University of Gdańsk, Institute of Oceanography, Gdynia, Poland

CRUISE REPORT

within EU project ECO2

(B3 field, southern Baltic Sea, Poland)

Adam Sokołowski, Jarosław Tęgowski

Gdynia 2012

1. OBJECTIVES

The oil-carrying field B3 in the southern Baltic Sea, which is currently exploited by LOTOS Petrobaltic S.A., is considered a potential industrial sub-seabed geologic carbon dioxide (CO_2) storage site and has been selected as a study area to assess the risk of CO2 leakage on marine environment within the EU RTD project ECO2 (www.eco2-project.eu). The architecture of capture rock formations (including depth range, porosity and permeability) and offshore location within the Cambrian floor provide a promising perspective for the carbon storage in the B3 field after its depletion. However, the potential of gas leaking from the reservoir to the surficial sediments and water column and its effect on the ecosystem are still poorly understood. Extensive field and laboratory study has been therefore set up within two Work packages (WP1 and WP4) to describe geological structure of the capture rock and to assess the influence of water acidification (increased CO_2 level) on marine benthic biota.

The first field campaign was organised to the B3 field in the southern Baltic Sea (Fig. 1) in June-September 2012; sailing from Gdansk and returning to Gdansk. Due to installation of new measurement instruments, adverse meteorological conditions and unexpected technical problems of the vessel the campaign was split into three separate cruises which took place on board the LOTOS Petrobaltic S.A. research vessel r/v "St. Barbara" in the following terms:

1) 29.06-13.07.2012 (WP1)
2) 22.07-4.08.2012 (WP1)
3) 27.08-3.09.2012 (WP4).

The primary objectives of the cruises were:

within WP1

1) to specify location of natural gas emissions from shallow and deep geological layers in the area of B3 field using hydroacoustical measurements of the bottom surface, sub-bottom layers and water column

within WP4

1) to assess the structure of meio- and macrofaunal benthic communities as well as basic geo-chemical parameters of pore water and surficial sediments in the area of B3 field.

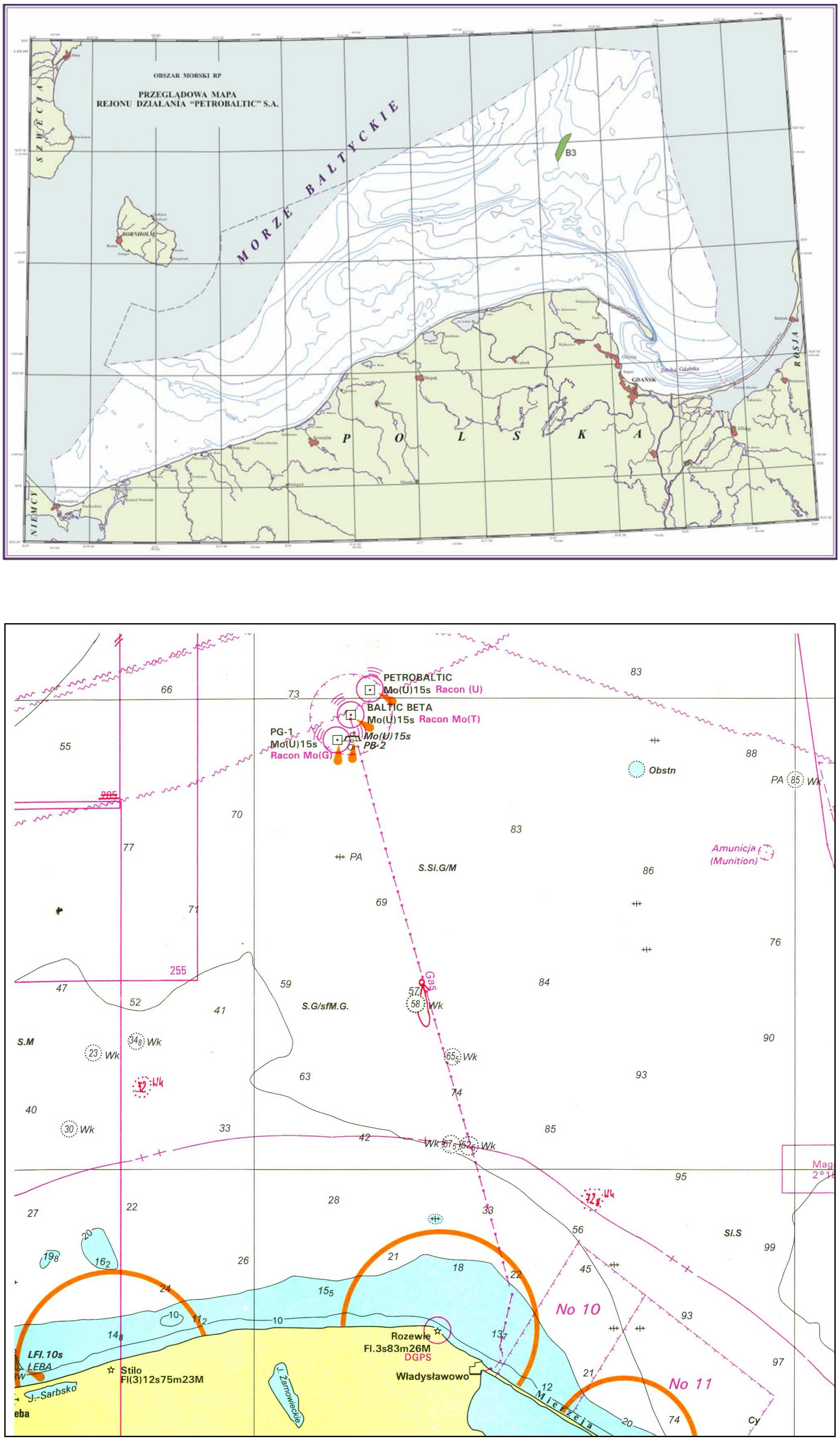


Fig. 1. Location of B3 field in the southern Baltic Sea (Hydrographic Office of the Polish Navy 1967, modified)

2. PARTICIPANTS

Cruise 1) 29.06-13.07.2012

Cruise chief: MSc Grzegorz Zajfert (LOTOS Petrobaltic S.A.)

Survey crew of Petrobaltic – 3 persons

Scientific staff:

Prof. UG, Dr. hab. Jarosław Tęgowski (Chief Scientist, UG)

Dr. Aliaksandr Lisimienka (technician, Maritime Institute in Gdańsk)

MSc Oskar Głowacki (PhD student, UG)

Cruise 2) 22.07-4.08.2012

Cruise chief: MSc eng. Kazimierz Grzesiak (LOTOS Petrobaltic S.A.)

Survey crew of Petrobaltic – 3 persons

Scientific staff: MSc Maria Rucińska-Zjadacz (PhD student)

Cruise 3) 27.08-3.09.2012

Cruise chief: MSc Paweł Sokólski (LOTOS Petrobaltic S.A.)

Survey crew of Petrobaltic – 3 persons

Scientific staff: Prof. UG, Dr. hab. Adam Sokołowski (Chief Scientist, UG)

MSc Marcelina Ziółkowska (PhD student, UG)

MSc Piotr Bałazy (technician, UG)

MSc Anita Jasińska (PhD student, UG).

