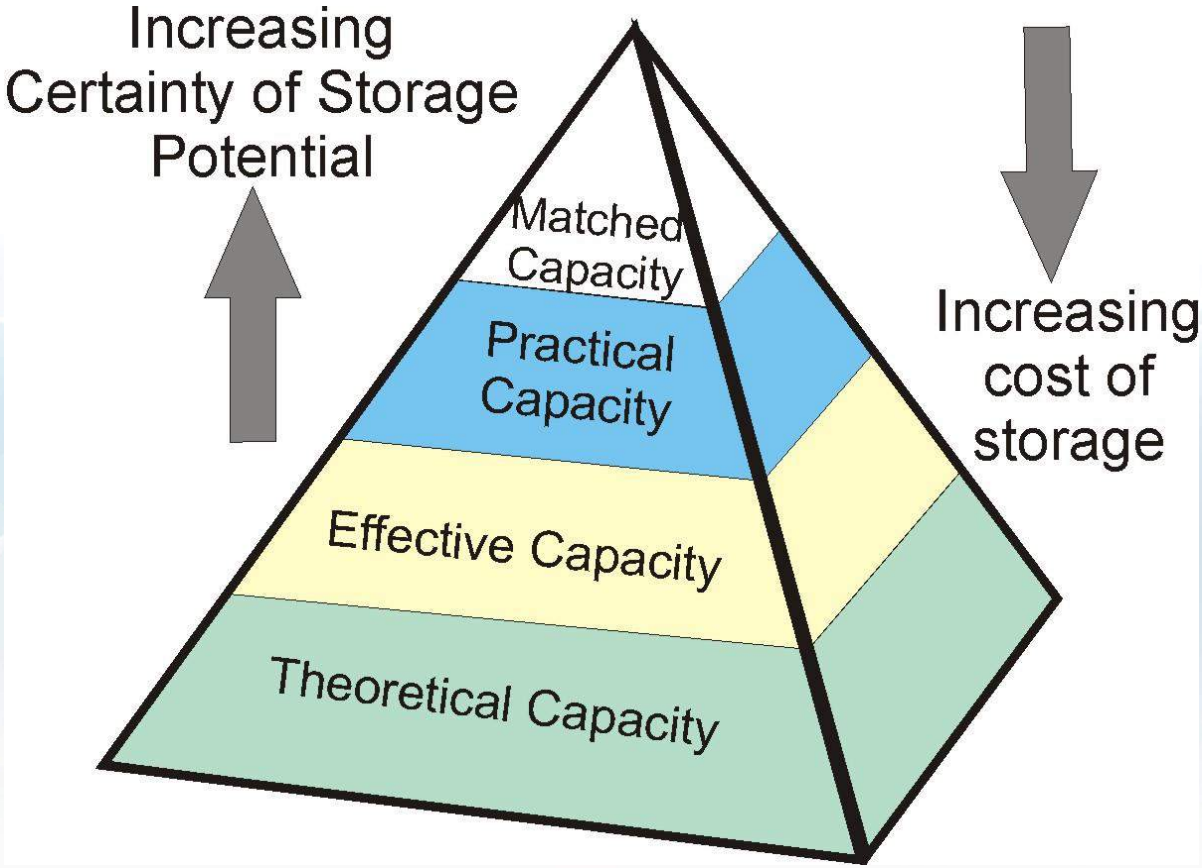
	Estimated CO_2 Storage Capacity (10^6 tonnes)
Regional Cambrian Below 900m	16,222
of which Dalders Monocline	1,924
Individual Baltic Sea Field Total	743
Dalders Structure	128

ONSHORE STORAGE CAPACITY

Table 18 Proportion of onshore CO_2 storage capacity

	Estimated CO_2 Storage Capacity (10^6 tonnes)	Estimated CO_2 Storage Capacity onshore (10^6 tonnes)	Percentage of the overall CO_2 storage capacity
		-	-
Regional Cambrian Below 900m	16,222	9151	56
of which Dalders Monocline	1,924	157	8
of which Dalders Structure	128	0	0
Individual Baltic Sea Field Total	743	88	12
of which in Poland	6	0	0
of which in Latvia	633	0	0
of which in Lithuania	31	31	100
of which in Kaliningrad	73	57	78

TECHNO ECONOMIC RESOURCE PYRAMID (CSLF 2007)



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DYNAMIC MODELING METHODOLOGY

- Approaches used
  - Analytical and semi-analytical for pressure evolution, estimation of the optimal number of wells in various conditions
  - Simulation of plume and pressure evolution using two approaches: TOUGH2/MP & Vertical Equilibrium Approach (Gasda *et al.*, 2009)
  - Evaluation of plume tip advancement after completion of injection phase (TOUGH2 & Analytical solution)

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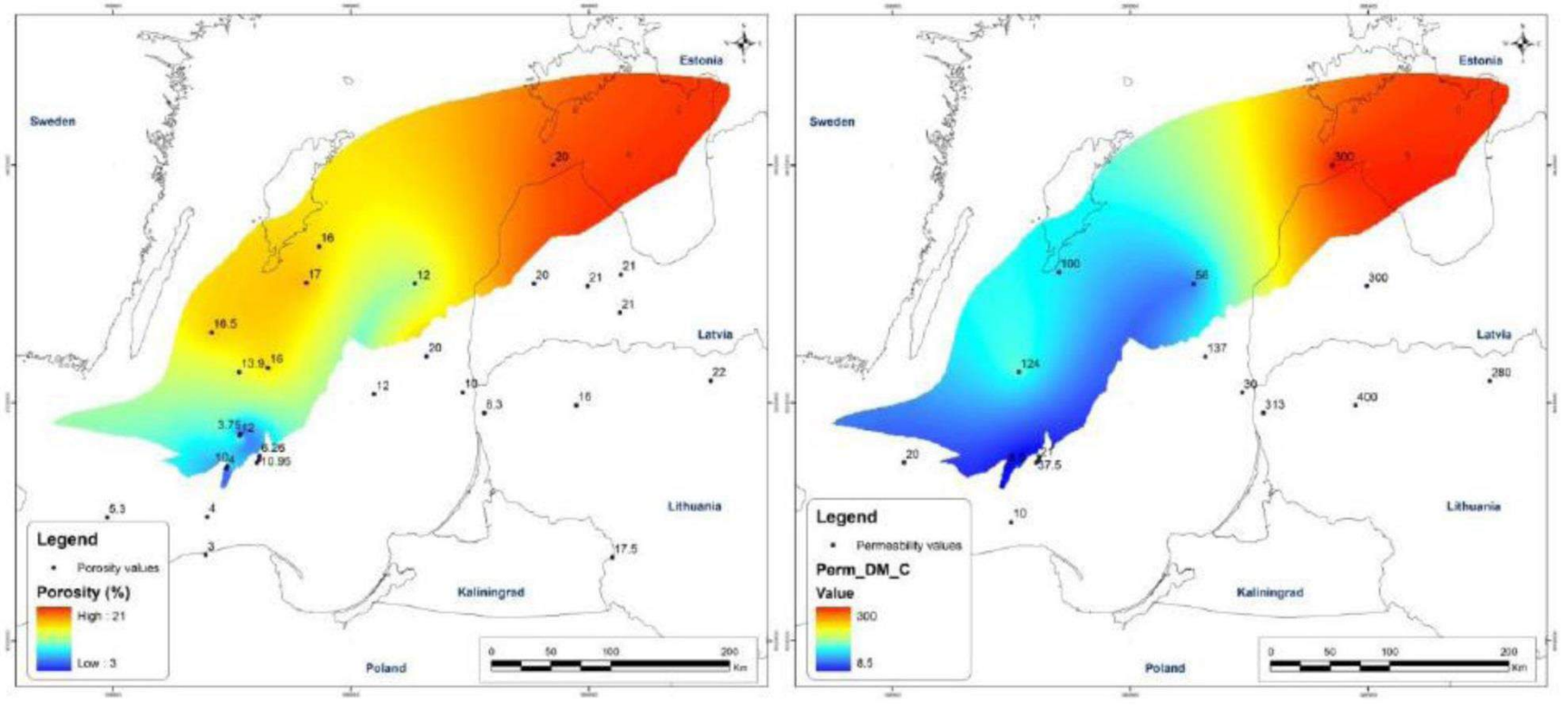
POROSITY AND PERMEABILITY OF DALDERS MONOCLINE



