Groundwater impact on coastal ecosystems: a geochemical view

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What is „Submarine Groundwater Discharge“

First description by „Strabo“ a roman geographer (63 BC-21 AD)

Submarine springs at the Syrian coast

Large groundwater inputs to coastal waters revealed by ^{226}Ra enrichments

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THE flow of ground water directly into the coastal ocean has been studied previously by *in situ* measurements, seep meters and diffusion gradient models[1]. Although these techniques provide ample evidence that such flows occur, they do not provide a means of quantifying the groundwater flux on a regional scale. Here I report large enrichments of ^{226}Ra in coastal waters of the South Atlantic Bight, and demonstrate that groundwater discharge is the main source of the ^{226}Ra surplus. Using ^{226}Ra data for brackish ground waters with estimates of residence times of nearshore waters, I conclude that the groundwater flux to these coastal waters must be about 40% of the river-water flux during the study period. Besides Ra, other metals, nutrients and organic compounds are expected to be enriched in brackish ground waters, so these findings require an upward revision of terrestrial fluxes of dissolved materials to these coastal waters, and perhaps a re-evaluation of such fluxes to the global ocean. These fluxes may be sensitive to hydrological factors, groundwater usage, dredging and sea-level change.

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What is „Submarine Groundwater Discharge“

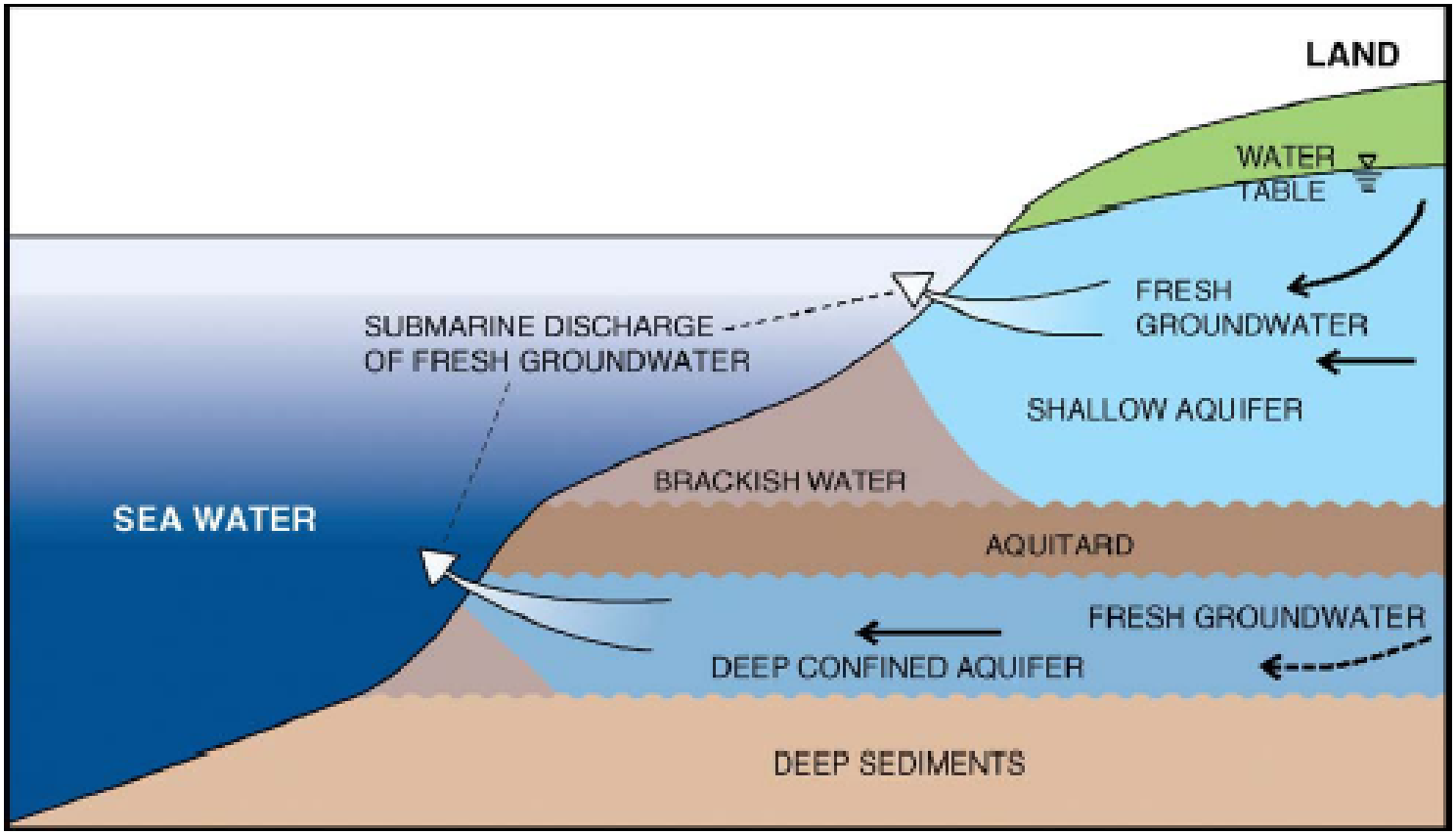
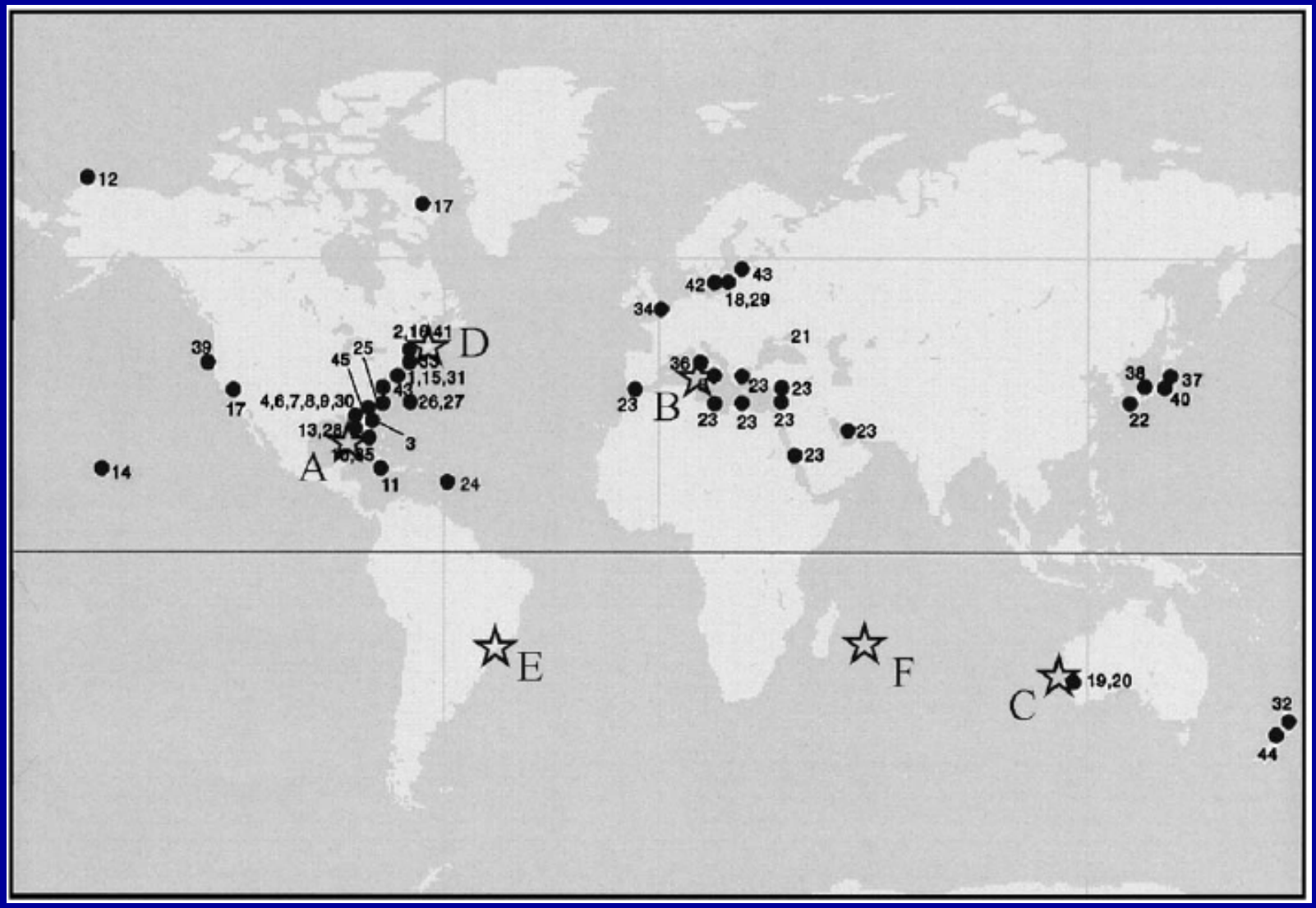


Fig. 1. Schematic depiction (no scale) of processes associated with SGD. Arrows indicate fluid movement.