The ship

All measurements and samplings were conducted from on board the LOTOS Petrobaltic S.A. vessel r/v "St. Barbara" (Fig. 2) of the following parameters:

Length: 78.6 m,

Breadth: 13.7 m,

Draught: 5.0 m,

Speed max. 14 kn,

Power: 4 x 1830 bhp,

Max persons: 43.

The vessel is well adapted to geological and geotechnical works and underwater drilling. The set of sonars, echosounders and subbottom profilers allow conducting geological documentation of the sea floor.

Fig. 2. Research vessel "St. Barbara" (Lotos Petrobaltic S.A.)

3. HYDROACOUSTICAL SURVEY

The cruise was split into two separate parts due to installation of new measurement instruments, adverse meteorological conditions and technical problems of the vessel. During each survey there were conducted hydroacoustical measurements of subbottom structure, bottom surface and water body - searching for traces of gas. The speed of ship during the measurement was up to 4 kn.

Equipment

Hydroacoustical equipment used on board:

1) chirp subbottom profiler (Edge-tech SB-0512),
2) sidescan sonar (Edge-tech DP-4200),
3) multibeam echosounder (Reson SeaBat 7125).

1) The **subbottom profiler** (Fig. 3) was used to detect gas lying in the sub-bottom layers to a depth of about 50 m below the surface of the bottom. Methodological details of measurements:

frequency 2.0kHz-12 kHz,

fm pulse length 20 ms,

beam width (-3dB) 16°,

vertical resolution 8 cm.

The output data were stored in “cod” digital format of Coda Octopus and copies (echograms) of registration containing traces of gas in sediment were stored electronically in TIFF format.

Fig. 3. Chirp subbottom profiler (Edge-tech SB-0512)

2) The **sidescan sonar** (Fig. 4) created an image of large areas of the seafloor and provided information about the types of surface sediments, seafloor geomorphologic structures, ripplemarks, stones, mud volcanoes, etc. and locations of possible gas leakage from the bottom. The output data were stored in “cod” format. Methodological details of measurements:

frequency 300/900 kHz dual simultaneous,

horizontal beam width 300 kHz 0.28°, 900 kHz - 0.2°,

resolution along track 300 kHz 1.3 m @ 150 m, 900 kHz: 18 cm @ 50 m,

resolution across track 300 kHz 3 cm, 900 kHz: 1 cm.

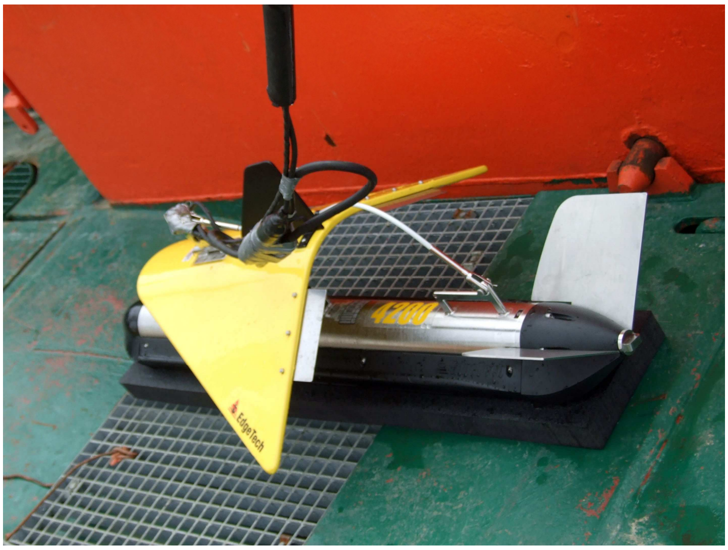


Fig. 4. Sidescan sonar (Edge-tech DP-4200)

3) The **multibeam echosounder** was used to determine a precise bathymetric model of B3 field area and angular dependence of acoustical signal backscattered intensity - information useful for determining geo-acoustical properties of sediments. In addition, acoustical signals scattered on objects floating in the water column – e.g. gas bubbles rising from the bottom were recorded. For registration of MBES data in format s7k QINSy hydrographic software was used. Before and during each survey hydroacoustical equipment was routinely calibrated. The basic parameters of multibeam echosounder are as follows:

frequency 400 kHz,

along-track transmit beamwidth 2° at 200kHz & 1° at 400kHz,

across-track receive beamwidth 1° at 200kHz & 0.5° at 400kHz,

number of beams 512EA/ED at 400kHz, 256EA/ED at 200kHz,

max swath angle 140° (165°),

typical depth 0.5m to 150m at 400kHz, 0.5m to 400m at 200kHz,

max depth 175m at 400kHz, 450m at 200kHz.

During the first three days of the cruise the Reson Seabat 7125 multibeam echosounder was calibrated.

Acoustical transects

All hydroacoustical measurements were performed during movement of the ship along the perpendicular transects (Fig. 5). The transects for both hydroacoustical cruises are listed in Table.1.

