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Coastal Research and Planning Institute, Klaipėda University

Project: A system for the sustainable management of Lithuanian marine resources using novel surveillance, modeling tools and ecosystem approach

Technical Report No. 8

SURVEILLANCE OF THE LITHUANIAN MARINE RESOURCES FROM SEDIMENT PROFILE IMAGES (SPI) USING THE BENTHIC HABITAT QUALITY (BHQ) INDEX AND SEDIMENT SURFACE IMAGES (SSI)

Project indicators:
1. Documented assessment of fish feeding ground quality
2. Documented assessment of water quality impact on spatial distribution of feeding and spawning grounds

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Surveillance of the Lithuanian marine resources from Sediment Profile Images (SPI) using the Benthic Habitat Quality (BHQ) index and Sediment Surface Images (SSI)	8	2011-03-30
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Abstract

In situ sediment profile imagery (SPI) and sediment surface imagery (SSI) were used to examine sediment structure and biogenic activity. At several locations, the sediment habitat quality was degraded due to hypoxic conditions and low biological activity both on top of and below surface sediments. The sediment profile camera work as an upside-down periscope penetrating the sediment surface and looking horizontally into the sediment. The image is about 17 cm wide and 26 cm high, with a typical penetration depth of 15 cm. Sediment profile image analysis according to the benthic habitat quality index (BHQ) is based on sediment surface structures, subsurface structures and the measurement of the apparent redox potential discontinuity (RPD).

Sediment at 117 m were very soft and with deep (20-25 cm) penetration and SPI analysis revealed low Benthic Habitat Quality (BHQ) that was supported by SSI with 100 % cover of *Beggiatoa* maths that indicate oxygen deficiency and high hydrogen sulfide concentrations with very bad conditions for benthic macrofauna.

Sediment at 95 m were sandy with moderate (5-9 cm) penetration and SPI analysis revealed low Benthic Habitat Quality (BHQ) that was supported by SSI with 25 % cover of Beggiatoa maths that indicate oxygen patches of oxygen deficiency and poor.

Several station at depths 81-62 m had mixed habitat and low (0-2 cm) penetration and large stones on the sediment surface both SPI and SSI.
SPI-stations 45, 46 and 47 at 72, 62 and 62 m respectively, were only investigated using video sledge but the conditions were very similar to conditions at 81m.

Coastal stations at depths (< 50 m) were transport bottoms composed of rippled sand sediments with low (0-3 cm) penetration and very limited SPI and SSI analysis could be performed.

4 keywords, Norwegian	4 keywords, English
1. 2. 3. 4.	1. Sediment Profile Image (SPI) 2. Sediment Surface Camera (SSI) 3. Baltic Sea 4. *Beggiatoa*

Preface

Fieldwork in this study was performed by Hans C Nilsson during June 2009. A technical report was delivered after field work with preliminary results that concluded that the SPI technique was not suitable for the majority of the stations investigated. This final technical report results from Sediment Profile Images (SPI) and Sediment Surface Images (SSI) from all stations in an attempt to extract as much information possible to support future investigations in the area.

Oslo, 2011-03-30

Karl Norling

Contents

Summary

In situ sediment profile imagery (SPI) and sediment surface imagery (SSI) were used to examine sediment structure and biogenic activity. At several locations, the sediment habitat quality was degraded due to hypoxic conditions and low biological activity both on top of and below surface sediments.

The sediment profile camera work as an upside-down periscope penetrating the sediment surface and looking horizontally into the sediment. The SPI image is about 17 cm wide and 26 cm high, with a typical penetration depth of 15 cm. Sediment profile image analysis according to the benthic habitat quality index (BHQ) is based on sediment surface structures, subsurface structures and the measurement of the apparent redox potential discontinuity (RPD). The SSI image is about 50 cm wide and 33 cm high. Sediment surface image analysis were performed to describe visible sediment structures, infauna structures and epifauna present.

Sediments at 117 m (SP-42b) were very soft and with deep (20-25 cm) penetration and SPI analysis revealed low BHQ that was supported by SSI with ~100 % cover of *Beggiatoa* maths that indicate oxygen deficiency and high hydrogen sulfide concentrations with very bad conditions for benthic macrofauna.