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CONCLUSIONS

- There is large theoretical storage capacity in the Baltic Sea basin beneath a 900 metre thick impermeable caprock.
- The maximum injection rate is sensitive to parameters such as formation thickness and permeability, and analyzing the effect of their local variability fully does require more detailed modelling than was possible in this preliminary study
- The southern Swedish sector, where dynamic modelling was undertaken by Uppsala University, could be suitable as a storage site for CO_2 captured from a limited number of industrial facilities
- The reservoir quality in the presently modelled area is not suitable to high injection rates and therefore not sufficient for commercial CO2 storage at the scale of projected emissions around the Baltic Sea.
- There are sweet spots in the Cambrian reservoir such as onshore Latvia, where there is commercial gas storage, and both onshore and offshore Kaliningrad, where there in ongoing hydrocarbon production

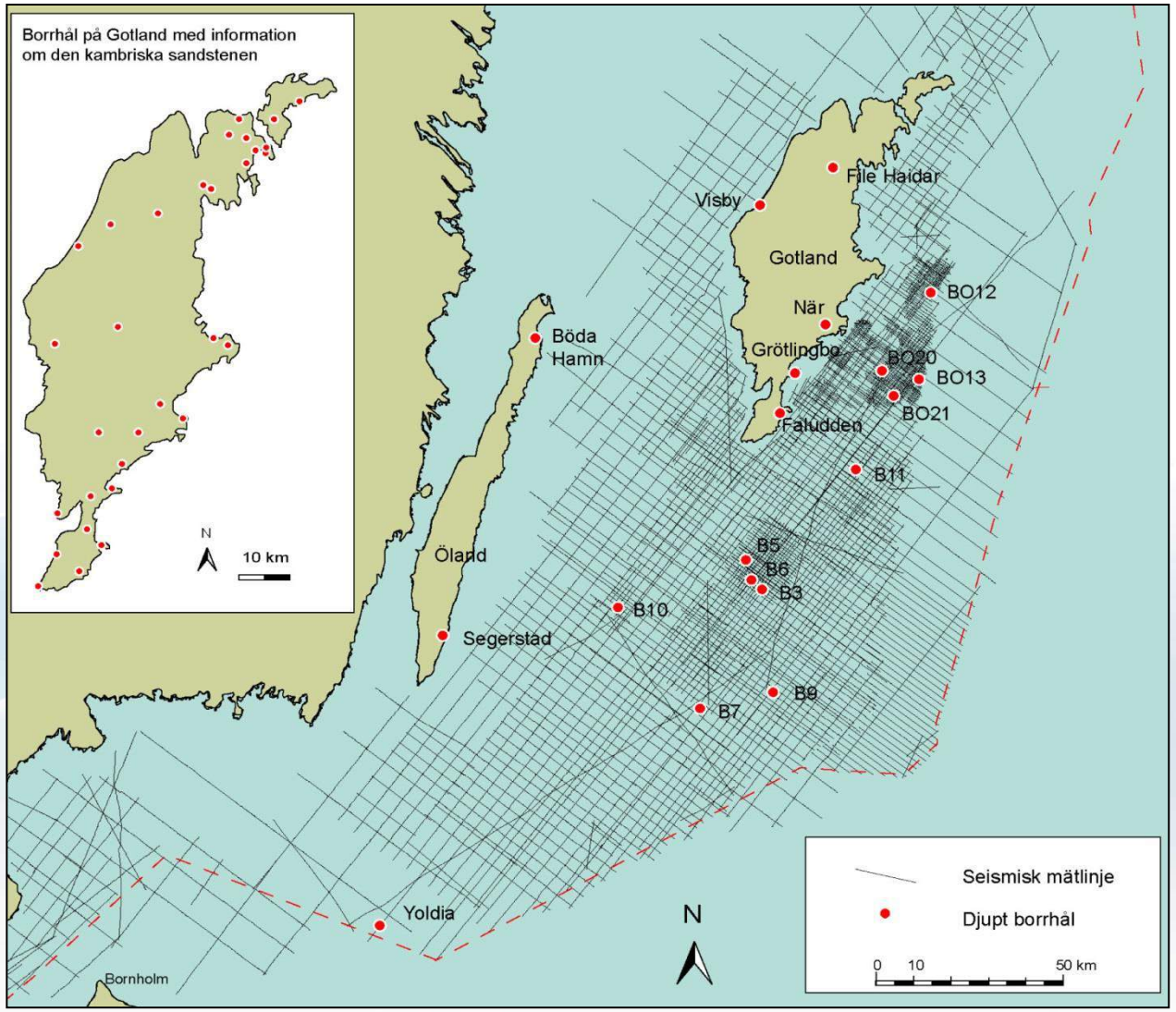
.

- ***Acquisition of further data will require much more regional cooperation***

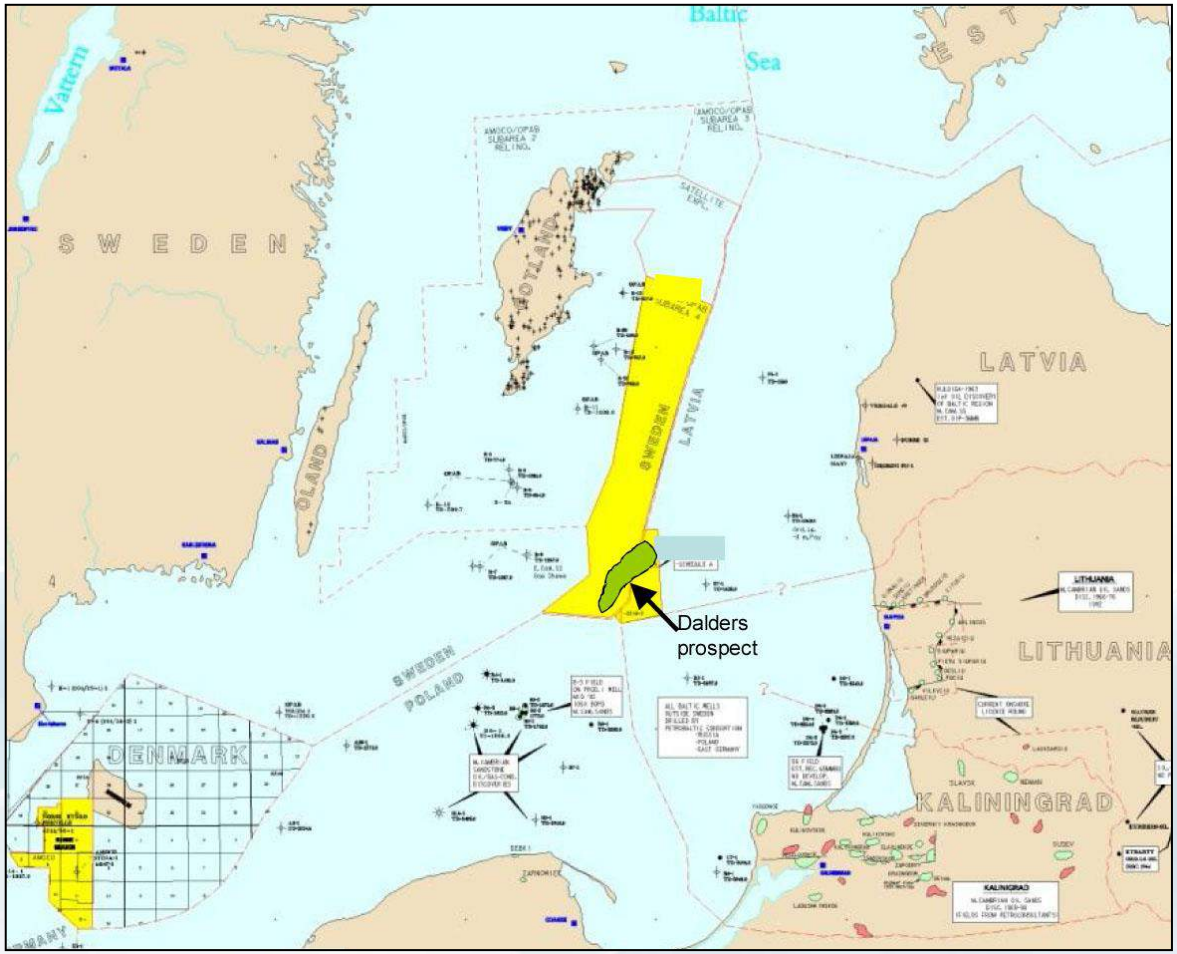
ACQUISITION OF FURTHER DATA WILL REQUIRE MUCH MORE REGIONAL COOPERATION

- The best data resides in the hydrocarbon exploration and production industry
- There are four countries neighbouring the Baltic Sea where most of the effort has been undertaken in the recent past
  - Sweden
  - Poland
  - Latvia
  - Russia (Kaliningrad)
- These will be reviewed briefly and the potential for cooperation discussed