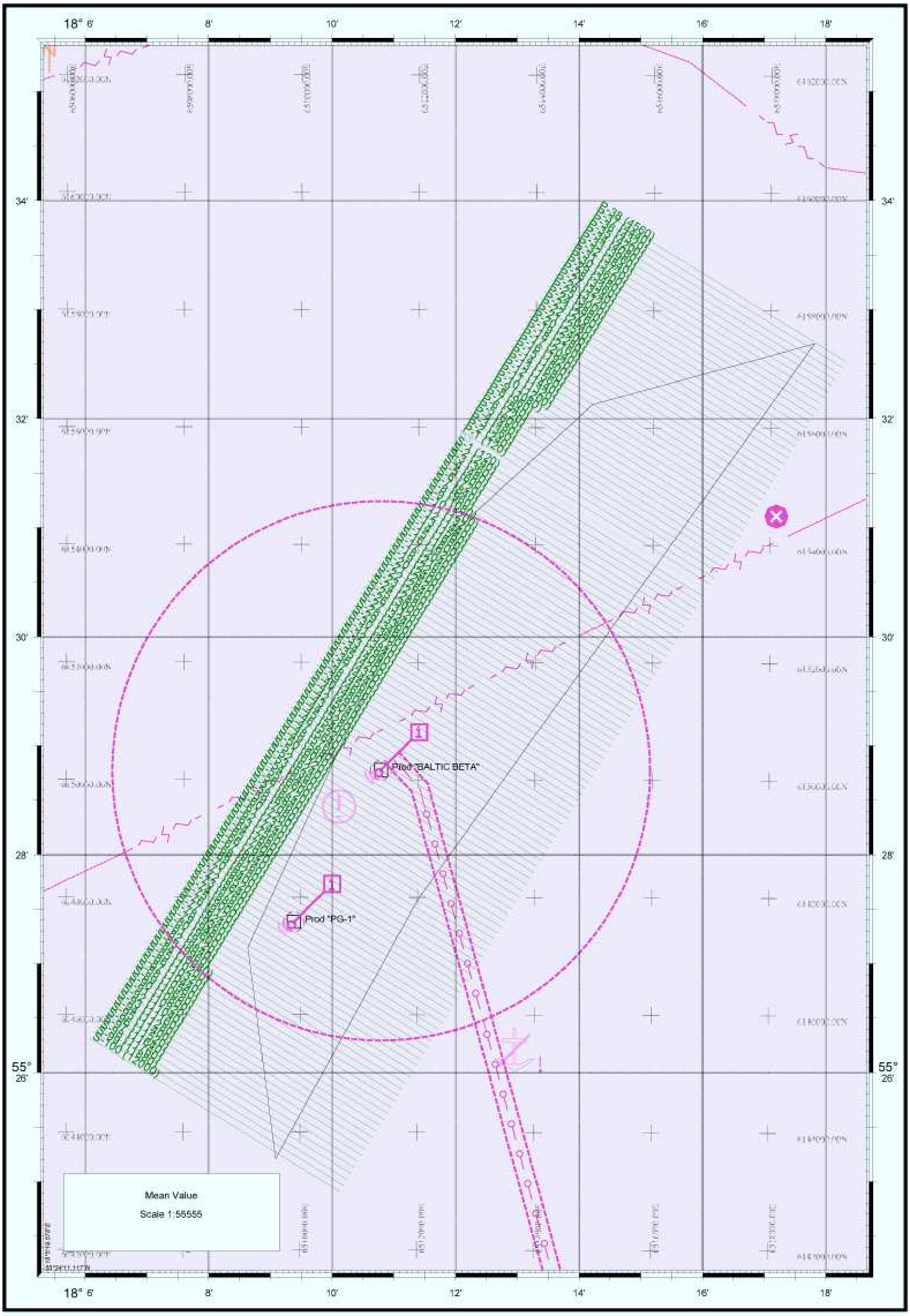


Fig. 5. The transects of hydroacoustical survey in the B3 field

Table 1. Geographical positions of acoustical transects.

Transect name	Easting1	Northing1	Easting2	Northing2
b3	6512640.5400	6155845.3600	6516918.4300	6153244.4500
P-38 (4560)	6515009.4900	6159741.7300	6519287.3800	6157140.8200
P-37 (4440)	6514947.1500	6159639.1900	6519225.0400	6157038.2800
P-36 (4320)	6514884.8100	6159536.6500	6519162.7000	6156935.7400
P-35 (4200)	6514822.4700	6159434.1200	6519100.3600	6156833.2100
P-34 (4080)	6514760.1300	6159331.5800	6519038.0200	6156730.6700
P-33 (3960)	6514697.7900	6159229.0500	6518975.6800	6156628.1400
P-32 (3840)	6514635.4400	6159126.5100	6518913.3400	6156525.6000
P-31 (3720)	6514573.1000	6159023.9700	6518851.0000	6156423.0600
P-30 (3600)	6514510.7600	6158921.4400	6518788.6600	6156320.5300
P-29 (3480)	6514448.4200	6158818.9000	6518726.3100	6156217.9900
P-28 (3360)	6514386.0800	6158716.3700	6518663.9700	6156115.4600
P-27 (3240)	6514323.7400	6158613.8300	6518601.6300	6156012.9200
P-26 (3120)	6514261.4000	6158511.2900	6518539.2900	6155910.3800
P-25 (3000)	6514199.0600	6158408.7600	6518476.9500	6155807.8500
P-24 (2880)	6514136.7200	6158306.2200	6518414.6100	6155705.3100
P-23 (2760)	6514074.3800	6158203.6900	6518352.2700	6155602.7800
P-22 (2640)	6514012.0400	6158101.1500	6518289.9300	6155500.2400
P-21 (2520)	6513949.7000	6157998.6100	6518227.5900	6155397.7000
P-20 (2400)	6513887.3600	6157896.0800	6518165.2500	6155295.1700
P-19 (2280)	6513825.0200	6157793.5400	6518102.9100	6155192.6300
P-18 (2160)	6513762.6700	6157691.0100	6518040.5700	6155090.1000
P-17 (2040)	6513700.3300	6157588.4700	6517978.2300	6154987.5600
P-16 (1920)	6513637.9900	6157485.9300	6517915.8800	6154885.0200
P-15 (1800)	6513575.6500	6157383.4000	6517853.5400	6154782.4900
P-14 (1680)	6513513.3100	6157280.8600	6517791.2000	6154679.9500
P-13 (1560)	6513450.9700	6157178.3300	6517728.8600	6154577.4200
P-12 (1440)	6513388.6300	6157075.7900	6517666.5200	6154474.8800
P-11 (1320)	6513326.2900	6156973.2500	6517604.1800	6154372.3400
P-10 (1200)	6513263.9500	6156870.7200	6517541.8400	6154269.8100
P-9 (1080)	6513201.6100	6156768.1800	6517479.5000	6154167.2700
P-8 (960)	6513139.2700	6156665.6500	6517417.1600	6154064.7400
P-7 (840)	6513076.9300	6156563.1100	6517354.8200	6153962.2000
P-6 (720)	6513014.5900	6156460.5700	6517292.4800	6153859.6600
P-5 (600)	6512952.2500	6156358.0400	6517230.1400	6153757.1300
P-4 (480)	6512889.9000	6156255.5000	6517167.8000	6153654.5900
P-3 (360)	6512827.5600	6156152.9700	6517105.4600	6153552.0600
P-2 (240)	6512765.2200	6156050.4300	6517043.1100	6153449.5200
P-1 (120)	6512702.8800	6155947.8900	6516980.7700	6153346.9800
S-1 (120)	6512578.2000	6155742.8200	6516856.0900	6153141.9100
S-2 (240)	6512515.8600	6155640.2900	6516793.7500	6153039.3800
S-3 (360)	6512453.5200	6155537.7500	6516731.4100	6152936.8400
S-4 (480)	6512391.1800	6155435.2100	6516669.0700	6152834.3000
S-5 (600)	6512328.8400	6155332.6800	6516606.7300	6152731.7700
S-6 (720)	6512266.5000	6155230.1400	6516544.3900	6152629.2300
S-7 (840)	6512204.1600	6155127.6100	6516482.0500	6152526.7000
S-8 (960)	6512141.8200	6155025.0700	6516419.7100	6152424.1600
S-9 (1080)	6512079.4700	6154922.5300	6516357.3700	6152321.6200