Sediments at 95 m (SP-43) were sandy with moderate (5-9 cm) penetration and SPI analysis revealed low Benthic BHQ that was supported by SSI with ~15 % cover of *Beggiatoa* maths that indicate oxygen deficiency in patches of the sediment habitat.

Station at depths 81 m (SP44) had mixed habitat and low (0-2 cm) penetration and large stones on the sediment surface both SPI and SSI. Because of the habitat conditions were SP-45, SP-46 and SP-47 at 72, 62 and 62 m respectively, only investigated using video sledge.

Coastal stations at depths (< 50 m) were transport bottoms composed of rippled sand sediments with low (0-3 cm) penetration and very limited SPI and SSI analysis could be performed.

Introduction

Marine resources in the Lithuanian coastal zone, including the Curonian lagoon, are strongly affected by the undergoing human activities (oil transportation and extraction, port development, that include also sediment dredging and disposal, fishery and recreation). Moreover, discharges from the Nemunas river with its drainage basin larger than the whole territory of Lithuania, directly affect water quality and productivity of the Curonian lagoon and adjacent Baltic sea. Turbid Lagoon's waters, enriched in nutrients and organic material, form a plume which spreads along the coastline and seawards, covering nearly 50% of the Lithuanian coastal area. The coastal areas affected by the plume are of great significance for maintenance and renewal of marine resources as the most productive bottom biotopes and important spawning grounds of commercial fish species.

This study incorporate sediment characteristics assessed from sediment profile images (SPI) and sediment structures and epifauna diversity and density assessed from sediment surface images (SSI). The SPI technique, introduced by Rhoads and Cande (1971), provides a useful assessment of sediment features and activity of benthic organisms (Nilsson and Rosenberg 1997) and succession due to disturbance (Rosenberg et al 2002). In the Lithuanian coastal zone, little previous information exists on spatial scale variation in sediment community conditions prior to the present project. In the present study, SPI was used in conjunction with faunal samples to provide an *in situ* description of the soft-bottom environment.

The primary aim of the work package 4 with the SPI investigation was to map the effects of the plume on the benthic habitat using grab samples, video and a sediment profile images and surface images (SPI & SSI). The secondary aim of the SPI investigation was to study sediment conditions along the depth gradient in Lithuanian waters.

Methods

Sediment profile imaging (SPI) and sediment surface imaging (SSI) was carried out at 26 stations in Lithuanian waters of the Baltic Sea during 16 and 17 of June 2009 (Fig. 1). At each SPI station 4 deployments were made with a rig holding a sediment profile camera and a sediment surface camera (Appendix Table 1).These techniques were used to take *in situ* digital images of surface sediments. After each deployment, the sediment images (SPI & SSI) were transferred to a computer, stored and analysed as described below. Results are presented in Appendix Table1.