Burnett (2000)

„Subterranean Estuary“

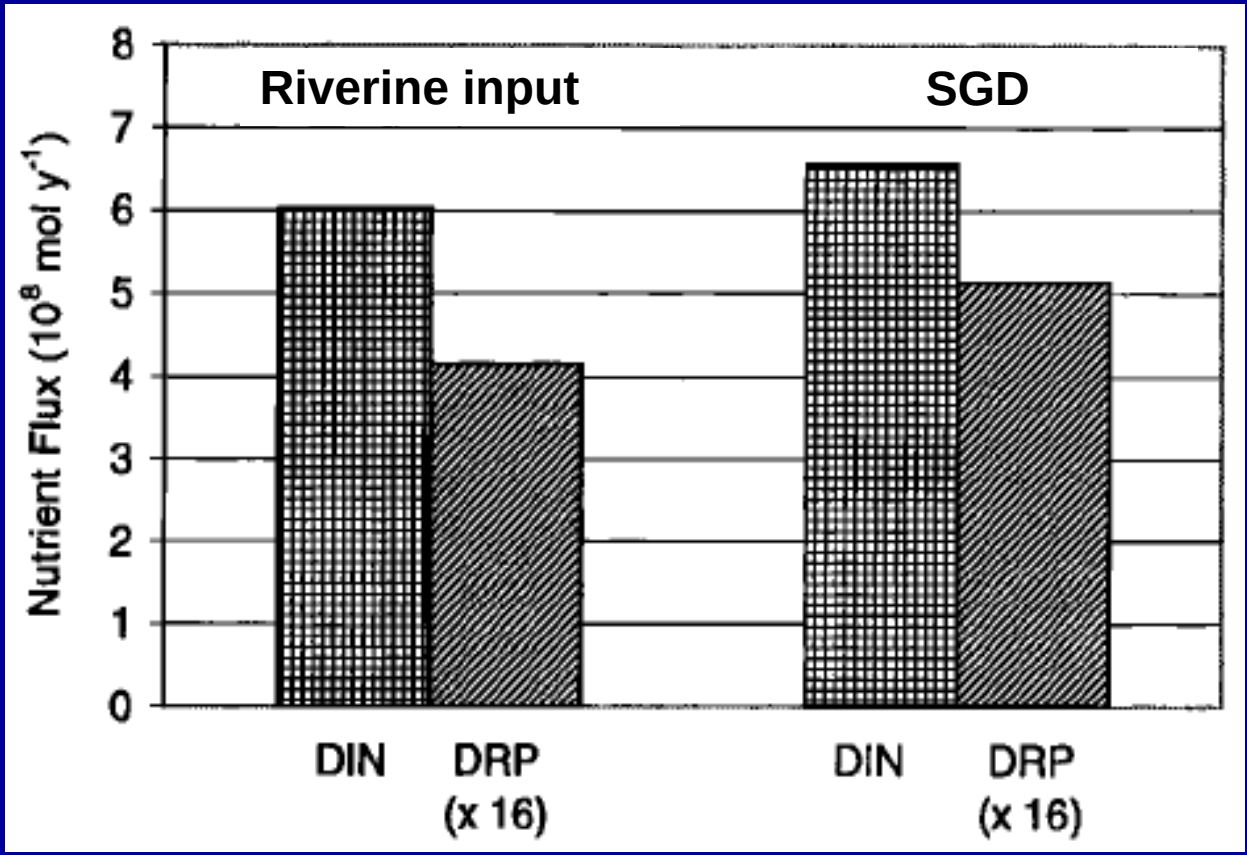
Submarine Groundwater Discharge - worldwide



Burnett et al. (2006)

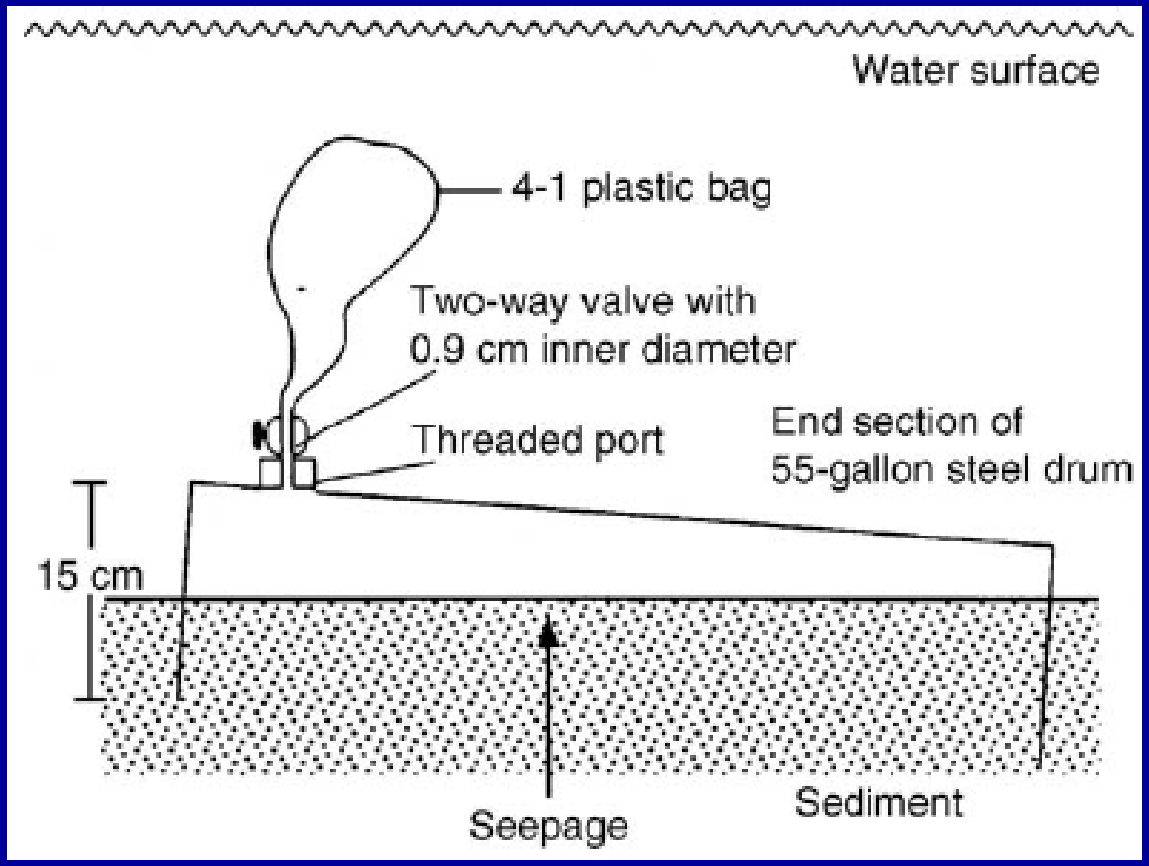
Why measuring Submarine Groundwater Discharge?

An example from South Carolina...



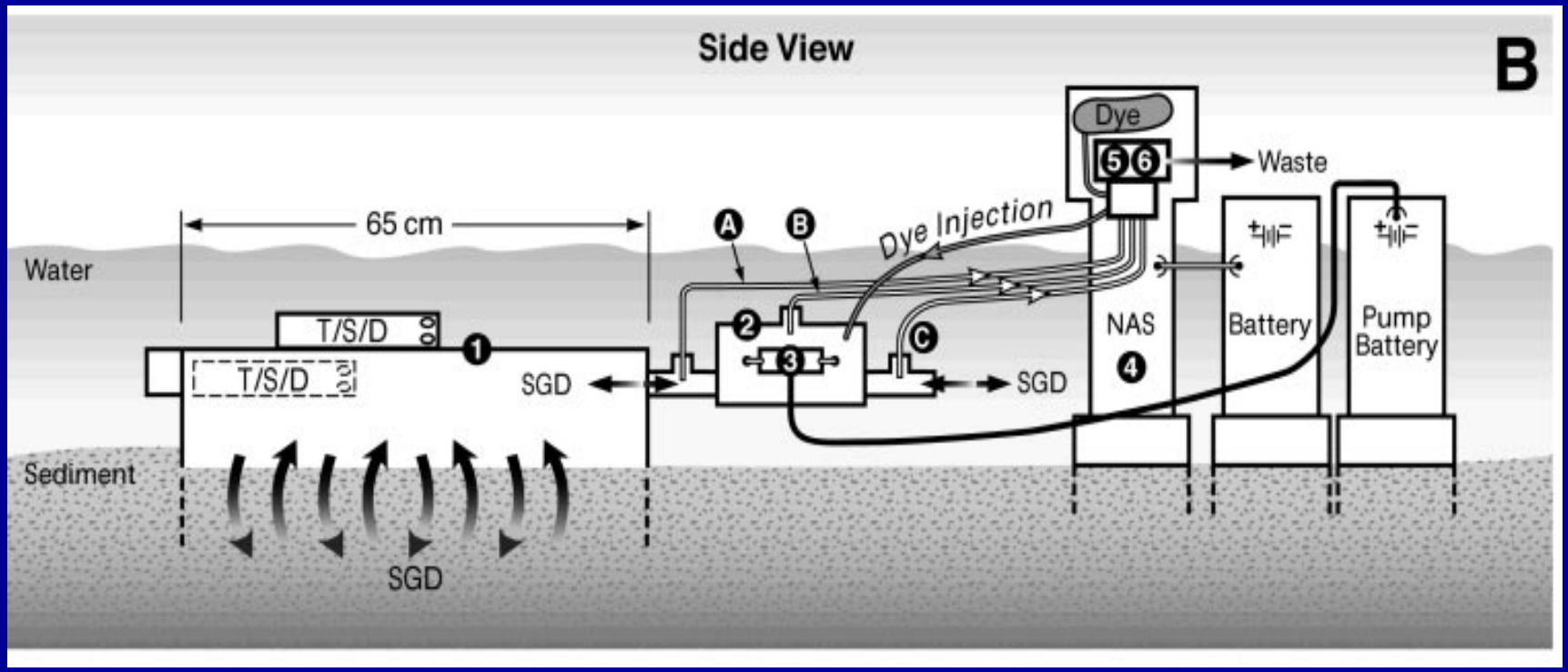
Krest et al. (2000)

How to measure „Submarine Groundwater Discharge“



Simple seepage meter (Lee-type; Lee 1977)

How to measure „Submarine Groundwater Discharge“



Automated seepage meter (Sholkovitz, 2003)

How to measure „Submarine Groundwater Discharge“

Geochemical Tracers:

Ra isotopes

- **Resulting from U and Th decay series**
- **Short- and long-living isotopes**
- **Enriched in saline groundwater due to desorption**

Rn isotopes

- **Resulting from U decay**
- **Noble gas => atmospheric loss**
- **Generally enriched in groundwater**

How to measure „Submarine Groundwater Discharge“

Geochemical Methods:

^{226}Ra

40 % of freshwater Input via SGD...