SWEDEN


Borrhål på Gotland med information om den kambriska sandstenen
N
10 km
Visby
File Haidar
Gotland
BO12
När
Böda Hamn
Grötlingbo
BO20
BO13
BO21
Faludden
B11
Öland
B5
B6
B3
B10
Segerstad
B9
B7
Yoldia
Bornholm
N
Seismisk mätlinje
Djupt borrhål
0 10 50 km

SWEDEN



SVENSKA PETROLEUM EXPLORATION

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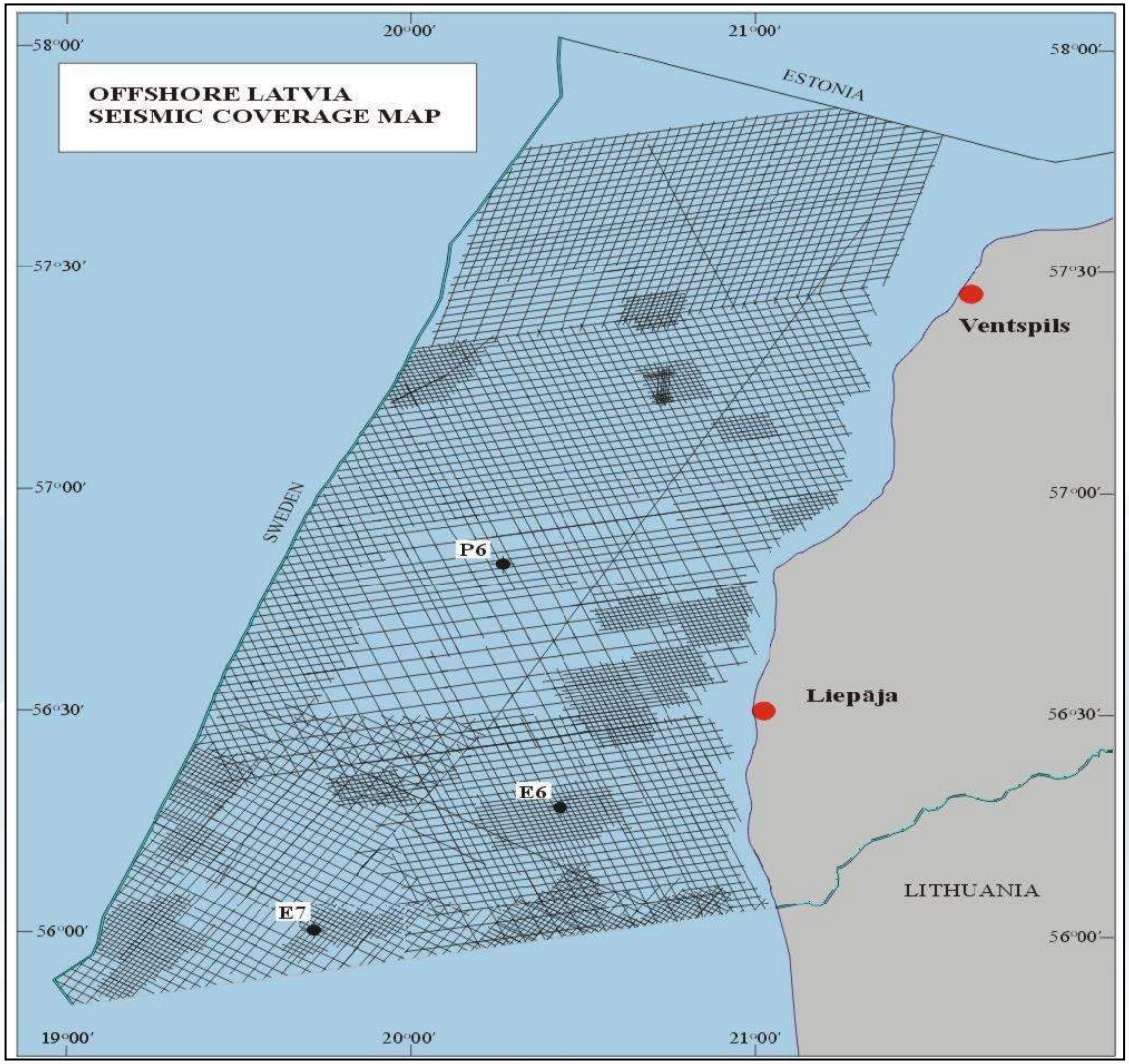
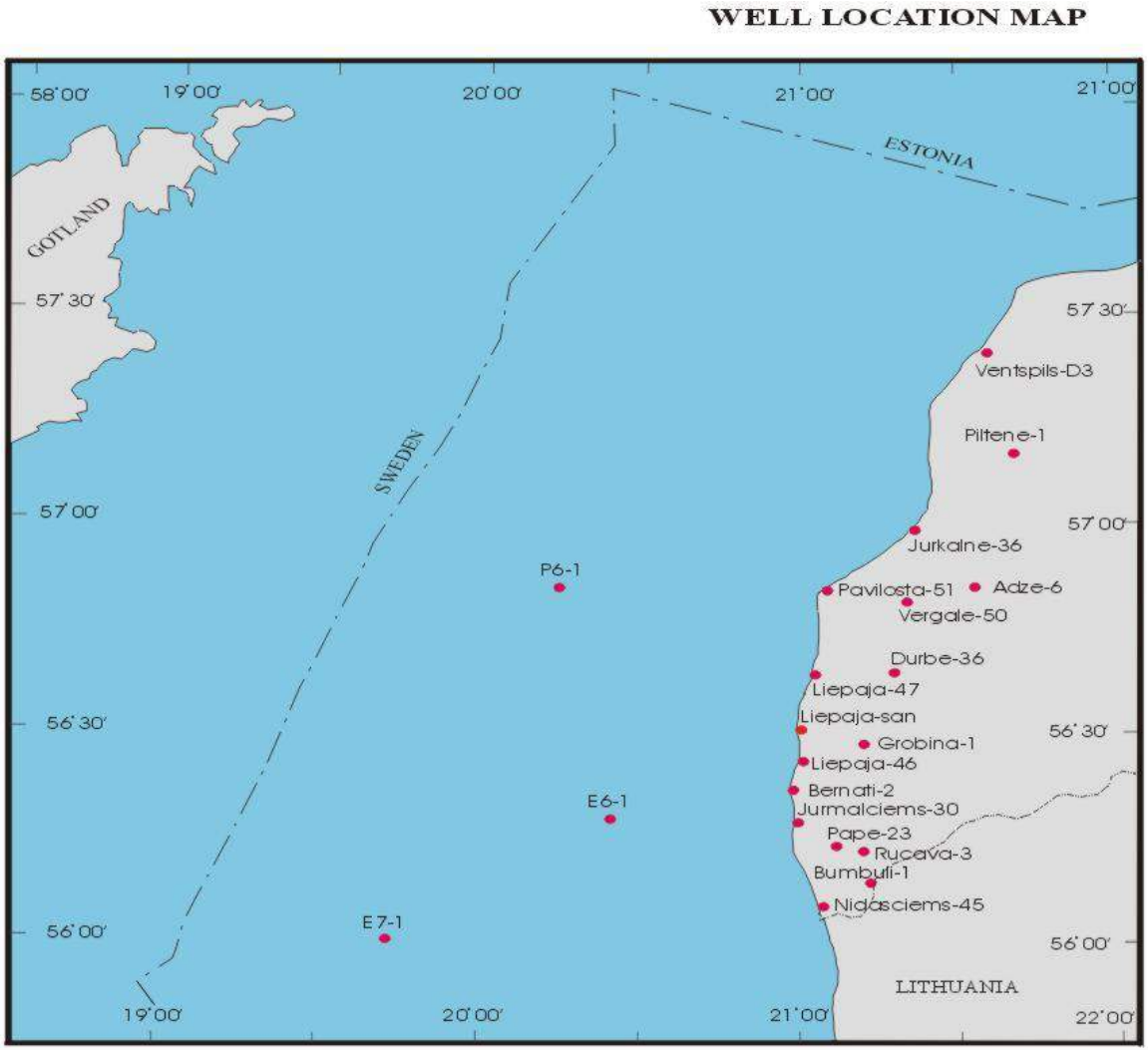
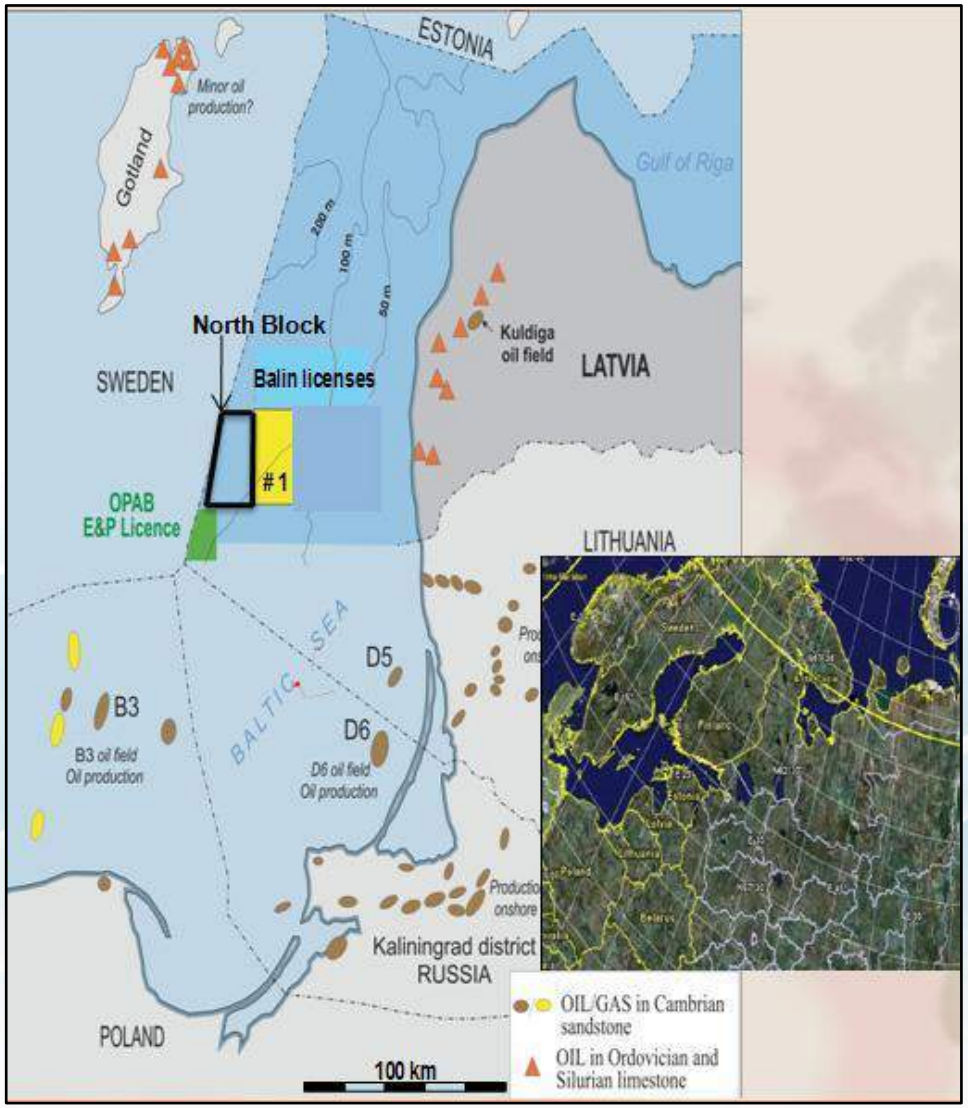
LATVIA