S-10 (1200)	6512017.1300	6154820.0000	6516295.0300	6152219.0900
S-11 (1320)	6511954.7900	6154717.4600	6516232.6900	6152116.5500
S-12 (1440)	6511892.4500	6154614.9300	6516170.3400	6152014.0200
S-13 (1560)	6511830.1100	6154512.3900	6516108.0000	6151911.4800
S-14 (1680)	6511767.7700	6154409.8500	6516045.6600	6151808.9400
S-15 (1800)	6511705.4300	6154307.3200	6515983.3200	6151706.4100
S-16 (1920)	6511643.0900	6154204.7800	6515920.9800	6151603.8700
S-17 (2040)	6511580.7500	6154102.2500	6515858.6400	6151501.3400
S-18 (2160)	6511518.4100	6153999.7100	6515796.3000	6151398.8000
S-19 (2280)	6511456.0700	6153897.1700	6515733.9600	6151296.2600
S-20 (2400)	6511393.7300	6153794.6400	6515671.6200	6151193.7300
S-21 (2520)	6511331.3900	6153692.1000	6515609.2800	6151091.1900
S-22 (2640)	6511269.0500	6153589.5700	6515546.9400	6150988.6600
S-23 (2760)	6511206.7000	6153487.0300	6515484.6000	6150886.1200
S-24 (2880)	6511144.3600	6153384.4900	6515422.2600	6150783.5800
S-25 (3000)	6511082.0200	6153281.9600	6515359.9100	6150681.0500
S-26 (3120)	6511019.6800	6153179.4200	6515297.5700	6150578.5100
S-27 (3240)	6510957.3400	6153076.8900	6515235.2300	6150475.9800
S-28 (3360)	6510895.0000	6152974.3500	6515172.8900	6150373.4400
S-29 (3480)	6510832.6600	6152871.8100	6515110.5500	6150270.9000
S-30 (3600)	6510770.3200	6152769.2800	6515048.2100	6150168.3700
S-31 (3720)	6510707.9800	6152666.7400	6514985.8700	6150065.8300
S-32 (3840)	6510645.6400	6152564.2100	6514923.5300	6149963.3000
S-33 (3960)	6510583.3000	6152461.6700	6514861.1900	6149860.7600
S-34 (4080)	6510520.9600	6152359.1300	6514798.8500	6149758.2200
S-35 (4200)	6510458.6200	6152256.6000	6514736.5100	6149655.6900
S-36 (4320)	6510396.2800	6152154.0600	6514674.1700	6149553.1500
S-37 (4440)	6510333.9300	6152051.5300	6514611.8300	6149450.6200
S-38 (4560)	6510271.5900	6151948.9900	6514549.4900	6149348.0800
S-39 (4680)	6510209.2500	6151846.4500	6514487.1400	6149245.5400
S-40 (4800)	6510146.9100	6151743.9200	6514424.8000	6149143.0100
S-41 (4920)	6510084.5700	6151641.3800	6514362.4600	6149040.4700
S-42 (5040)	6510022.2300	6151538.8400	6514300.1200	6148937.9400
S-43 (5160)	6509959.8900	6151436.3100	6514237.7800	6148835.4000
S-44 (5280)	6509897.5500	6151333.7700	6514175.4400	6148732.8600
S-45 (5400)	6509835.2100	6151231.2400	6514113.1000	6148630.3300
S-46 (5520)	6509772.8700	6151128.7000	6514050.7600	6148527.7900
S-47 (5640)	6509710.5300	6151026.1600	6513988.4200	6148425.2600
S-48 (5760)	6509648.1900	6150923.6300	6513926.0800	6148322.7200
S-49 (5880)	6509585.8500	6150821.0900	6513863.7400	6148220.1800
S-50 (6000)	6509523.5000	6150718.5600	6513801.4000	6148117.6500
S-51 (6120)	6509461.1600	6150616.0200	6513739.0600	6148015.1100
S-52 (6240)	6509398.8200	6150513.4800	6513676.7200	6147912.5800
S-53 (6360)	6509336.4800	6150410.9500	6513614.3700	6147810.0400
S-54 (6480)	6509274.1400	6150308.4100	6513552.0300	6147707.5000
S-55 (6600)	6509211.8000	6150205.8800	6513489.6900	6147604.9700
S-56 (6720)	6509149.4600	6150103.3400	6513427.3500	6147502.4300
S-57 (6840)	6509087.1200	6150000.8000	6513365.0100	6147399.9000
S-58 (6960)	6509024.7800	6149898.2700	6513302.6700	6147297.3600
S-59 (7080)	6508962.4400	6149795.7300	6513240.3300	6147194.8200

S-60 (7200)	6508900.1000	6149693.2000	6513177.9900	6147092.2900
S-61 (7320)	6508837.7600	6149590.6600	6513115.6500	6146989.7500
S-62 (7440)	6508775.4200	6149488.1200	6513053.3100	6146887.2200
S-63 (7560)	6508713.0800	6149385.5900	6512990.9700	6146784.6800
S-64 (7680)	6508650.7300	6149283.0500	6512928.6300	6146682.1400
S-65 (7800)	6508588.3900	6149180.5200	6512866.2900	6146579.6100
S-66 (7920)	6508526.0500	6149077.9800	6512803.9400	6146477.0700
S-67 (8040)	6508463.7100	6148975.4400	6512741.6000	6146374.5400
S-68 (8160)	6508401.3700	6148872.9100	6512679.2600	6146272.0000
S-69 (8280)	6508339.0300	6148770.3700	6512616.9200	6146169.4600
S-70 (8400)	6508276.6900	6148667.8400	6512554.5800	6146066.9300
S-71 (8520)	6508214.3500	6148565.3000	6512492.2400	6145964.3900
S-72 (8640)	6508152.0100	6148462.7600	6512429.9000	6145861.8600
S-73 (8760)	6508089.6700	6148360.2300	6512367.5600	6145759.3200
S-74 (8880)	6508027.3300	6148257.6900	6512305.2200	6145656.7800
S-75 (9000)	6507964.9900	6148155.1600	6512242.8800	6145554.2500
S-76 (9120)	6507902.6500	6148052.6200	6512180.5400	6145451.7100
S-77 (9240)	6507840.3100	6147950.0800	6512118.2000	6145349.1800
S-78 (9360)	6507777.9600	6147847.5500	6512055.8600	6145246.6400
S-79 (9480)	6507715.6200	6147745.0100	6511993.5200	6145144.1000
S-80 (9600)	6507653.2800	6147642.4800	6511931.1700	6145041.5700
S-81 (9720)	6507590.9400	6147539.9400	6511868.8300	6144939.0300
S-82 (9840)	6507528.6000	6147437.4000	6511806.4900	6144836.5000
S-83 (9960)	6507466.2600	6147334.8700	6511744.1500	6144733.9600
S-84 (10080)	6507403.9200	6147232.3300	6511681.8100	6144631.4200
S-85 (10200)	6507341.5800	6147129.8000	6511619.4700	6144528.8900
S-86 (10320)	6507279.2400	6147027.2600	6511557.1300	6144426.3500
S-87 (10440)	6507216.9000	6146924.7200	6511494.7900	6144323.8100
S-88 (10560)	6507154.5600	6146822.1900	6511432.4500	6144221.2800
S-89 (10680)	6507092.2200	6146719.6500	6511370.1100	6144118.7400
S-90 (10800)	6507029.8800	6146617.1200	6511307.7700	6144016.2100
S-91 (10920)	6506967.5300	6146514.5800	6511245.4300	6143913.6700
S-92 (11040)	6506905.1900	6146412.0400	6511183.0900	6143811.1300
S-93 (11160)	6506842.8500	6146309.5100	6511120.7500	6143708.6000
S-94 (11280)	6506780.5100	6146206.9700	6511058.4000	6143606.0600
S-95 (11400)	6506718.1700	6146104.4400	6510996.0600	6143503.5300
S-96 (11520)	6506655.8300	6146001.9000	6510933.7200	6143400.9900
S-97 (11640)	6506593.4900	6145899.3600	6510871.3800	6143298.4500
S-98 (11760)	6506531.1500	6145796.8300	6510809.0400	6143195.9200
S-99 (11880)	6506468.8100	6145694.2900	6510746.7000	6143093.3800
S-100 (12000)	6506406.4700	6145591.7600	6510684.3600	6142990.8500

All goals have been met successfully. All transects were completed except three which were limited due to due underwater constructions (oil rigs). Measurements were conducted simultaneously providing consistent information on the structure of a top layer of bottom sediments (subbottom profiler), bottom surface (2D scan – sidescan sonar) as well as precise bathymetry, intensity of backscattered acoustical signal and gas fluxes in the water column (multibeam echosounder).