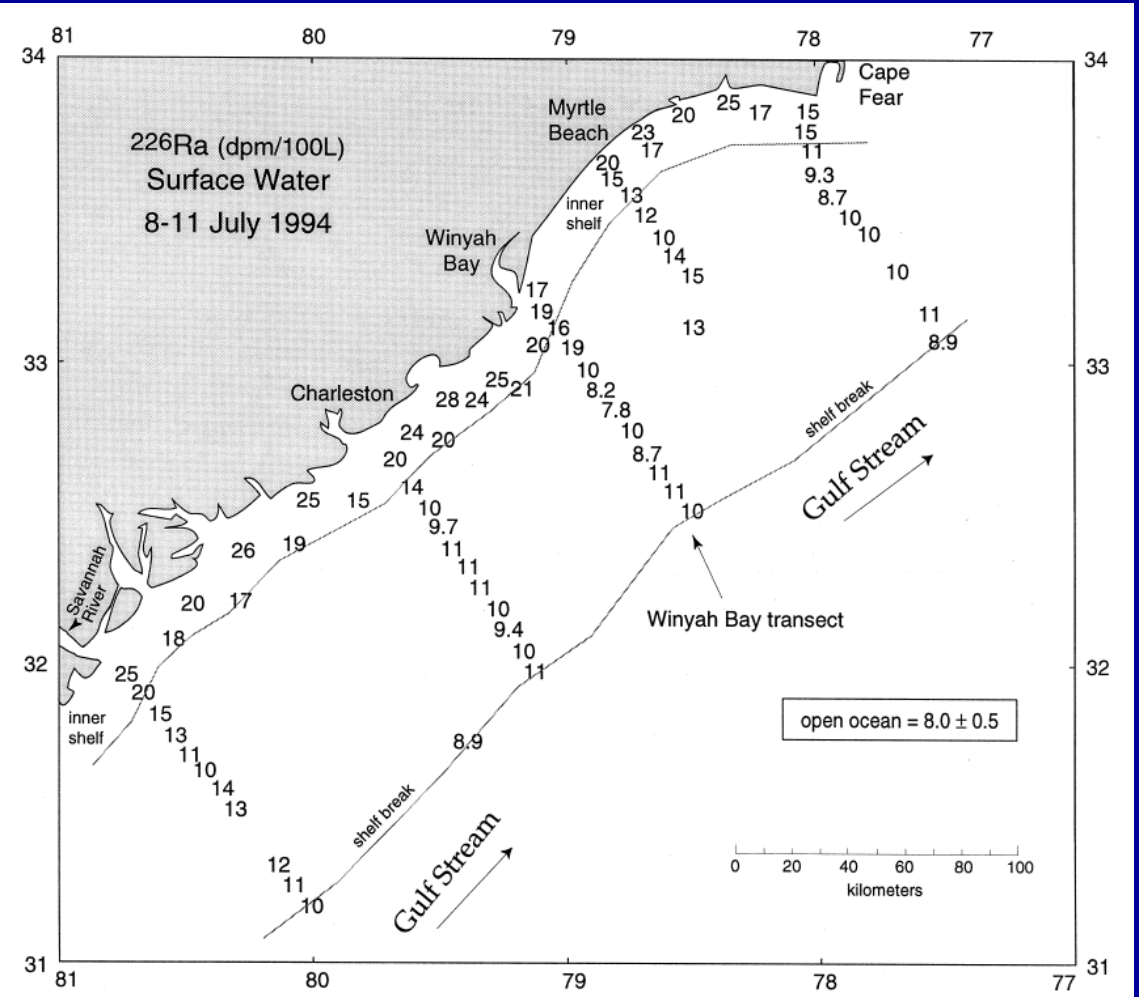
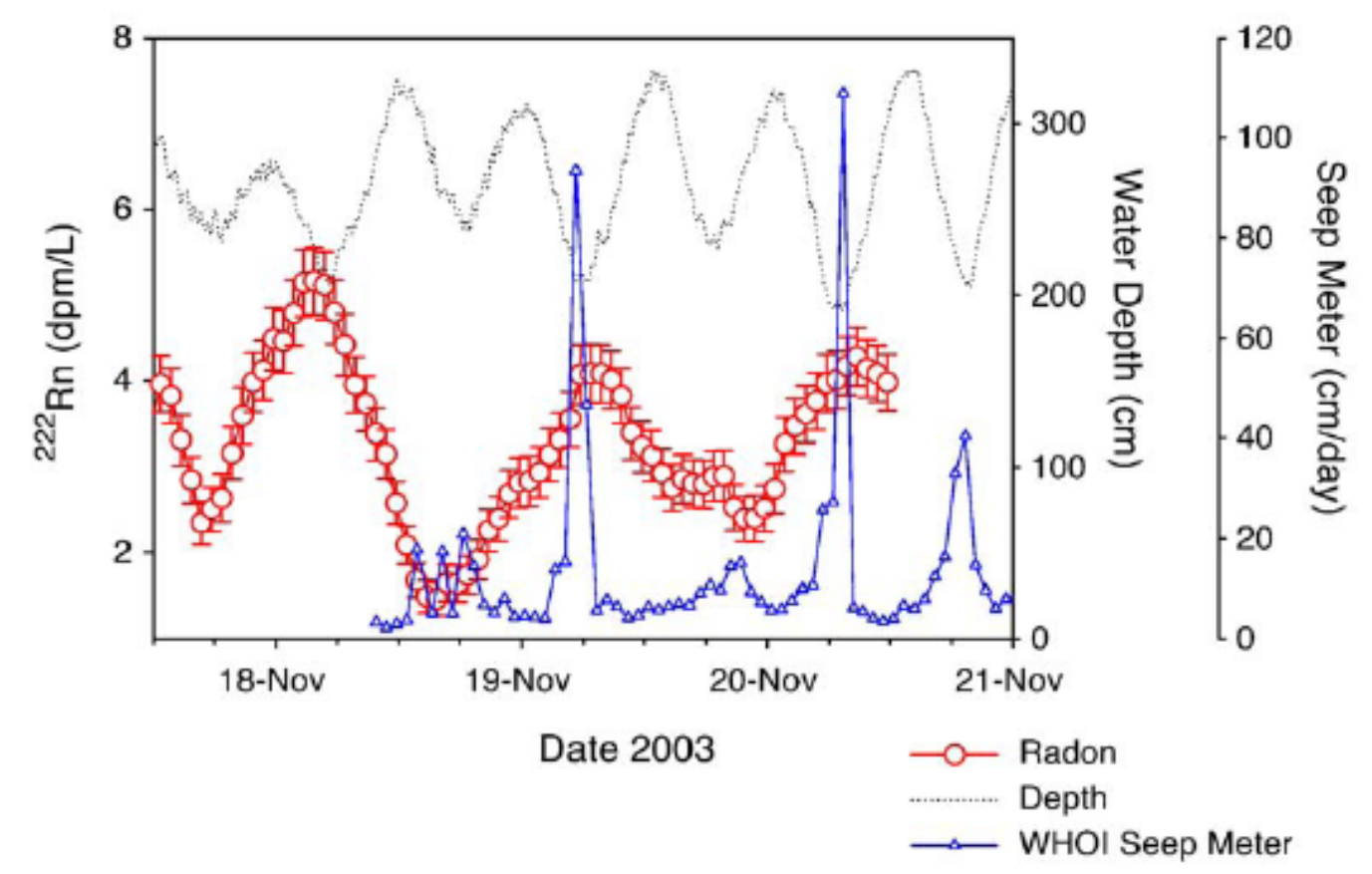


Fig. 2. The distribution of ^{226}Ra in surface waters of the South Atlantic Bight, July 1994. Modified from Moore (1996).