OFFSHORE LATVIA
SEISMIC COVERAGE MAP
58°00′
20°00′
21°00′
ESTONIA
57°30′
Ventspils
57°00′
SWEDEN
P6
Liepāja
56°30′
E6
LITHUANIA
E7
56°00′
19°00′

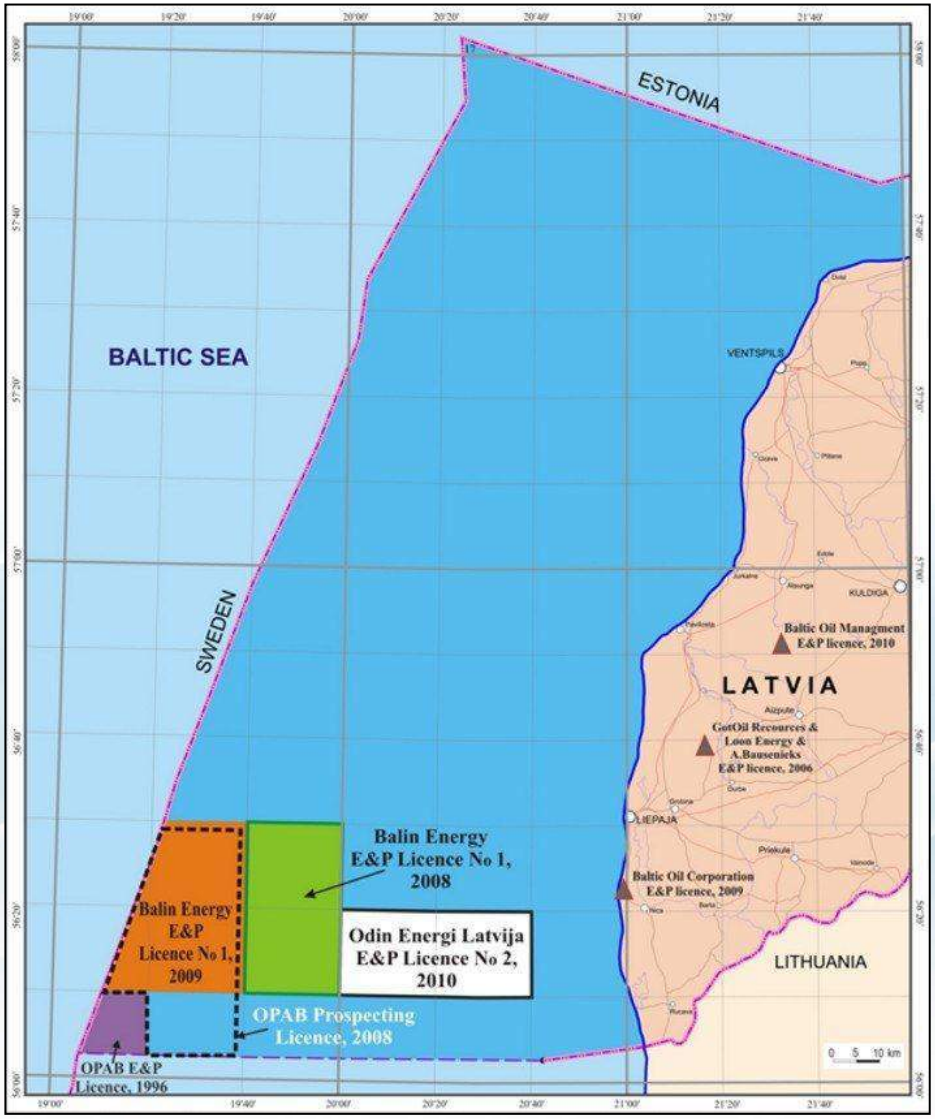
LATVIA

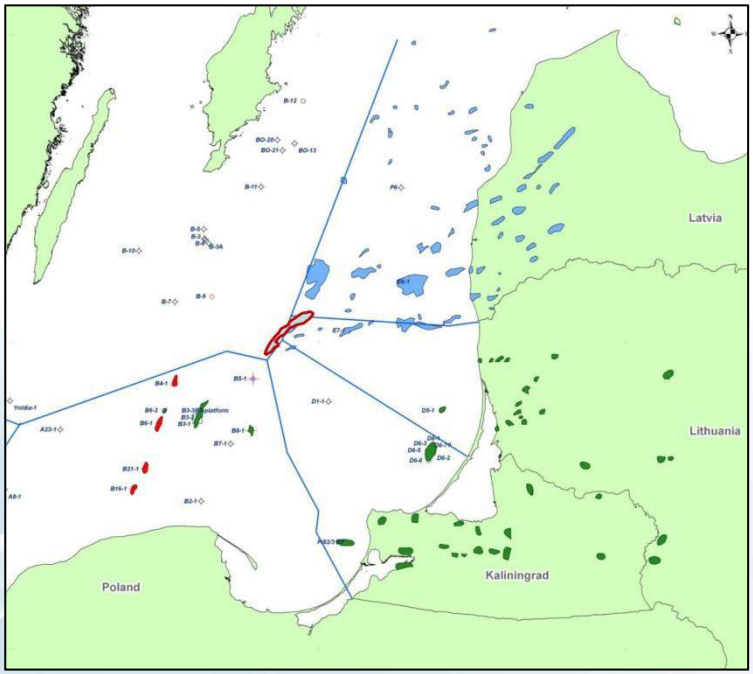

WELL LOCATION MAP
58°00′
19°00′
20°00′
21°00′
21°00′
ESTONIA
GOTLAND
57°30′
57°30′
Ventspils-D3
Piltene-1
SWEDEN
57°00′
57°00′
Jurkalne-36
P6-1
Pavilosta-51
Adze-6
Vergale-50
Durbe-36
Liepaja-47
Liepaja-san
56°30′
56°30′
Grobina-1
Liepaja-46
Bernati-2
E6-1
Jurmalciems-30
Pape-23
Rucava-3
Bumbuli-1
Nidasciems-45
E7-1
56°00′
56°00′
LITHUANIA
19°00′
20°00′
21°00′
22°00′