Preliminary results

The first results of subbottom profiler data processing delivered information on spatial distribution of gas diffusion chimneys and sea bottom effusion craters in the investigated area (Fig.6).

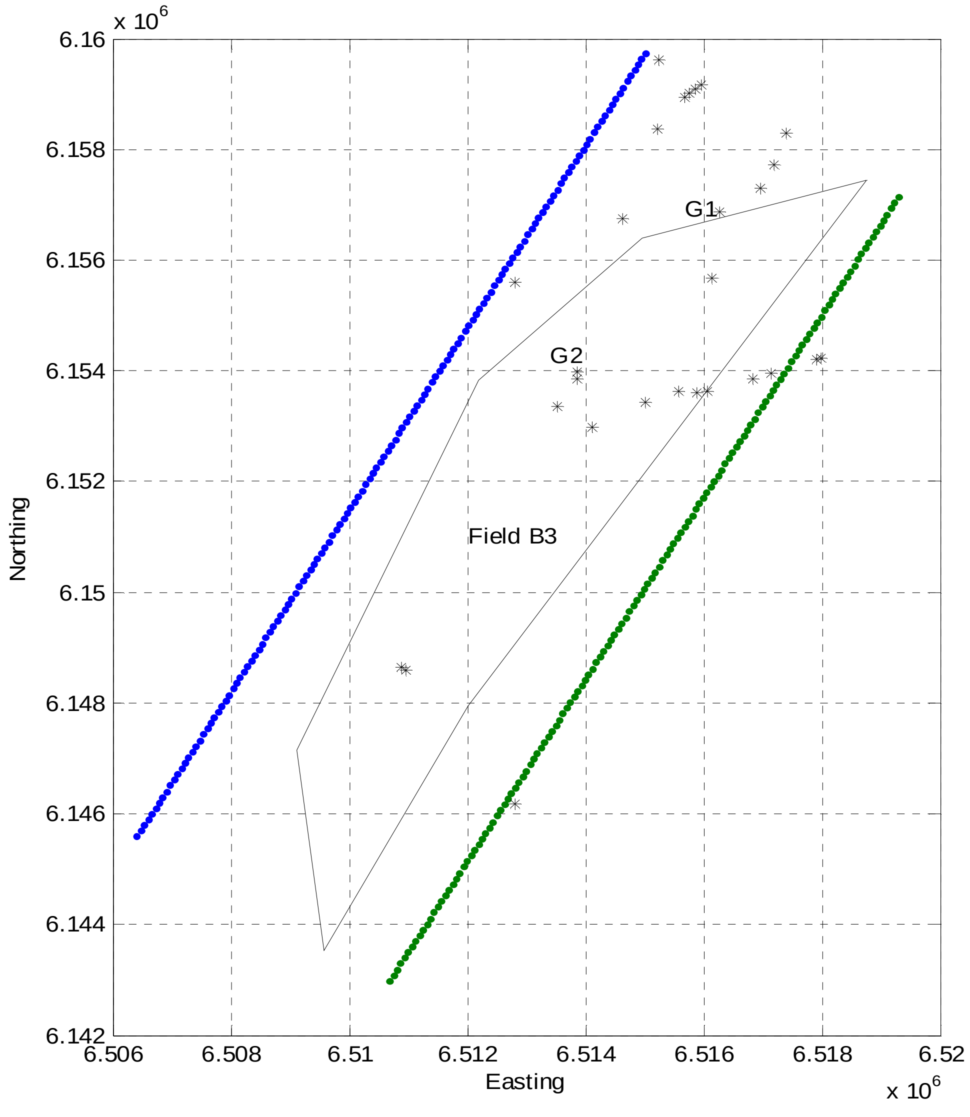


Fig. 6. Southern Baltic oil field B3 (border depicted by black solid line). Star points show positions of gas diffusion chimneys and bottom sea craters. The blue and green dots are starting and finishing points of 138 hydroacoustical transects which are perpendicular?? to the main axis of the field.

Two examples of vertical hydrocarbon migration zones are presented in Figures 7 and 8 while the examples of mosaic maps constructed from sidescan sonar are shown in Fig. 9a, b.

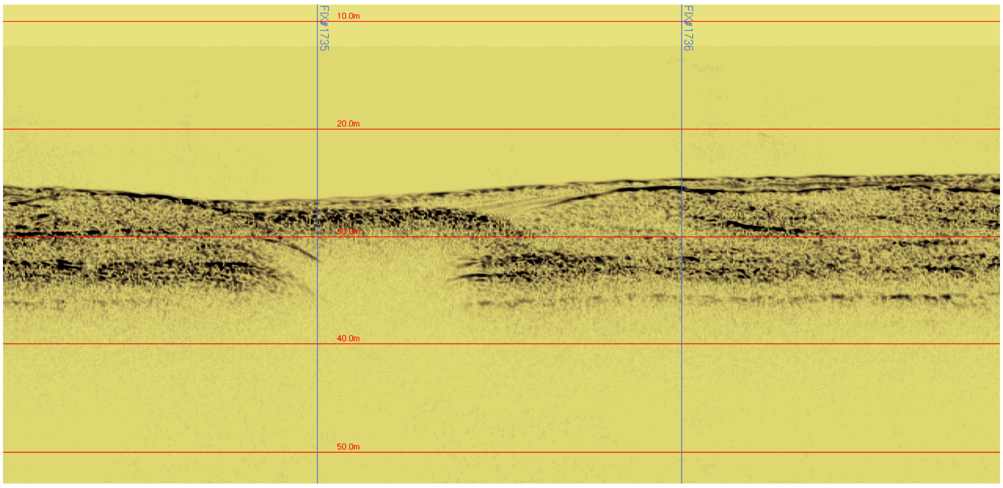


Fig. 7. The sea crater and top part of gas diffusion chimney. The position of this structure is visible in Fig.6 as G1