How to measure „Submarine Groundwater Discharge“

Geochemical Methods:

^{222}Rn



Cable et al. (1996)

SGD in the southern Baltic:

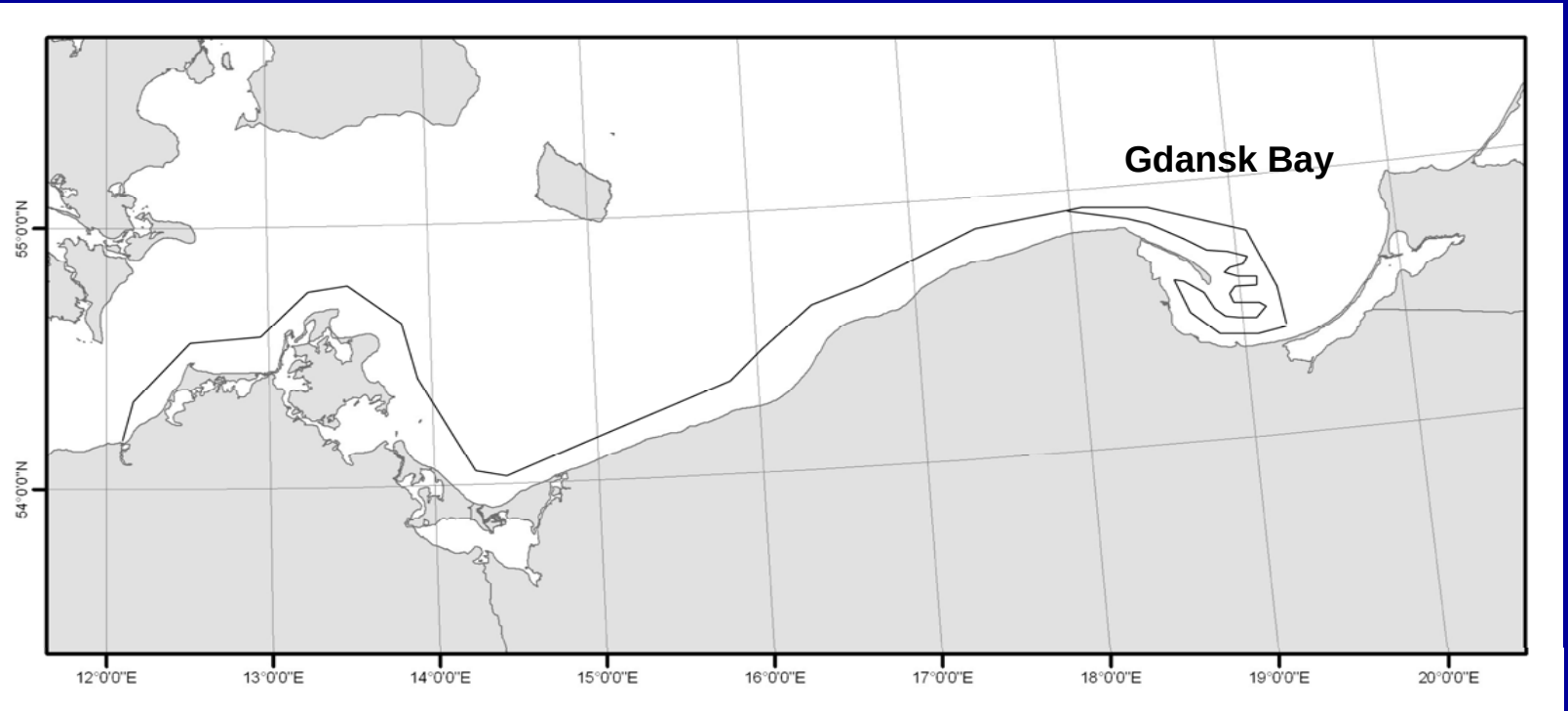
Identification of SGD

Geochemical characterization

Quantification

Influence on biota

„Submarine Groundwater Discharge“ – Gdansk Bay



Cruise with R/V „Prof. A. Penck“ in June 2009:

Equipment: Scan-Fish with pump, CTD-rosette, multicorer

Parameter: T and S, Ra- and Rn-isotopes, CH_4, nutrients, metals, ...

„Submarine Groundwater Discharge“ – Gdansk Bay

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„Submarine Groundwater Discharge“ – Gdansk Bay

Fotos: Michael Schlüter

After identification of seepage sites:

Installation of a seepage meter...

Submarine Groundwater Discharge

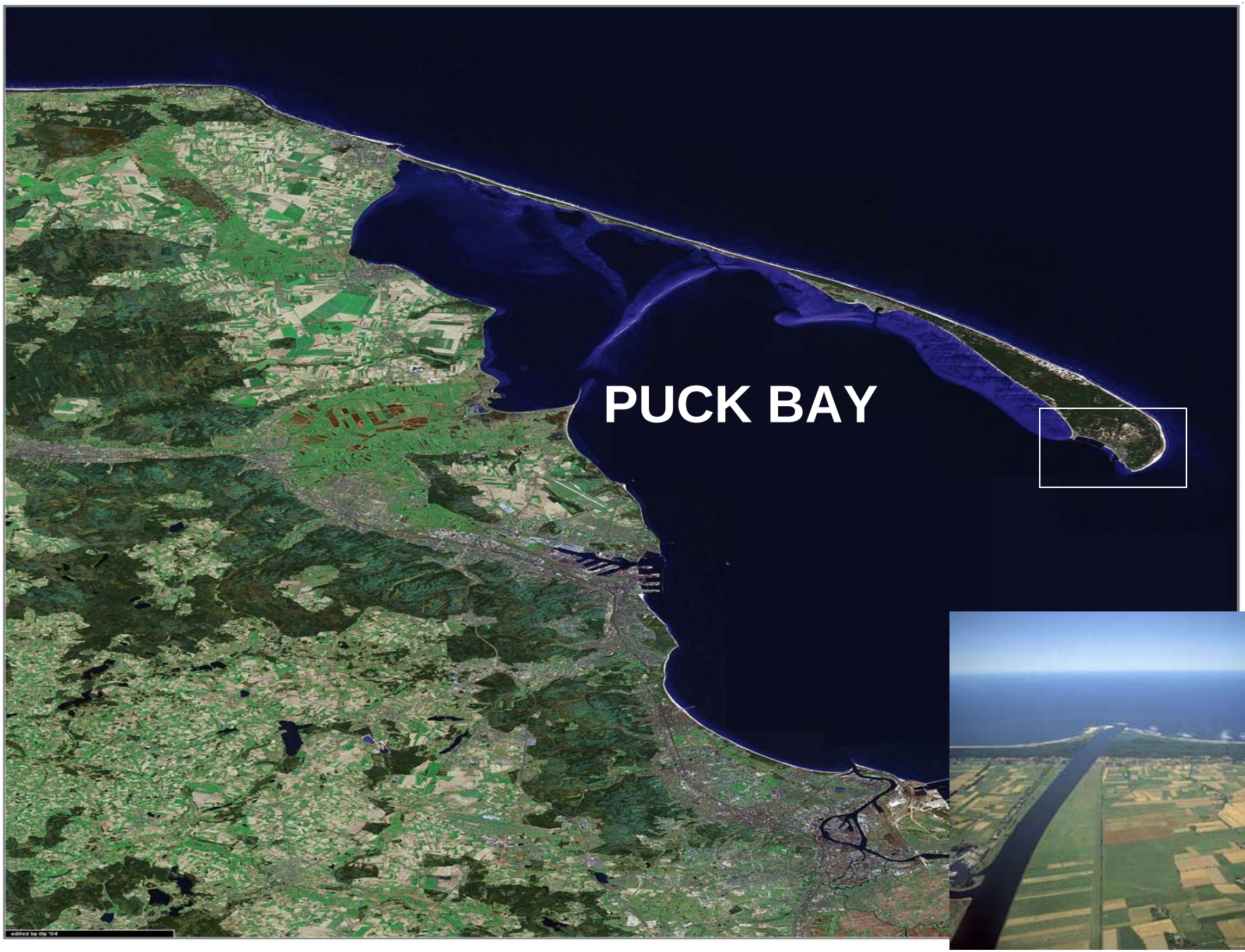
Lech Kotwicki Department of Ecology

- Identification of sedimentological characteristics of SGD areas
- Identification and quantification
- Geochemical characteristics
- **Groundwater seepage impact on biota**
- Hydrological mass balance
- Changes of geochemical parameters in water column

Institute of Oceanology

Polish Academy of Sciences


Gulf of Gdansk
PUCK BAY


PUCK BAY

MARINE STATION IN HEL

MARINE STATION IN HEL

SUGGESTED SAMPLING SITE


UWAGA !!!
BADANIA
NAUKOWE
UWAGA!!!
HUMANS
SCIENTIST

Groundwater seepage at Hel Peninsula

COSA results from field campaign Hel 2003

cosa

Coastal Sands as Biocatalitycal Filter

Clean biological use of organic waste
up to 75 kg wet weight per m^2

≈ 5,5 mln €/year

Observation:

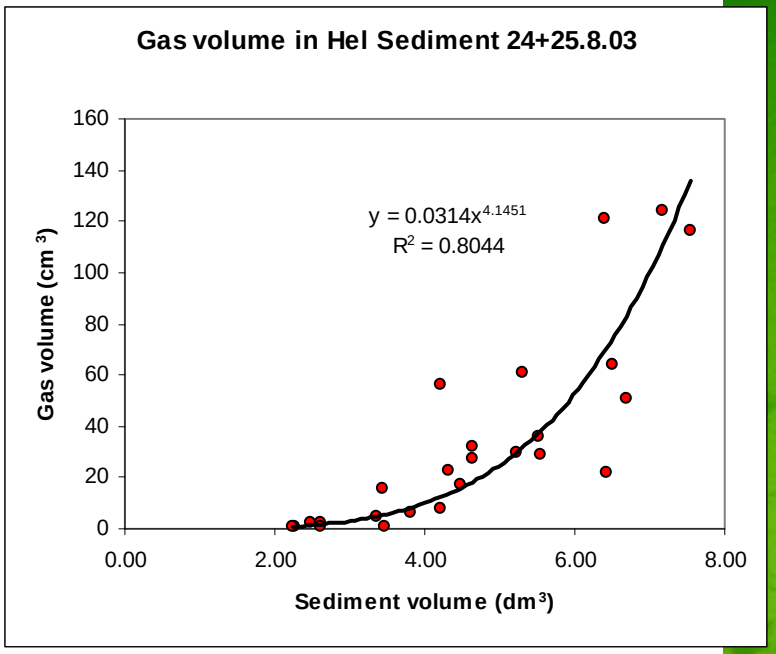
Large methane bubbles in sediment cores in the shallow sublittoral at Hel