LATVIA – BALIN ENERGY 2013



LATVIA – SVENSKA PETROLEUM/OPAB





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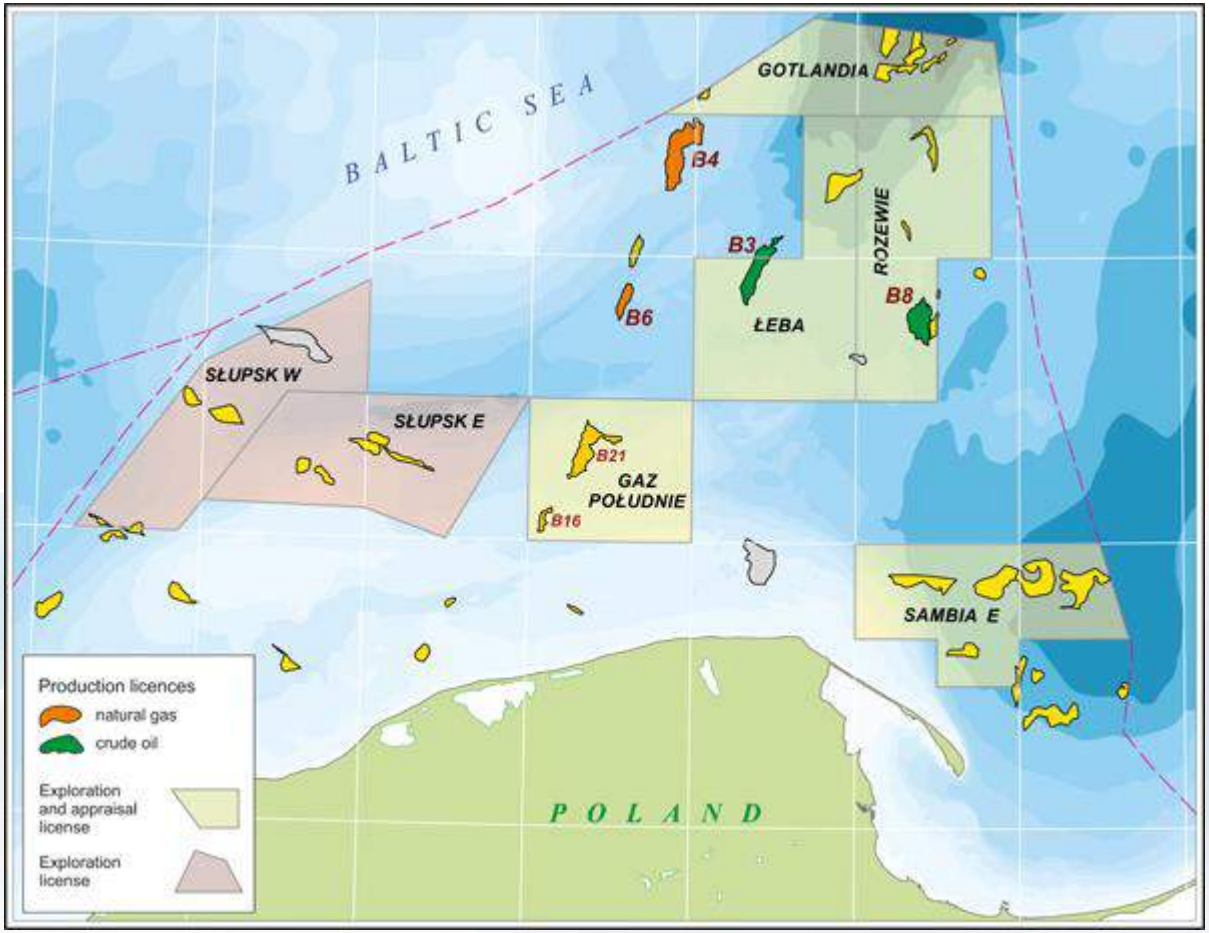
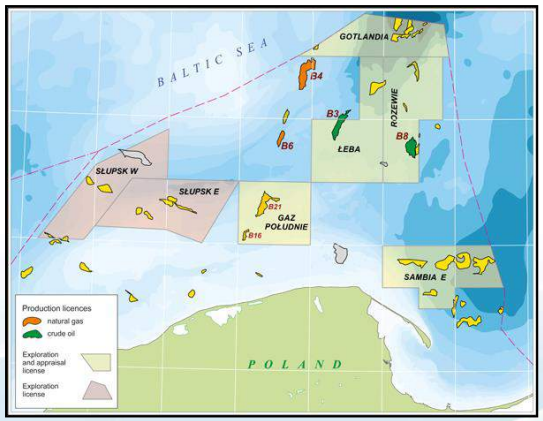
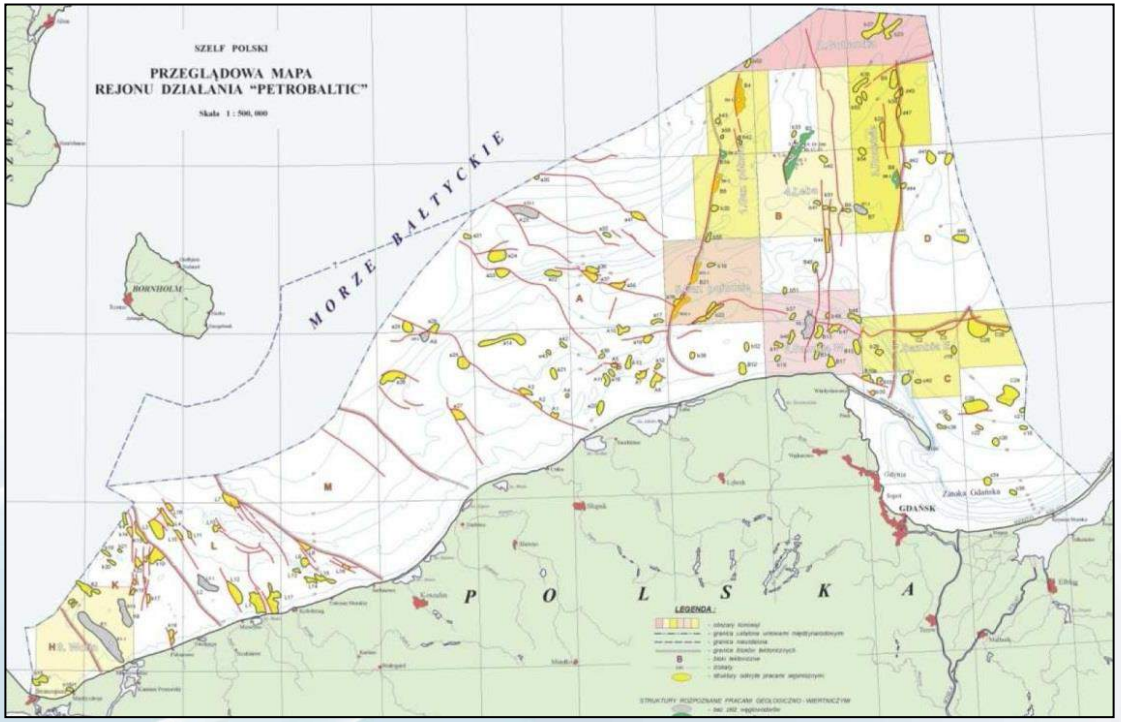
POLAND


BALTIC SEA
GOTLANDIA
B4
B3
B6
ŁEBA
ROZEWIE
B8
SŁUPSK W
SŁUPSK E
B21
GAZ
POŁUDNIE
B16
SAMBIA E
POLAND
Production licences
natural gas
crude oil
Exploration and appraisal license
Exploration license