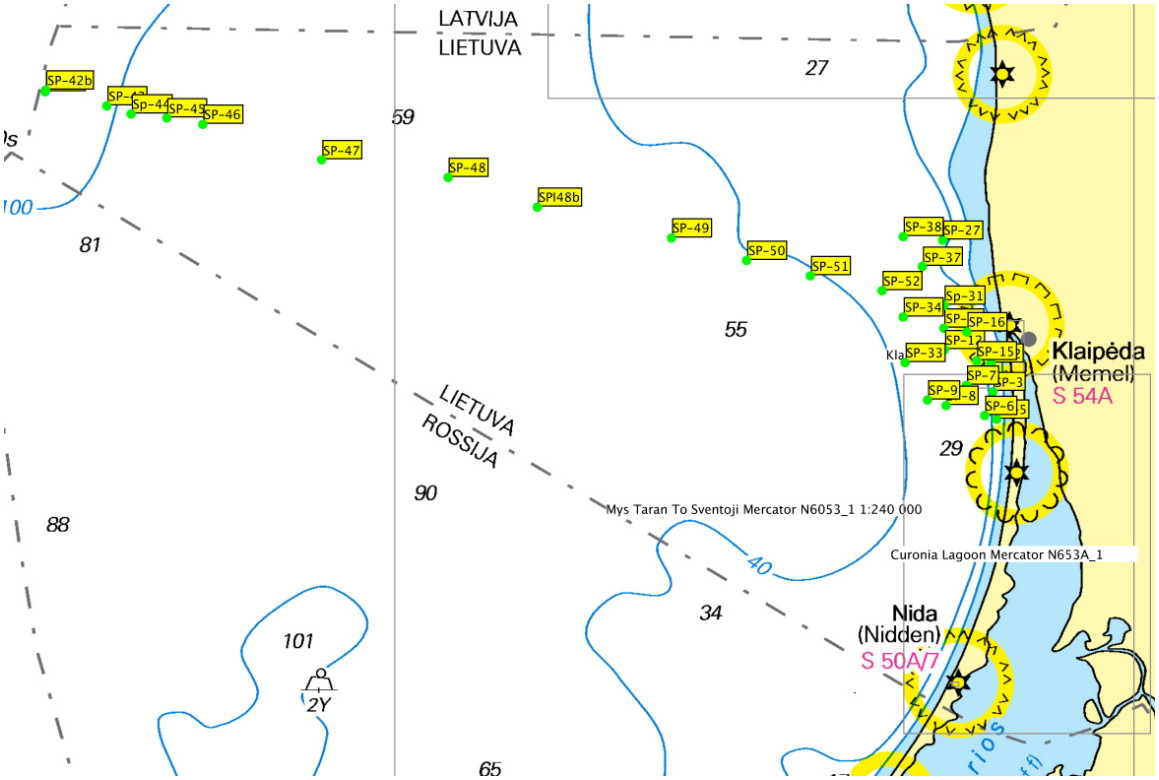

Figure 1. *Station map.*

SPI

A camera was mounted to a wedge-shaped casing in a tripod which was lowered to the bottom. The casing was supplied with an anterior vertical glass window and penetrated by its own weight into the sediment. The images obtained measure 17.3 x 26 cm. In the present study the camera used was a digital Canon EOS 50D 15.1 megapixels for Sediment profile imaging (SPI).

From the SPI images, an index of quality status can be calculated, the benthic habitat quality (BHQ) index (Figure 2, see also Nilsson and Rosenberg 1997). The BHQ-index parameters (1) sediment surface structures (presence of tubes, faecal pellets, pits, and mounds), (2) structures in the sediment (burrows, voids, and presence of infauna), and (3) mean depth of the apparent redox potential discontinuity (aRPD). The index value varies from 0 (severely disturbed with no macrofauna) to 15 ('undisturbed' and mature benthic community), with values above 7 generally indicating good environmental status.

The index has been shown to correlate with macrofaunal number of species, abundance and biomass (Rosenberg et al. 2002). The apparent redox potential discontinuity (aRPD) depth measured using SPI has been shown to correspond to redox potential discontinuity (RPD) measured by electrodes (Rosenberg et al. 2001). For calculation of the index, the sediment penetration depth should be about 5 cm or more. The penetration depth, i.e. the depth to which the camera prism sinks into the sediment in

10 s, depends on factors such as sediment grain size distribution, porosity, water and organic content as well as biogenic structures e.g. tubes and burrows. The technique is described in more detail by Nilsson and Rosenberg (1997).