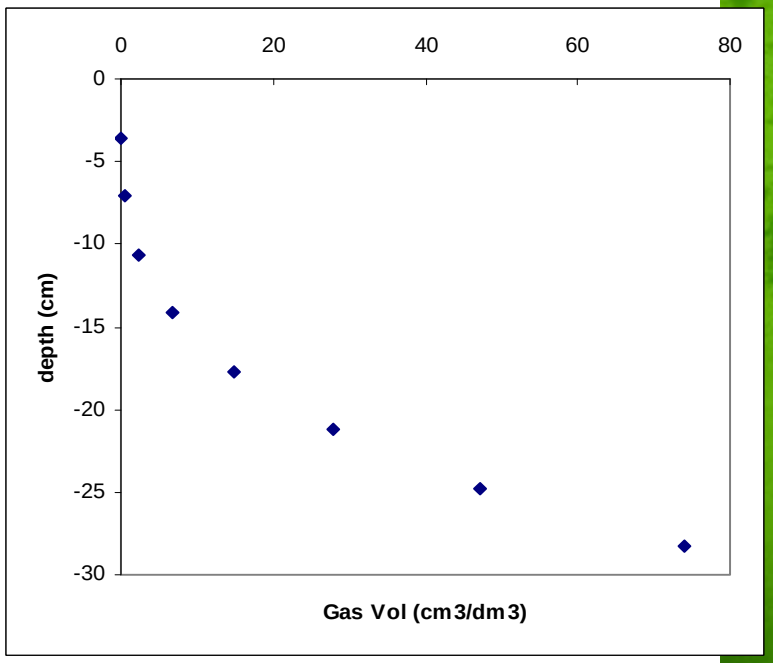
Objective:

Assess whether **groundwater seepage** could be the cause for methane production
Investigate consequences

Methods:

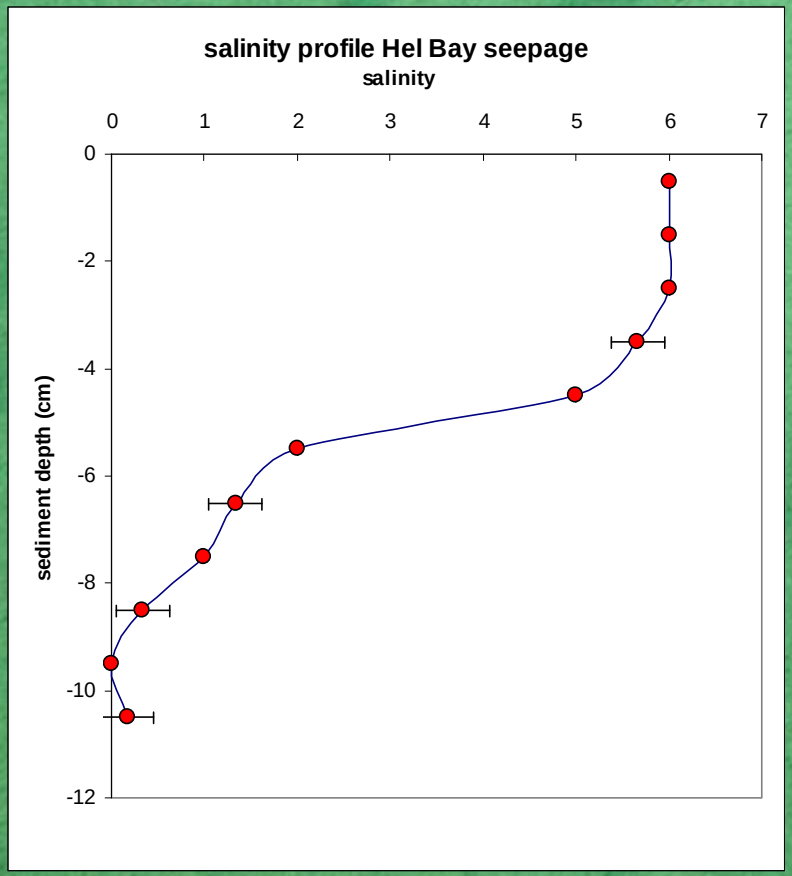
Quantification of methane using benthic chambers
Salinity profiles in sediment cores taken at gas seep sites
Salinity transects along and across Hel bay
Seepage meter installation
Pore water analyses