POLAND – LOTOS PETROBALTIC LICENSES





LOTOS

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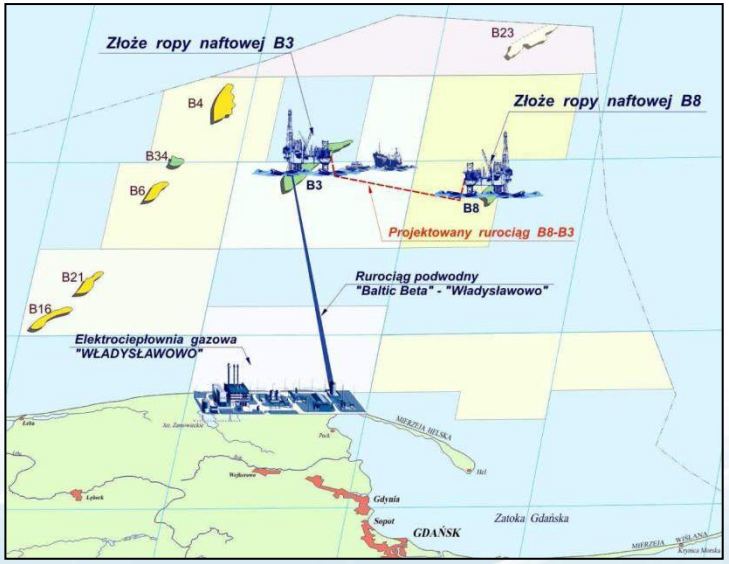
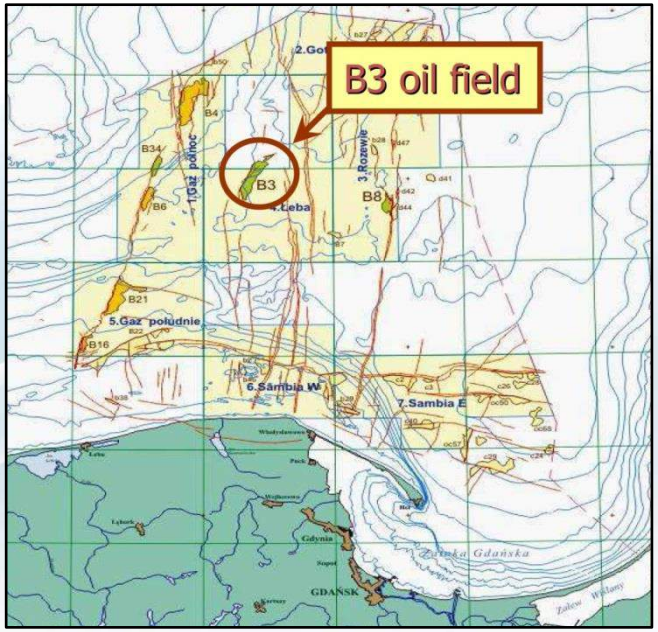
POLAND – POTENTIAL CCS PROJECT





LOTOS

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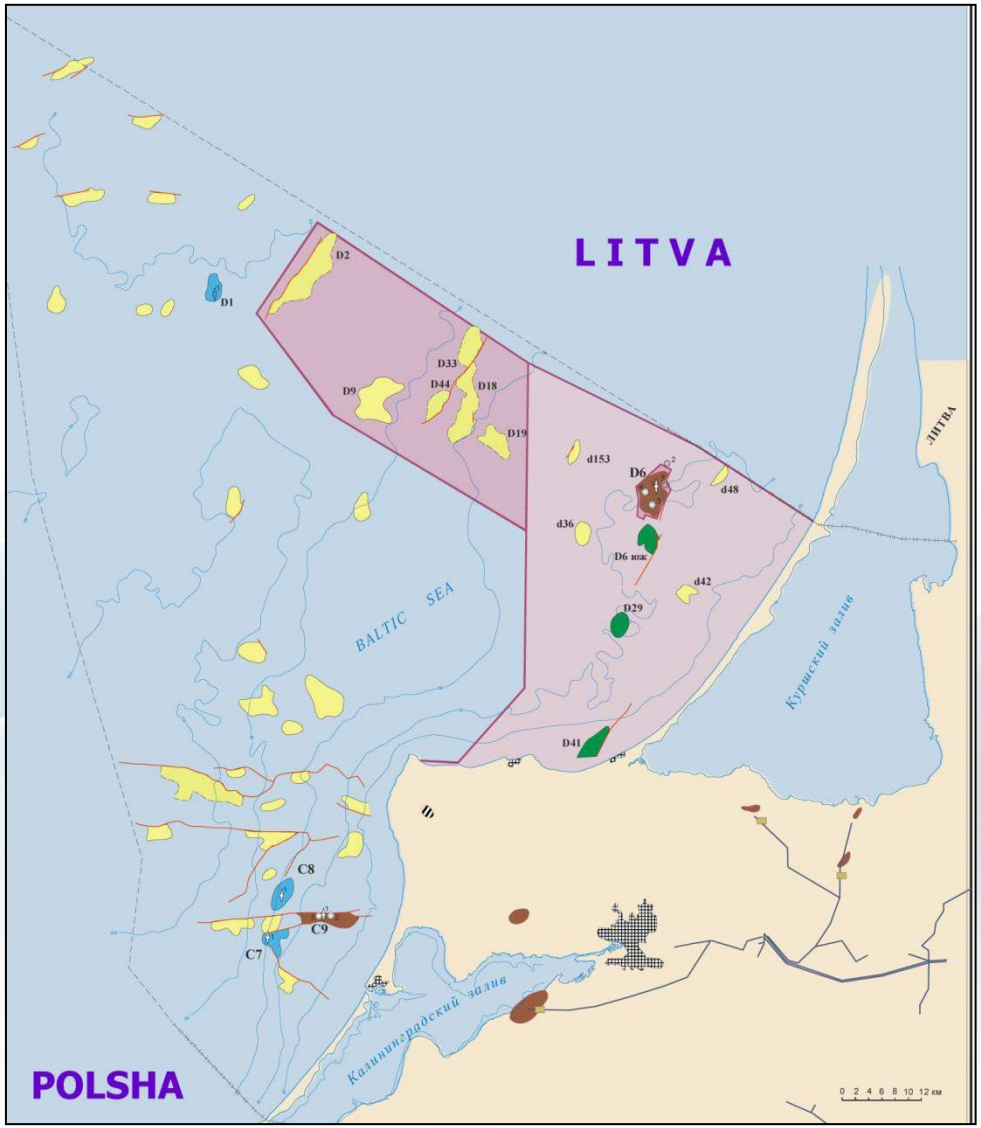
RUSSIA/KALININGRAD



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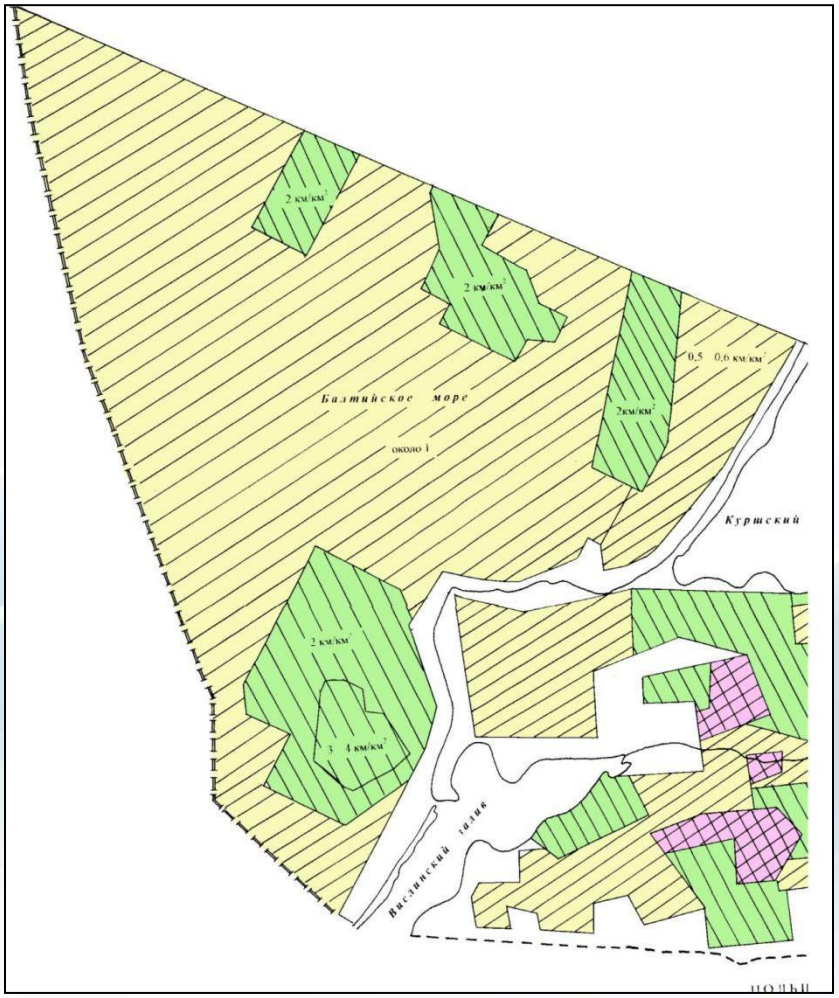
KALININGRAD – KRAVTSOVSKOYE OILFIELD