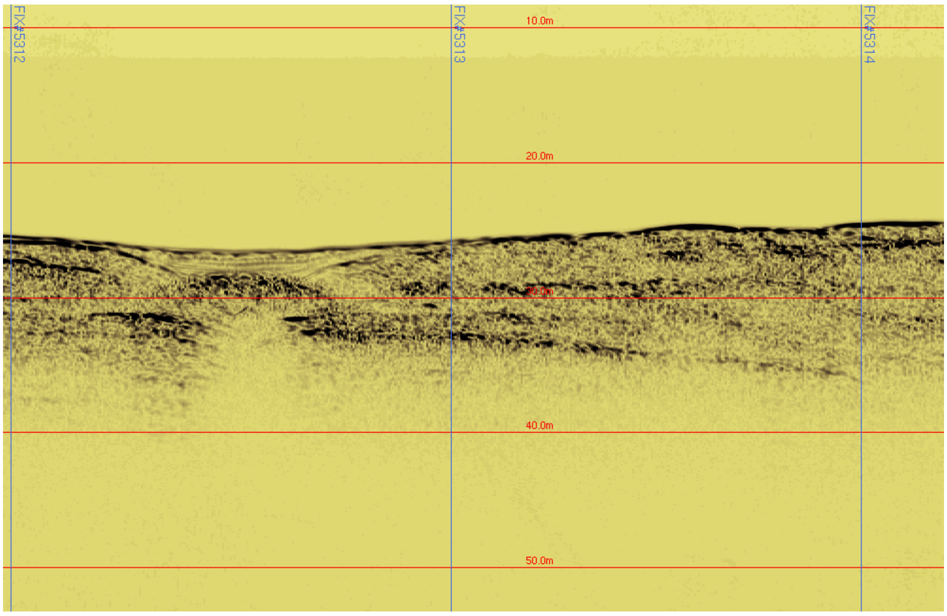
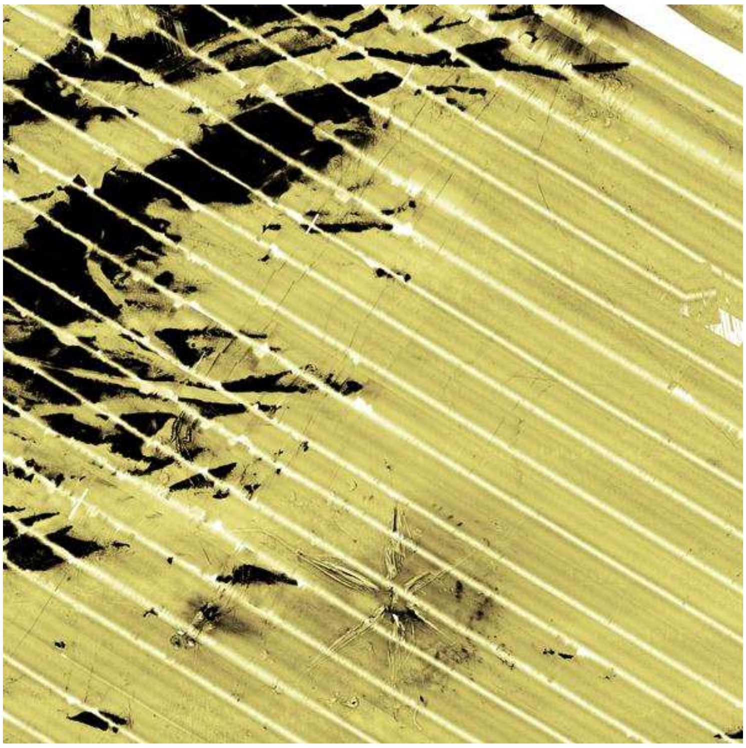


Fig. 8. The sea crater and top part of gas diffusion chimney. The position of this structure is visible in Fig.6 as G2

a)



b)

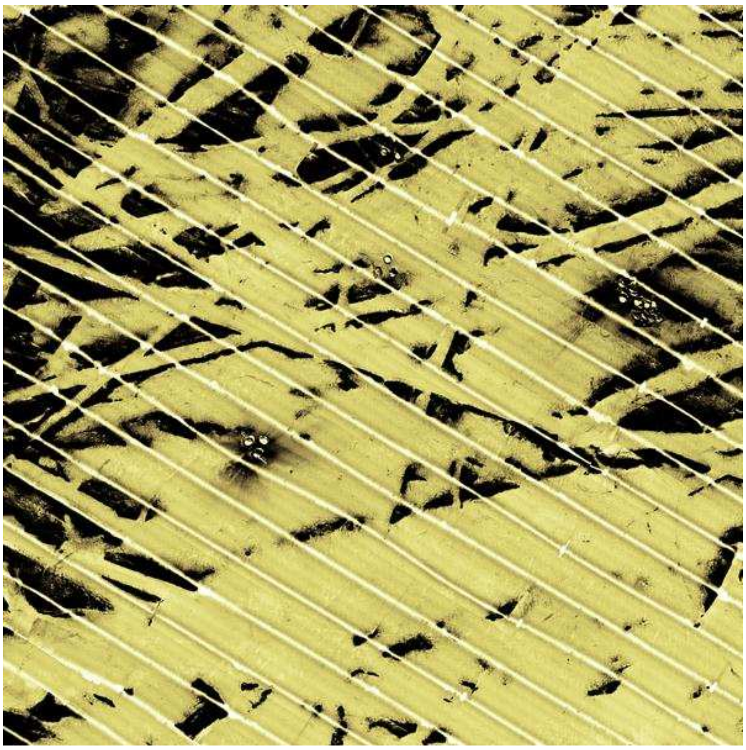


Fig. 9. The mosaic map of seafloor part at B3 area

4. BIOGEOCHEMICAL SURVEY

Twenty three sites within an area of the B3 field (Fig. 10) were sampled for overlying-bottom water, surface sediments and pore waters between August 27, 2012 and September 3, 2012 (Table 2).