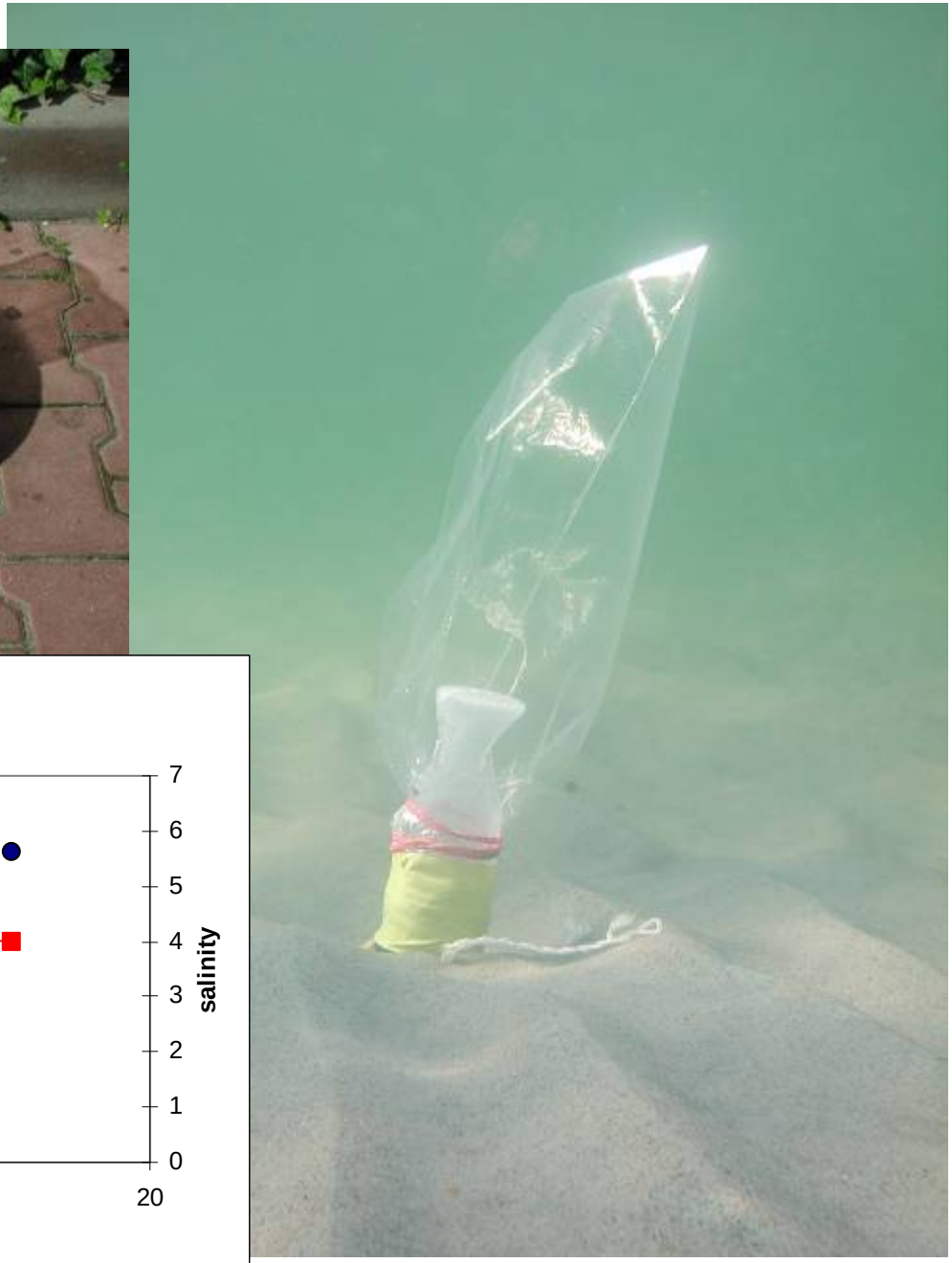


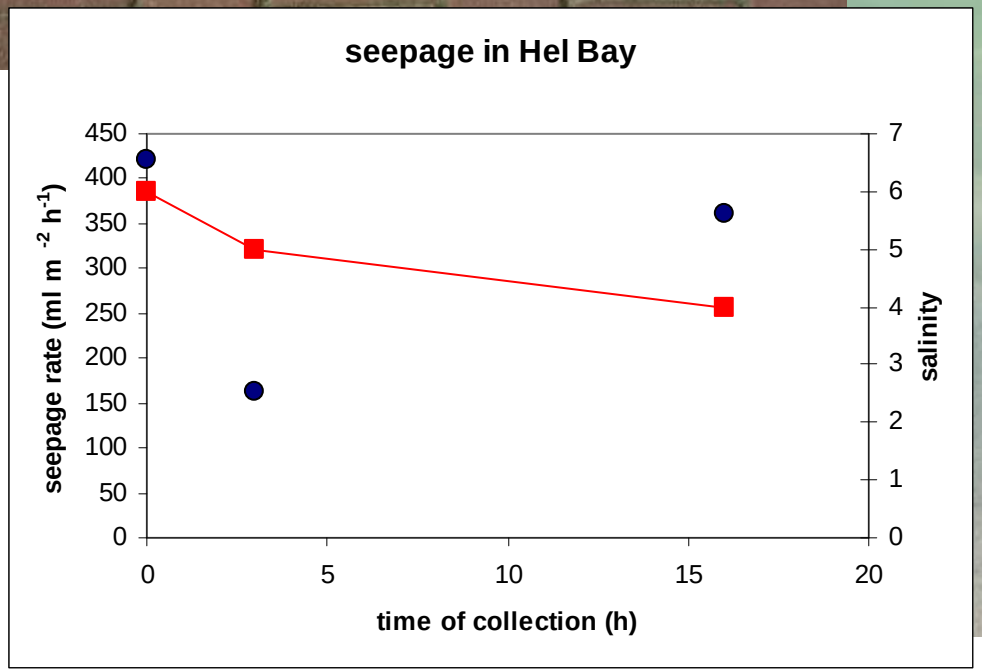


methane quantification

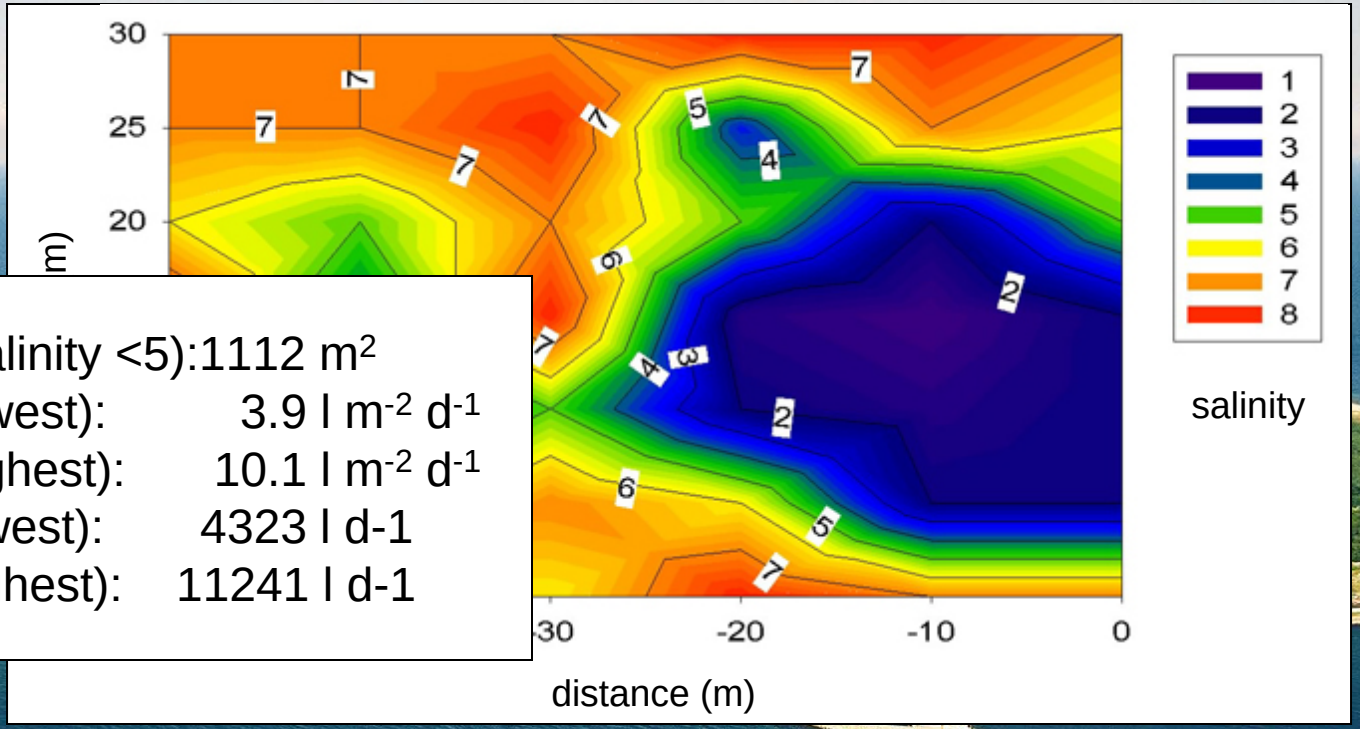
salinity profile in methane zone

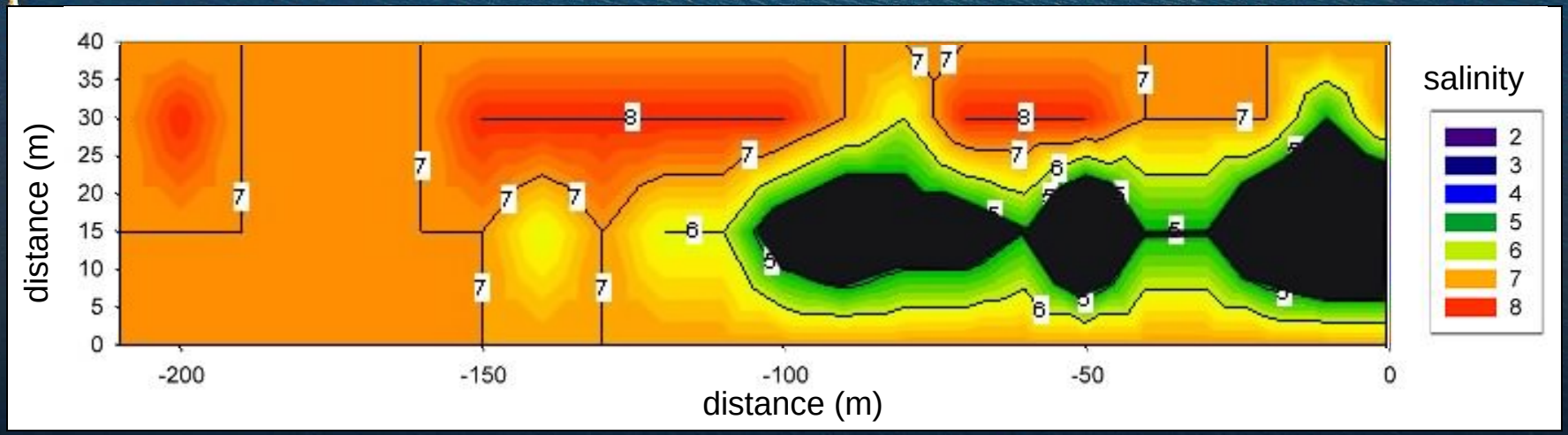


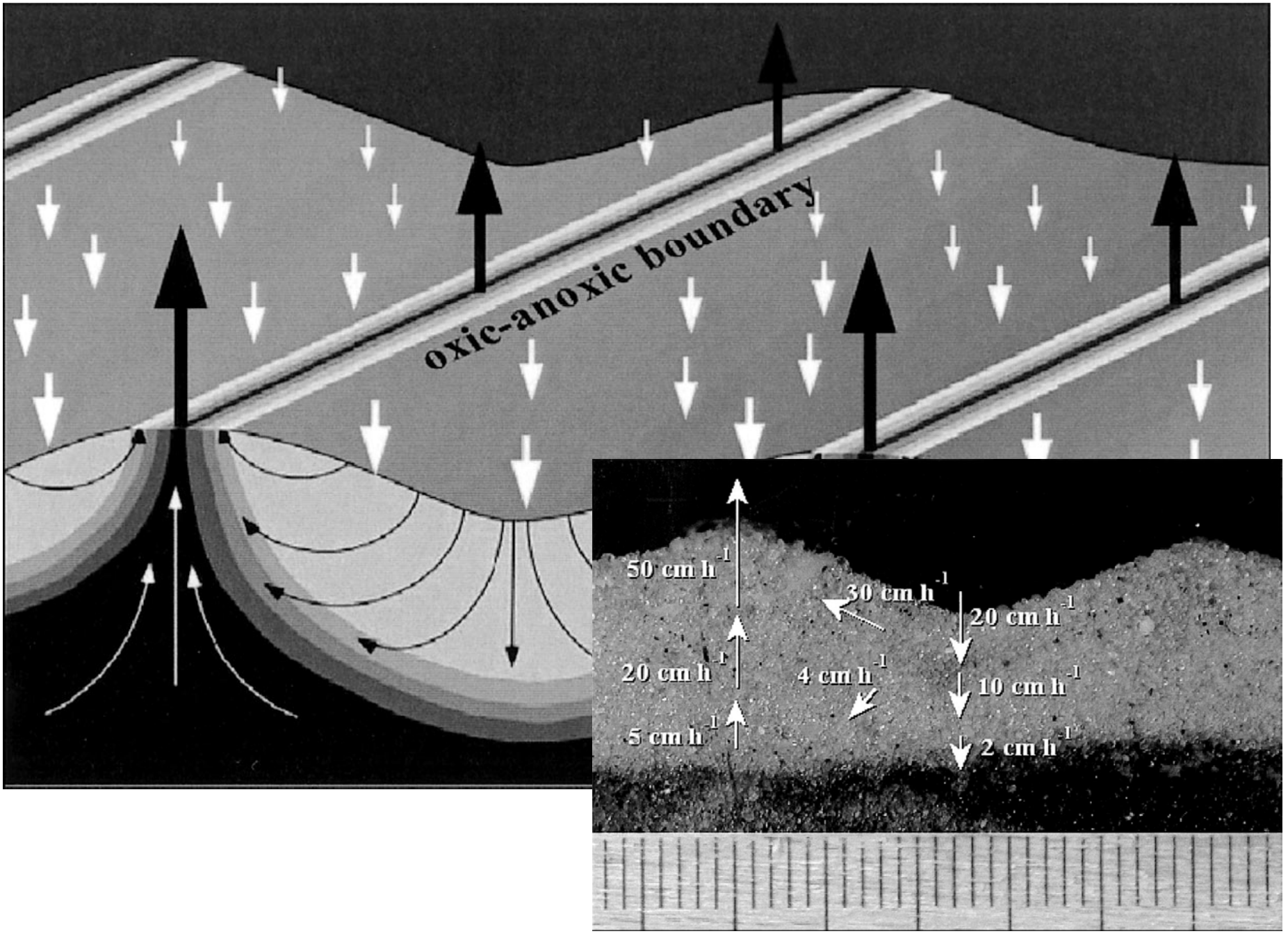


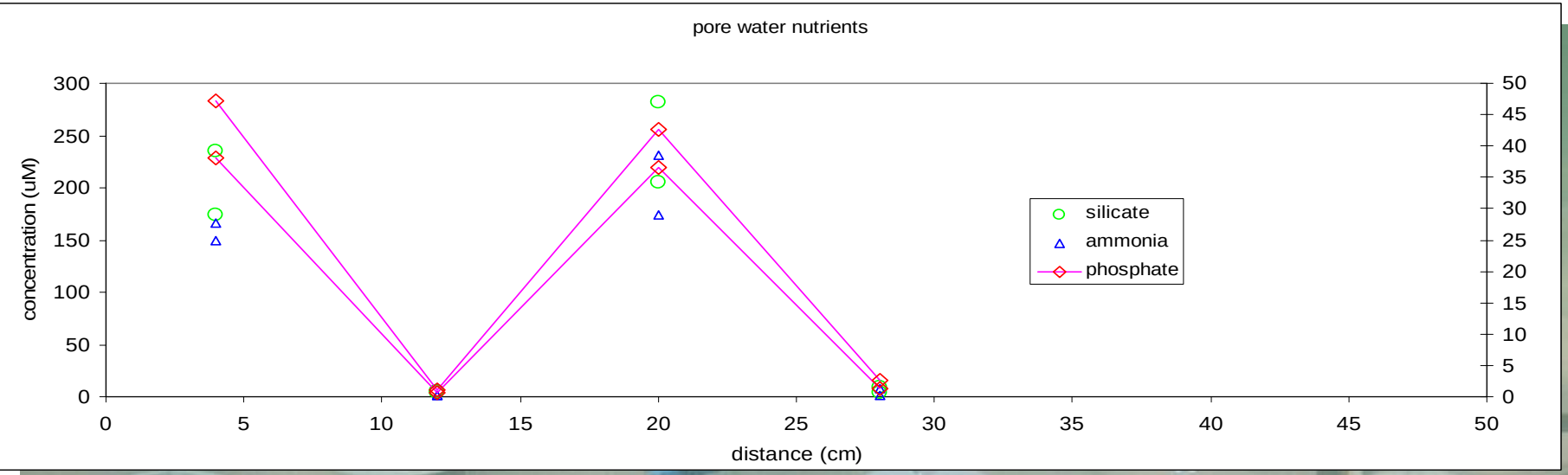

seepage in Hel Bay
seepage rate (ml m -2 h-1)
salinity
time of collection (h)
0
50
100
150
200
250
300
350
400
450
0
1
2
3
4
5
6
7
0
5
10
15
20

Seepage area (salinity <5):1112 m^2
Seepage rate (lowest): 3.9 l m^{-2} d^{-1}
Seepage rate (highest): 10.1 l m^{-2} d^{-1}
Seepage bau (lowest): 4323 l d-1
Seepage bau (highest): 11241 l d-1

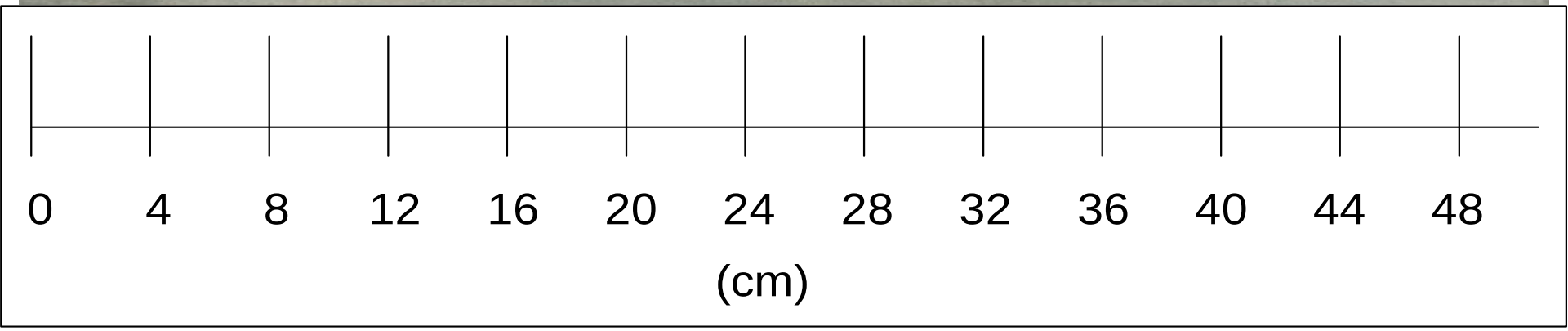





oxic-anoxic boundary
50 cm h-1
30 cm h-1
20 cm h-1
20 cm h-1
4 cm h-1
10 cm h-1
5 cm h-1