LUKOIL

KALININGRAD – SEISMIC TO 2006



LUKOIL

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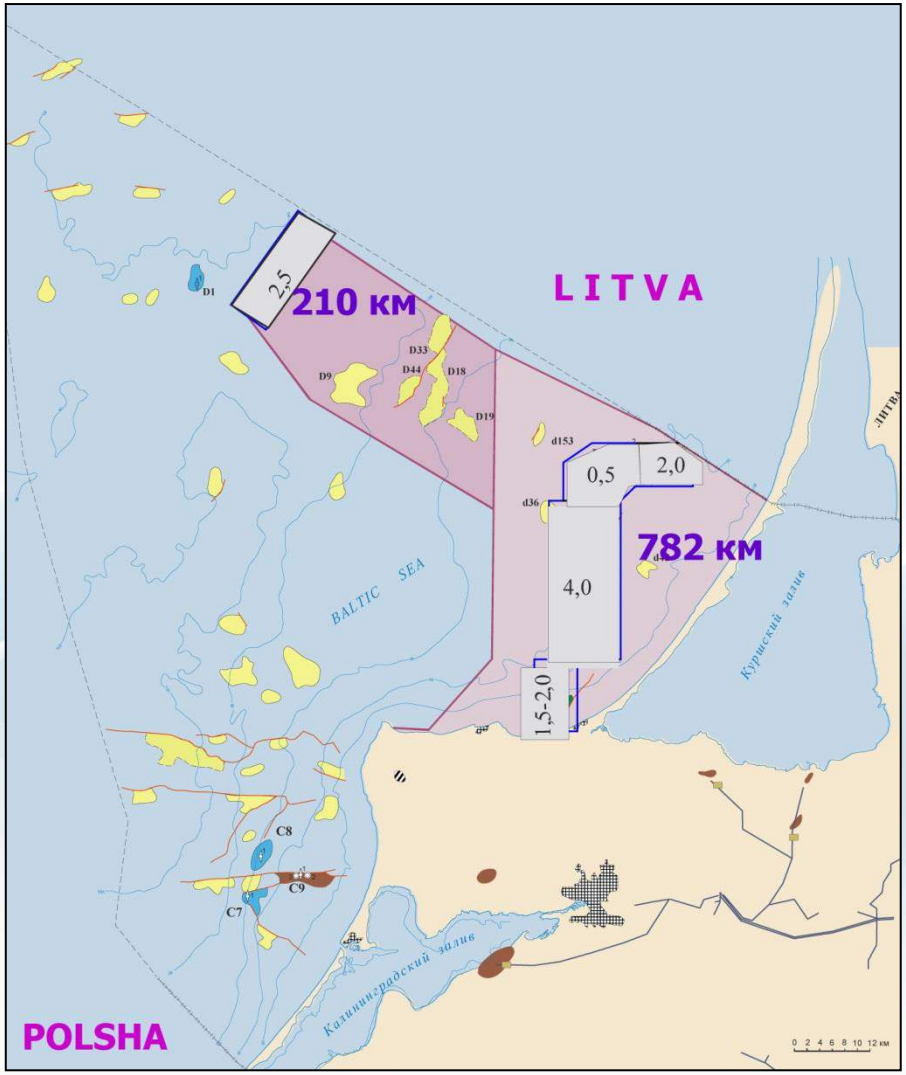
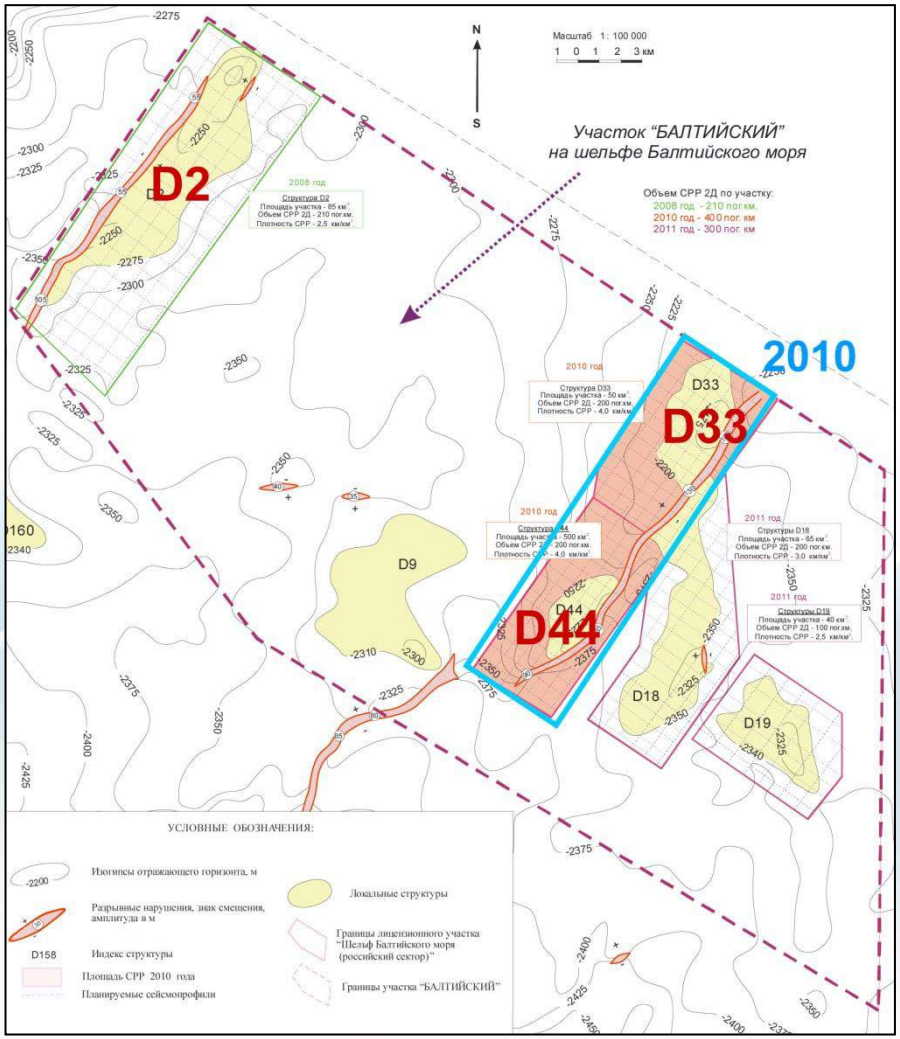
KALININGRAD – SEISMIC 2006-2008



KALININGRAD – SEISMIC 2010



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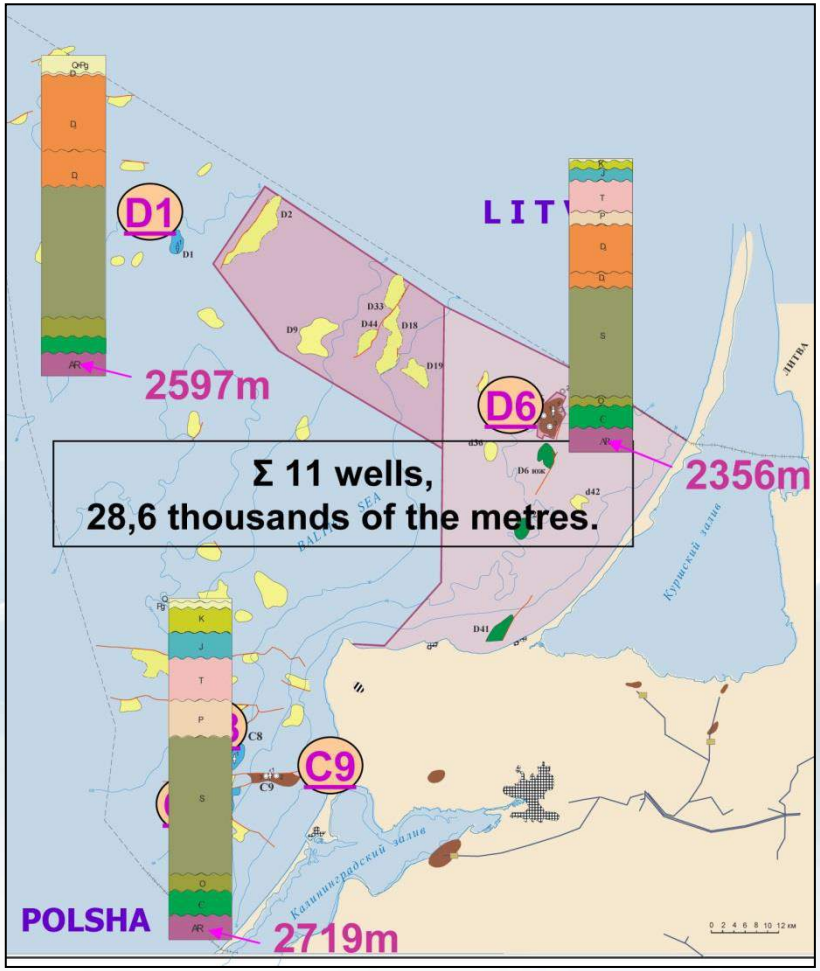
KALININGRAD – EXPLORATION WELLS