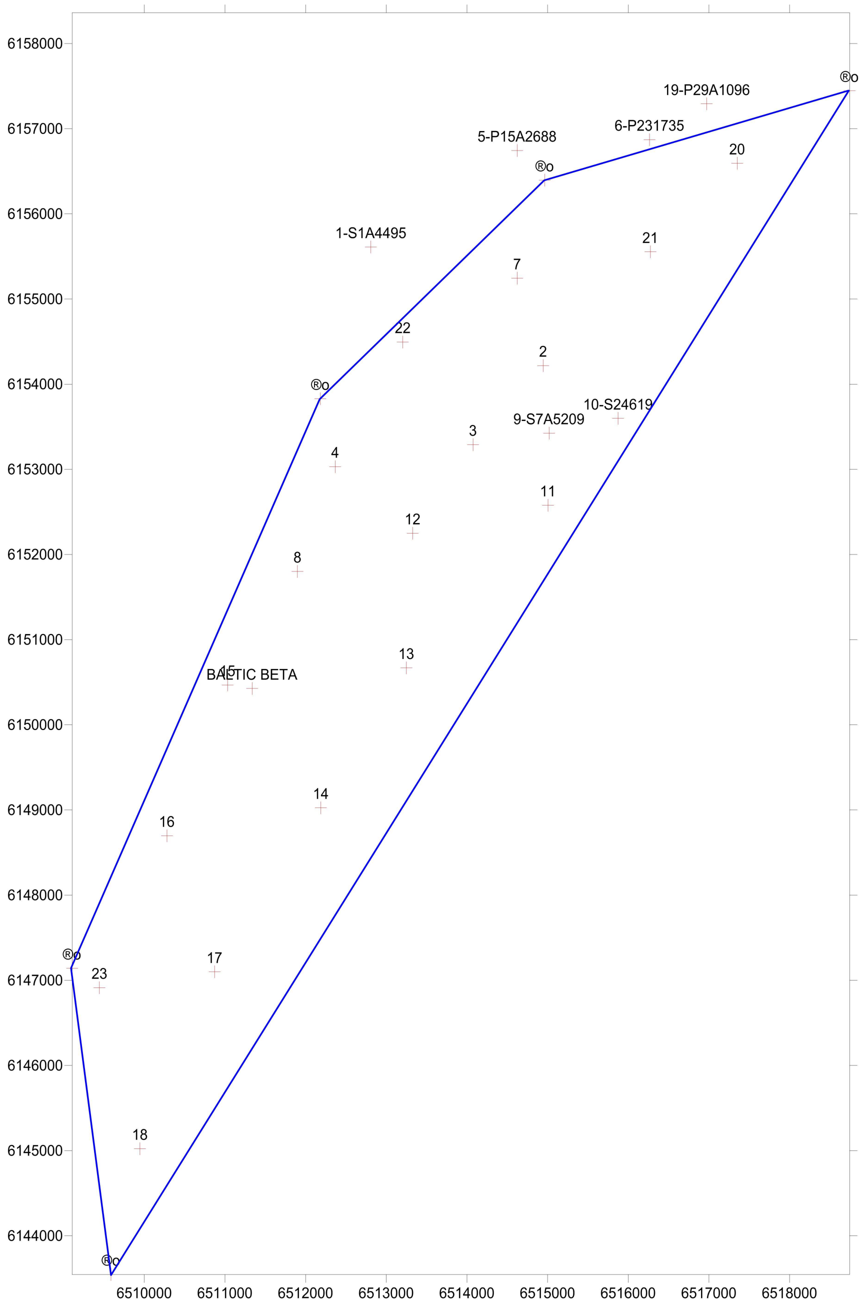


Fig. 10. Location of sampling sites in the B3 field (border depicted by blue line) for biological and geochemical measurements (WN32 coordinates)

Exception was site 5 where only hydrological parameters in the overlying-bottom water were measured *in situ*. Sampling sites were selected to represent a range of bottom sediment types (Fig. 11) and areas where gas diffusion chimneys and sea bottom effusion craters had been identified with hydroacoustical methods during the previous cruises (WP1).

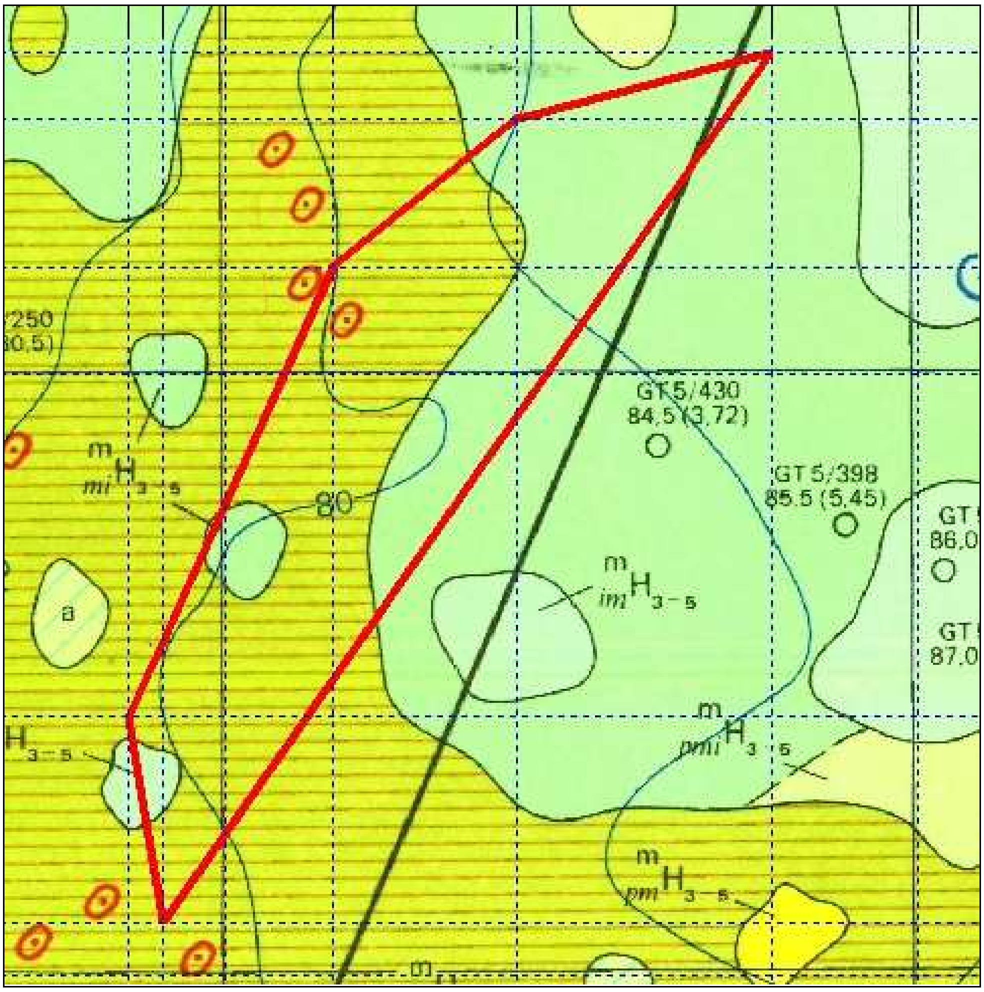
Table 2. Details of sampling in the B3 field

Date	Hour	Site no	Indication of gas diffusion chimneys	Research type	Depth (m)	Geographical position	
29.08.2012	08:30	1	S1A_4495	H, G-Ch, B*	81	55°31.700' N	18°12.170' E
	10:28	2		H, B	84	55°30.948' N	18°14.202 E
	12:04	3		H, B	82	55°30.448' N	18°13.370' E
	13:12	4		H, B	80	55°30.312' N	18°11.742' E
	14:38	5	P15_2678	H	84	55°32.309' N	18°13.910; E
	15:50	6	P23_1735	H, G-Ch, B	86	55°32.382' N	18°15.466' E
	17:46	7		H, B	83	55°31.517' N	18°13.901' E
30.08.2012	10:42	8		H, B	81	55°29.653' N	18°11.304' E
	11:05	9	S7A_5209	H, G-Ch, B	84	55°30.523' N	18°14.286' E
31.08.2012	12:08	10	S2_4619	H, G-Ch, B	85	55°30.615' N	18°15.091' E
30.08.2012	15:37	11		H, G-Ch, B	83	55°30.070' N	18°14.257' E
	17:25	12		H, B	83	55°29.892' N	18°12.658' E
	18:44	13		H, B	81	55°29.043' N	18°12.597' E
31.08.2012	08:24	14		H, B	81	55°28.156' N	18°11.576' E
	13:00	15		H, G-Ch, B	81	55°28.930' N	18°10.480' E
	14:37	16		H, B	79	55°27'976' N	18°09.761' E
	15:10	17		H, G-Ch, B	80	55°27.119' N	18°10.329' E
	17:14	18		H, B	80	55°25.998' N	18°09.442' E
01.09.2012	07:52	19	P29A_1096	H, G-Ch, B	88	55°32.611' N	18°16.120' E
	09:40	20		H, G-Ch, B	81	55°32.232' N	18°16.479' E
	11:15	21		H, B	86	55°31.674' N	18°15.451' E
	13:03	22		H, G-Ch, B	81	55°31.106' N	18°12.524' E
	15:30	23		H, B	81	55°27.029' N	18°08.948' E

* H - hydrological measurements in the overlying-bottom water

G-Ch - geochemical measurements in the overlying-bottom water and surface sediments

B - biological sampling



- sand-silt-gravel on the subaqual loam
- marine clayey silt on the marine clays and silty clays of the Yoldia sea and Ancylus lake
- iron-manganese (Fe-Mn) nodules
- clayey silt

Fig. 11. Oil-carrying field B3 in the southern Baltic Sea B3 (border depicted by red line) on the map of surface sediments (Geological Atlas of the Southern Baltic 1995 modified)