2 cm h-1


pore water nutrients
concentration (uM)
distance (cm)
silicate
ammonia
phosphate
0
50
100
150
200
250
300
0
5
10
15
20
25
30
35
40
45
50

1
4
2
5
3
6

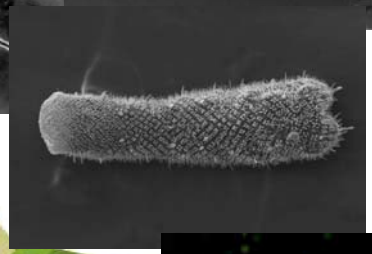

0
4
8
12
16
20
24
28
32
36
40
44
48
(cm)

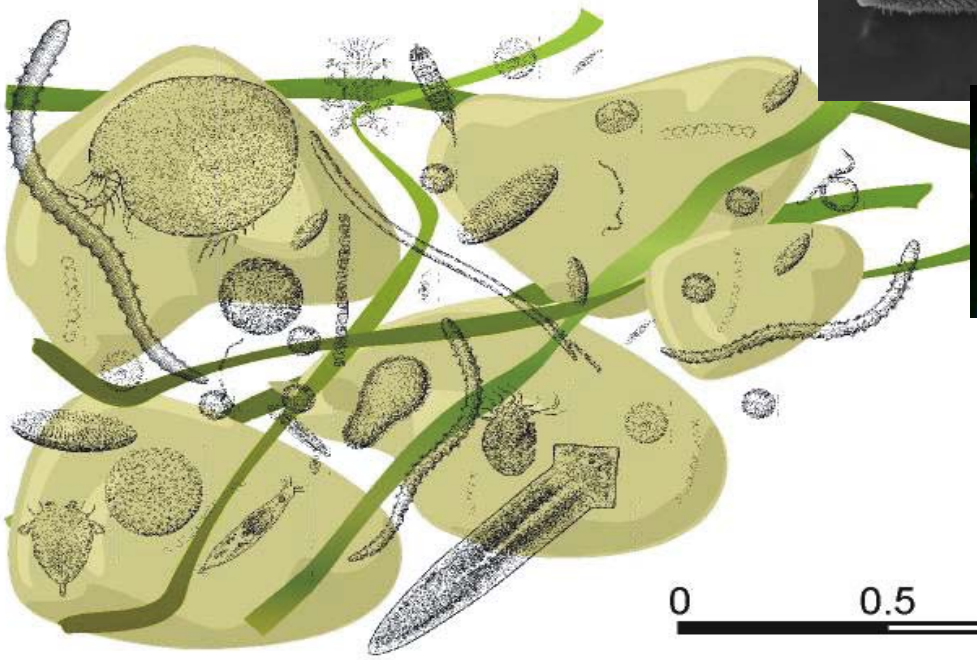
preliminary conclusions

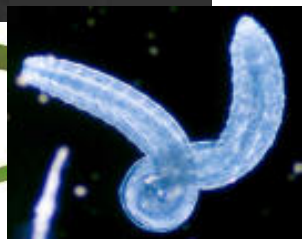
methane production is related to groundwater seepage, low salinity and methane bubble zones overlap.

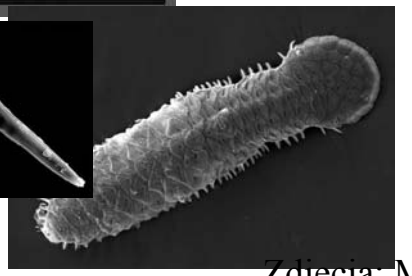
high nutrient concentration in upwelling pore fluid supports this hypothesis assuming groundwater release in observation area of roughly 10 000 l d^{-1} approximately 2.0 mol silicate, 1.5 mol ammonia and 0.4 mol phosphate are released in this area by the groundwater upwelling each day.