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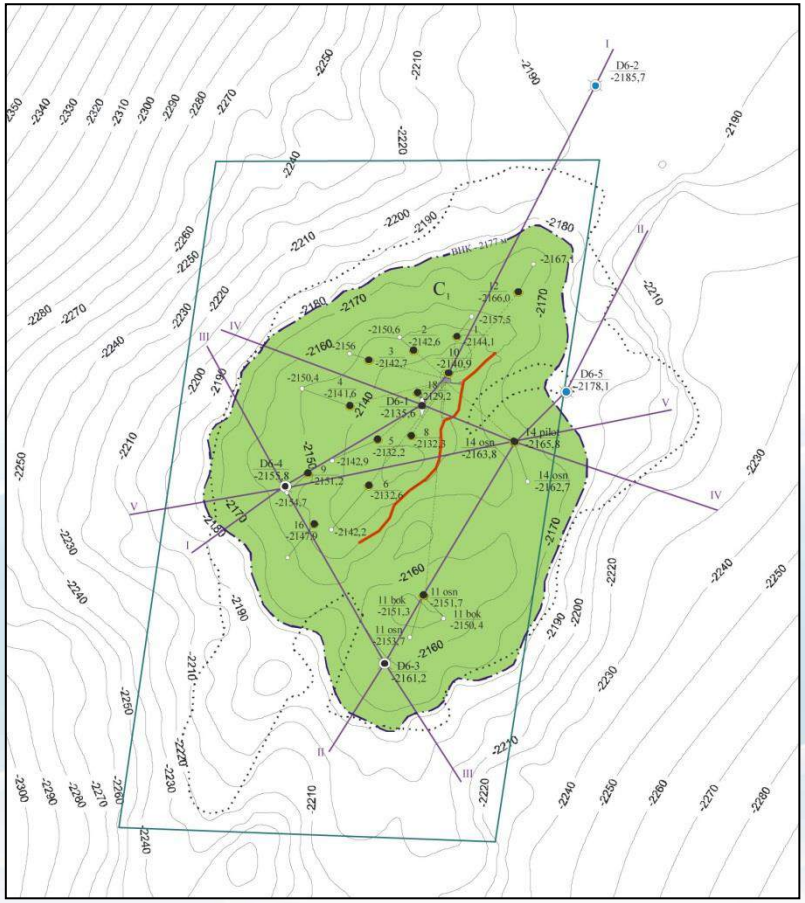
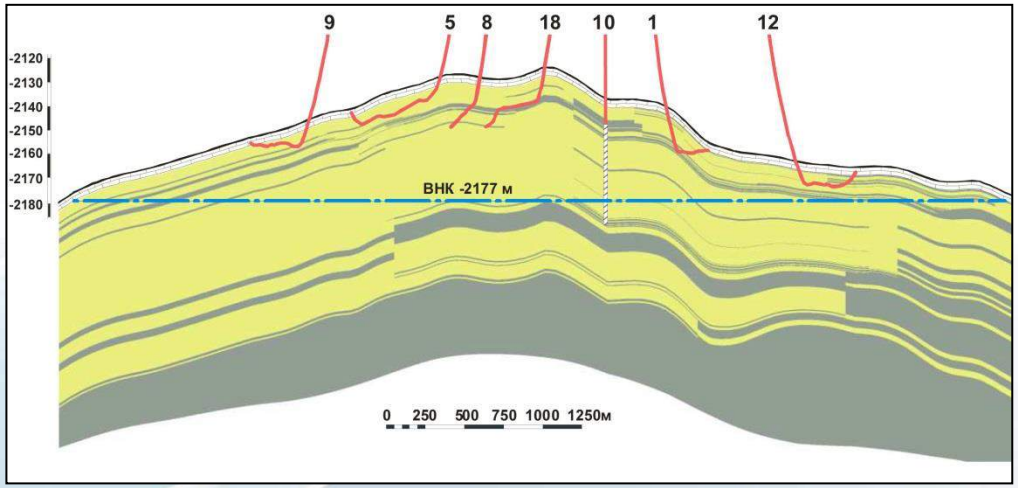
KALININGRAD – KRAVTSOVSKOYE OILFIELD





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RECOMMENDATIONS – BASTOR II

- Existing seismic line data should be calibrated to available well data and reinterpreted to identify fault structures and map reservoir porosity and permeability variations
- Improved estimates of seal fracture pressures based on well leak off test data and core sample analyses are needed
- New seismic and well data is required, in particular in the north east of the Dalders Monocline, including offshore Latvia, where this study has indicated better reservoir qualities exist than in the current study area
- Reservoir formation data from core samples and wire line logs should be obtained from any newly drilled wells to better understand porosity, permeability and formation pressures associated with reservoirs in different areas of the Baltic Sea
- Additional reservoir data covering both onshore and offshore Kaliningrad should be obtained
- In order to achieve better understanding of the potential to store captured CO2 in the region, Baltic Sea State cooperation is imperative.

RECOMMENDATIONS – REGIONAL COOPERATION

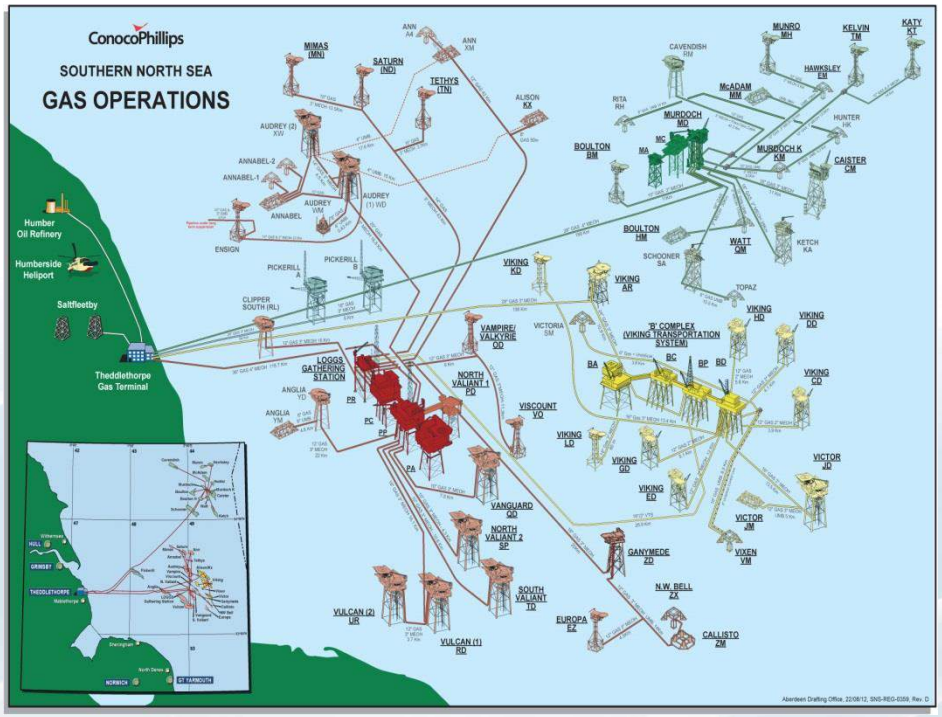
- The easiest and most cost effective way of implementing the majority of these recommendations is through collaborative cooperation with the principle oil companies operating in the region
  - They own the most valuable data
- This raises significant commercial and competitive issues
  - Both at a national and individual company level
- This issue was addressed in BASTOR II through agreement with Svenska Petroleum/OPAB, Poland, Latvia and Russia/Kaliningrad
  - It requires a trusted third party!

RECOMMENDATIONS – REGIONAL COOPERATION

- A trusted third party will be needed to:
  - Project manage the next phase of geological characterisation
  - Work with the national geological surveys and governments
  - Win the confidence of the oil companies and obtain key relevant data from them
    - Demonstrate to the oil companies that they benefit from data aggregation by a better understanding of the regional geology
  - Aggregate the data into a common structure so that commercial value is hidden but exponential increase in potential site characterisation is achieved.
    - This should also be of considerable value to the oil companies

EXAMPLE OF THIRD PARTY VALUE

UK NORTH SEA - THEDDLETHORPE CATCHMENT AREA



SLR DEVELOPING NEW BUSINESS MODEL

- 19 commercially competitive oil companies
- 42 separate fields
- Approximately 60 fixed structures
- 4 major pipeline systems
- 1 major gas processing terminal
- No one company or group of companies can see the whole picture
- Only by all companies providing commercially sensitive data to a third party can a new business model be developed for the benefit of all.

Could this be a model for the Baltic Sea?

DISCUSSION

For further information, pleased contact:

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