4.1. Hydrological parameters

Overlying-bottom water was sampled by means of a modified 5 dm3 Teflon GoFlo water sampler (Niskin type) equipped with metal end stoppers and Teflon sealed polyethylene valves. Equipment was modified to collect overlying-bottom water samples at a constant height of 20 cm above the sea bottom. The closure of the sampler was controlled by a 20 cm long polypropylene rope and plastic-lined metal counterweight. When the rope touched the sediment the counterweight closed the valves of the sampler, whereby the sampler remained in its original position to prevent entrance of material resuspended from the sediment (mobile surface sediments and biogenic “fluff”) due to usage of the sampler. At each site, basic hydrological parameters of overlying-bottom water, including temperature, salinity, dissolved oxygen concentration, pH and Eh were recorded with a WTW Multiline P4 analyser, YSI Model 58 dissolved oxygen meter and Eh meter. In addition, the same hydrological parameters were measured in water at a distance of 5 cm above the sea floor which was collected with a standard Niemistö gravity corer with an internal diameter of 76 mm (Fig. 12).

Fig. 12. Niemistö corer used to sample surface sediments and overlying bottom water

4.1. Geochemical measurements

Sediment samples were collected in four replicates from ten sites (1, 6, 9, 10, 11, 15, 17, 19, 20, 22) using plexi-glass tubes with a Niemistö gravity corer. Immediately after taking the samples one replicate was divided into 1 cm thick slices from the surface to the depth of 5 cm and into 5.0-7.5 cm, 7.5-10.0 cm and 10.0-15.0 cm slices in the deeper part of the sediment core. Reduction potential was directly recorded in each layer and then the subsamples were frozen separately in dense polyethylene bags at -20°C for determination of granulometric structure, moisture content (W), loss of ignition (LOI) and C, N, P and chlorophyll *a* (chl *a*) contents. Sediment samples for methane concentration were taken from the second sediment core. Sub-sections of wet sediment from three surface layers: 0-2.5, 2.5-5.0 and 5.0-7.5 cm were transferred to headspace vials containing 2.5% NaOH. The vials were closed immediately with rubber stoppers and stored in dark at 4^{o}C until analysis. Pore waters from five sediment layers (0-2.5 cm, 2.5-5.0 cm, 5.0-7.5 cm, 7.5-10.0 cm and 10.0-12.5 cm) were sampled directly from two remaining sediment cores using standard CSS Rhizons (5 cm porous part, diameter 2.5 mm; Fig. 13).

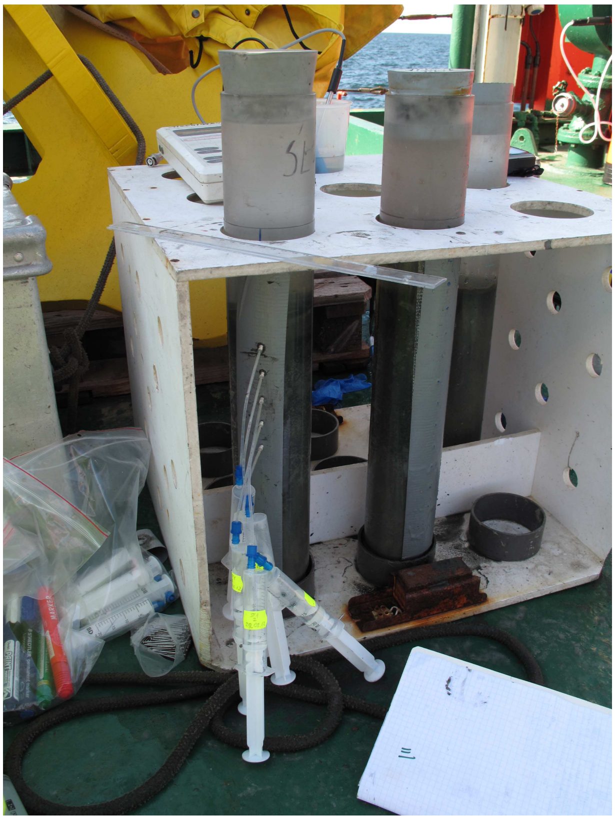


Fig. 13. CCS rhizons for sampling interstitial water from the Niemistö corer

Pore water samples for dissolved inorganic and organic carbon (DIC and DOC) measurements were filtered through Millipore glass-fiber filters (0.22 µm) and stored in dark at 4^{o}C until analysis. Concentrations of hydrogen sulphide, phosphates, ammonia, nitrites, sulphates and total alkalinity in pore waters were measured in two or three replicates on board. Each sample was diluted with distilled water or oxygen-free water in the case of H_2S. Hydrogen sulphide concentration was analysed using methylene blue colorimetric method (Parsons et al. 1989) while dissolved phosphates were measured by molybdenum blue colorimetric method (Hansen and Koroleff 1999). Ammonia was determined by modified indophenol blue spectrophotometric method (Koroleff 1983). Nitrites were measured via the diazo reaction based on the method of Grasshoff (1983) and sulphate measurements were performed on the basis of the colorimetric method with barium chloride. Total alkalinity was determined through an acidimetric titration (0.01M HCl) according to Anderson et al. (1999). The same analyses were made simultaneously in the overlying-bottom water.

4.3. Biological samples

Surface sediments for biological analysis (0-30 cm) were sampled in triplicate with a Van Veen grab (with penetration enhanced by 32 kg; 0.1 m^2 surface area). The top 30 cm section represents the fraction of the sediments that most benthic invertebrates can penetrate and is the biological relevant portion of the sediment. Sediments were gently wet sieved through a 1 mm mesh size net to reduce the amount of sediment and inorganic debris, and to sort out the macrobenthic organisms, which were then preserved in polyethylene vials with 4% buffered formaldehyde. Special care was taken to remove delicate or enmeshed specimens from the sieve mesh. In addition, the top 5 cm thick core was taken in four replicates with a polypropylene syringe and preserved in 4% buffered formaldehyde for analysis of meiofaunal communities.

5. ACKNOWLEDGEMENTS

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6. LITERATURE

Anderson L.G., Turner D.R., Wedborg M., Dyrssen D., 1999. Determination of total alkalinity and total dissolved inorganic carbon. In: Grasshoff K., Kremling K., Ehrhardt M. (eds.), Methods of seawater analysis. Wiley-VCH, Weinheim, 144-146

Grasshoff K., 1983. Determination of nitrite, nitrate, oxygen, thiosulphate. In: Grasshoff K., Kremling K., Ehrhardt M. (eds.), Methods of seawater analysis. Wiley-VCH, Weinheim, 139-142, 143-150, 61-72, 81-84

Hansen H., Koroleff F., 1999. Determination of nutrients. In: Grasshoff K., Kremling K., Ehrhardt M. (eds.), Methods of seawater analysis. Wiley-VCH, Weinheim, 159-228

Koroleff F., 1983. Determination of ammonia. In: Grasshoff K., Kremling K., Ehrhardt M. (eds.), Methods of seawater analysis. Wiley-VCH, Weinheim, 150-157

Parsons T., Maita Y., Lalli C., 1984. A manual of chemical and biological methods for seawater analysis. Pergamon Press, Oxford, 173 pp.