It is not a desert!!!



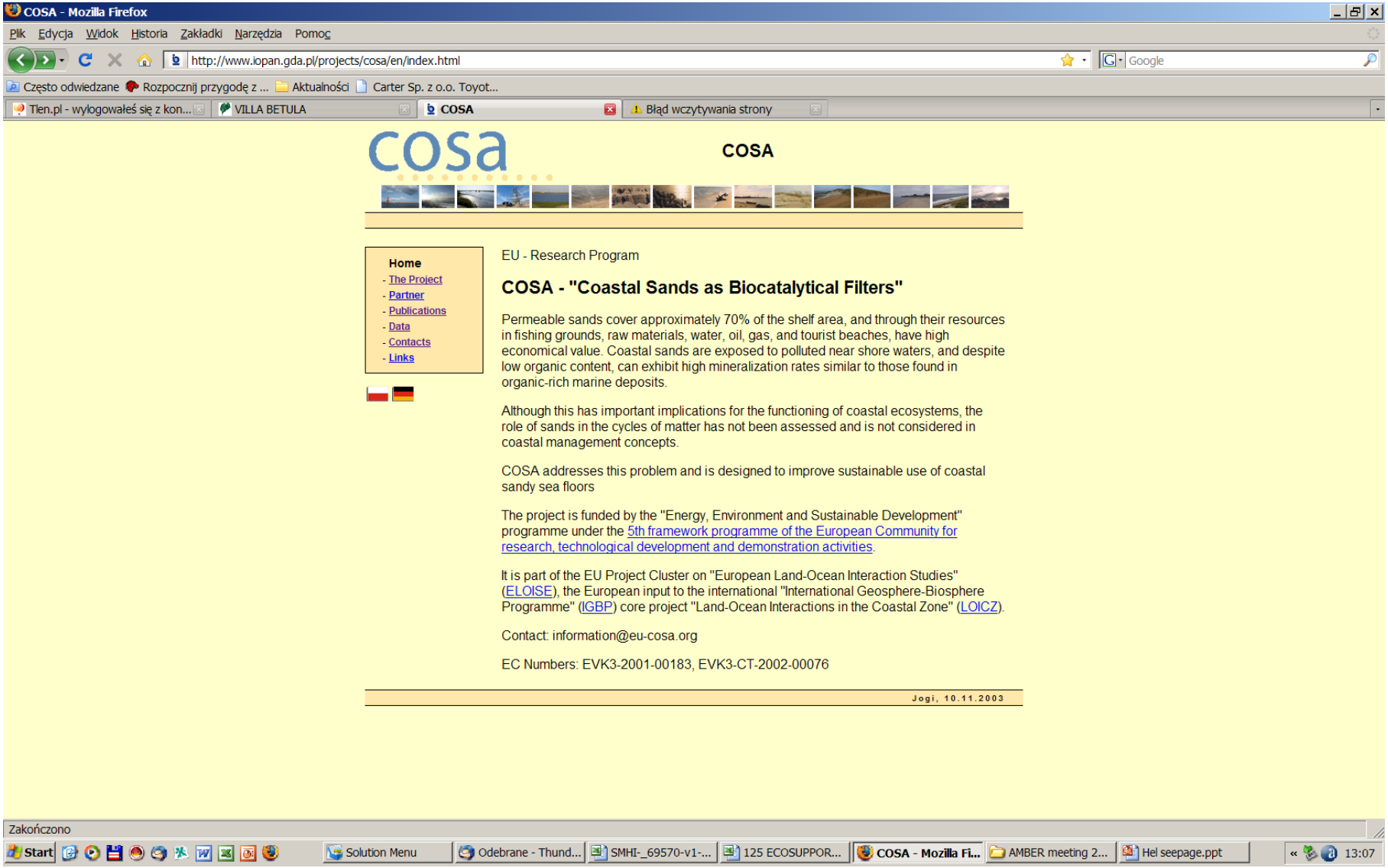




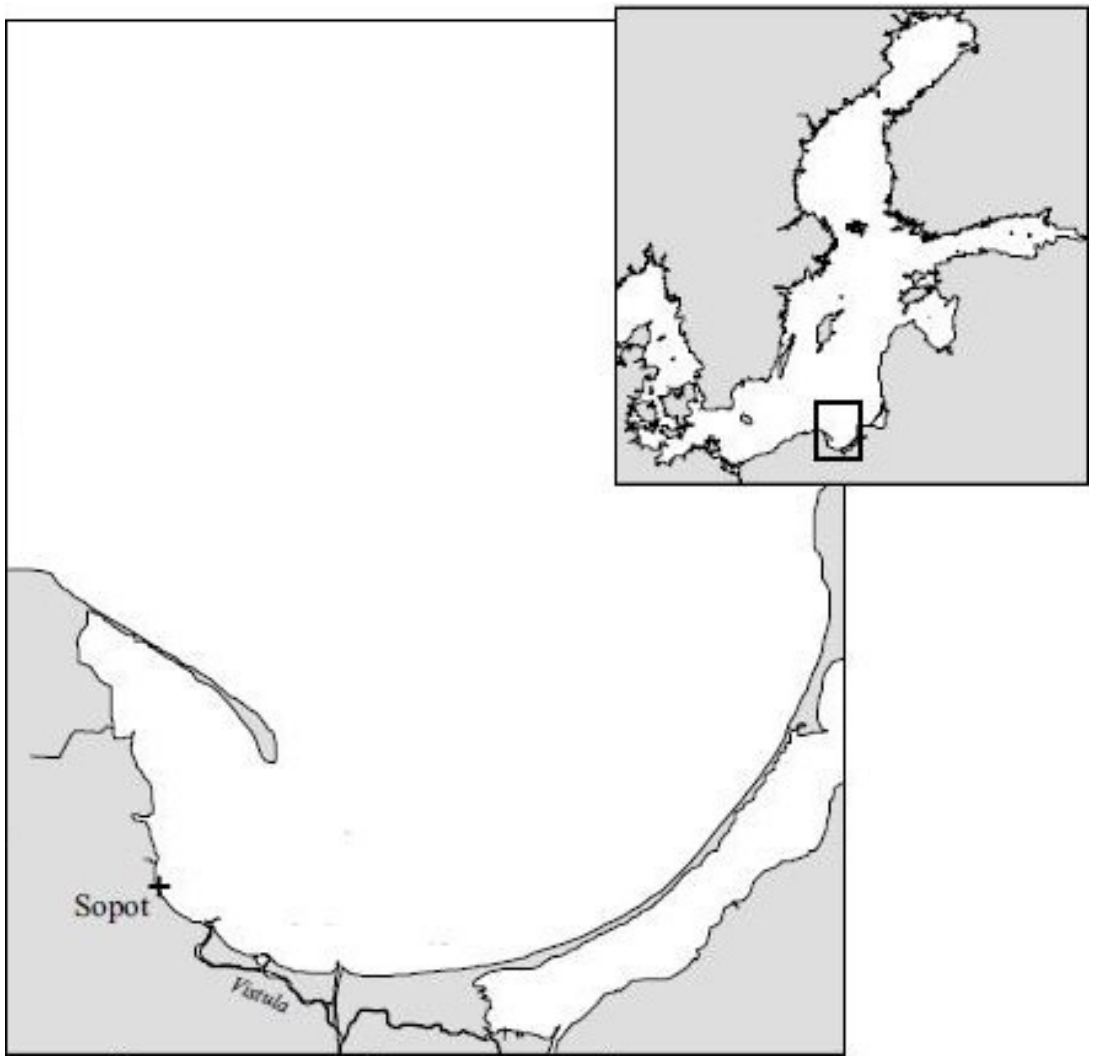


Zdjęcia: Matthew D. Hooge, Rick Hochberg; http://hooge.developmentalbiology.com/meiofauna

http://www.iopan.gda.pl/projects/cosa/



Geochemical composition of groundwater seepage



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Institute of Oceanology PAS

COLLECTING SAMPLES

Including seasonal changes	Including weekly changes	Including daily changes
spring (April)	after sunny days	– checking if concentrations of components vary during a day
summer (July)	during sunny days	
autumn (October)	after rainy days	
winter (February)	during rainy days	

- discover the relantionships between the

The analysis which are planned to be done:

- **DIC/DOC,**
- **TRACE METALS**
- **STABLE ISOTOPES**
- **NUTRIENT ANALYSIS**

DIC/DOC

- HyPerTOC analyser (Thermo Electron Corp., the Netherlands) will be used to measure carbon (UV/persulphate oxidation and non-dispersive infrared detection (Sharp, 2002).

TRACE METALS
(Cd, Pb, Fe, Al, Cu, Co, Ni, Zn, Ag, Hg)
STABLE ISOTOPES
(^{204}Pb, ^{206}Pb,^{207}Pb, ^{208}Pb,)

- ELAN 9000 ICP-MS (Inductivly Coupled Plasma Mass Spectrometry), PerkinElmer will be used to measure this metals

STABLE ISOTOPES RATIOS
$\delta^{13}C$, $\delta^{15}N$

- Elementary Analizator Flash EA Series 112/ IR-MS Delta V Advantage, Thermo ELECTRION CORPORATION will be used to measure the isotopes ratios

NUTRIENT ANALYSIS

NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}

- **the colorimetric** analysis will be used to measure this ions