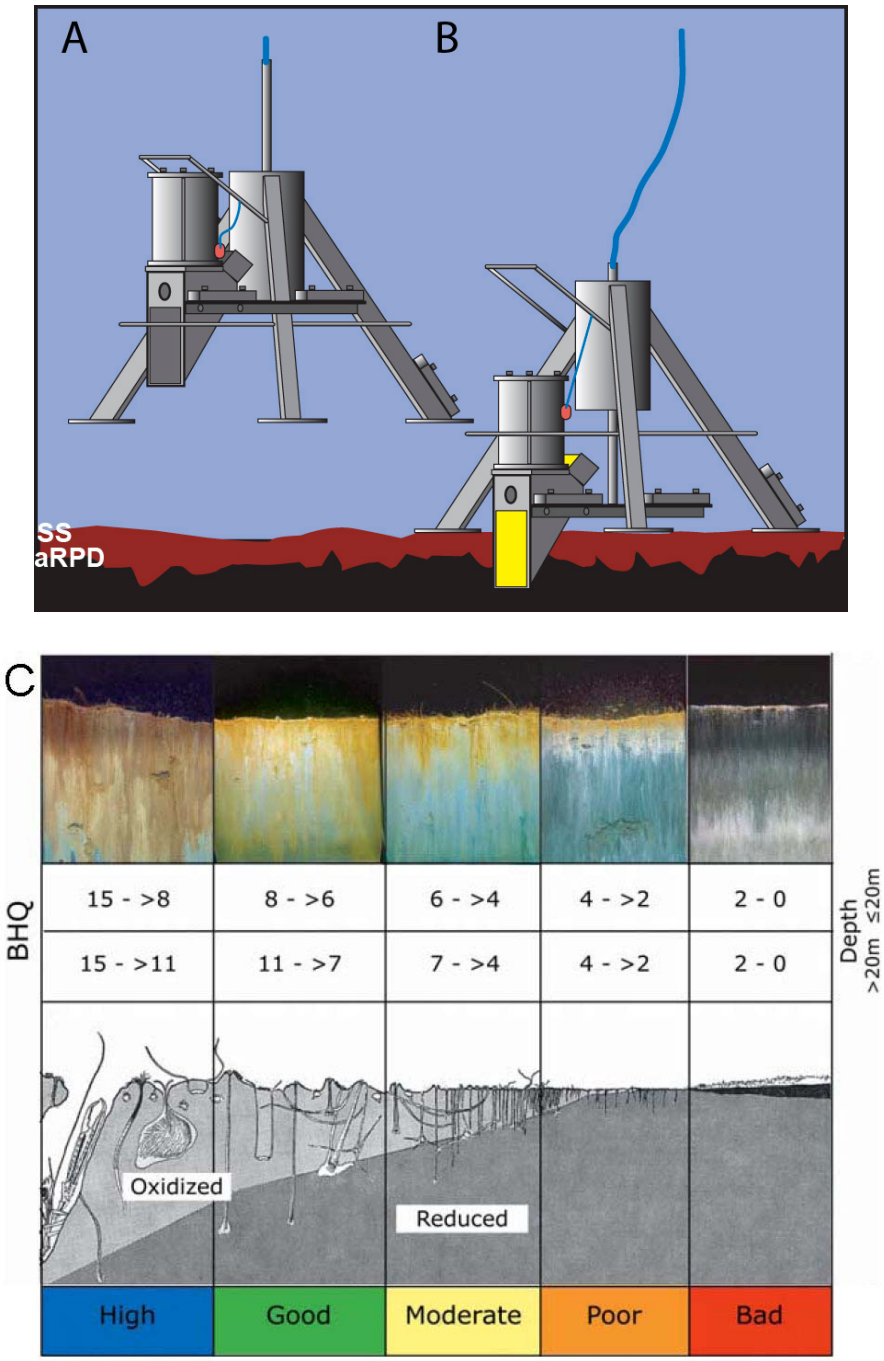

Figure 2. *Diagram of a sediment profile camera in operation. (A) The sediment profile camera just above the sediment surface. (B) The prism has penetrated the sediment surface and the image is exposed. Sediment surface (SS) and the apparent redox potential discontinuity (aRPD) is marked in the line drawing. (C) Model of the faunal successional stages along a gradient of increasing disturbance from left to right (after Pearson and Rosenberg, 1978). Sediment profile images (colours enhanced) are shown on the top where brownish colour indicates oxidized conditions and black reduced conditions,*

and the benthic habitat quality (BHQ) indices (Nilsson and Rosenberg, 1997) are presented for depths >20m and ≤20m. Figure modified from Rosenberg et al. (2004).

SSI

Additional sediment surface images (SSI) were taken during the landing of the tripod (about 0.5 m from the sediment surface, image size 30 x 50 cm) using a digital Canon EOS 40D 10.1 megapixels lit by two flashes positioned at each side of the camera.

From the SSI images were information of surface structures (e.g. boulders, silt and rippled sand), fauna structures (rare <15 per image <90m-^{2}, moderate 15-30 per image 90-180m-^{2}, common >30 per image >180 m-^{2}) and visible organisms (*Beggiatoa* and epifauna e.g. *Saduria entomon*) were registered, see Figure 3.

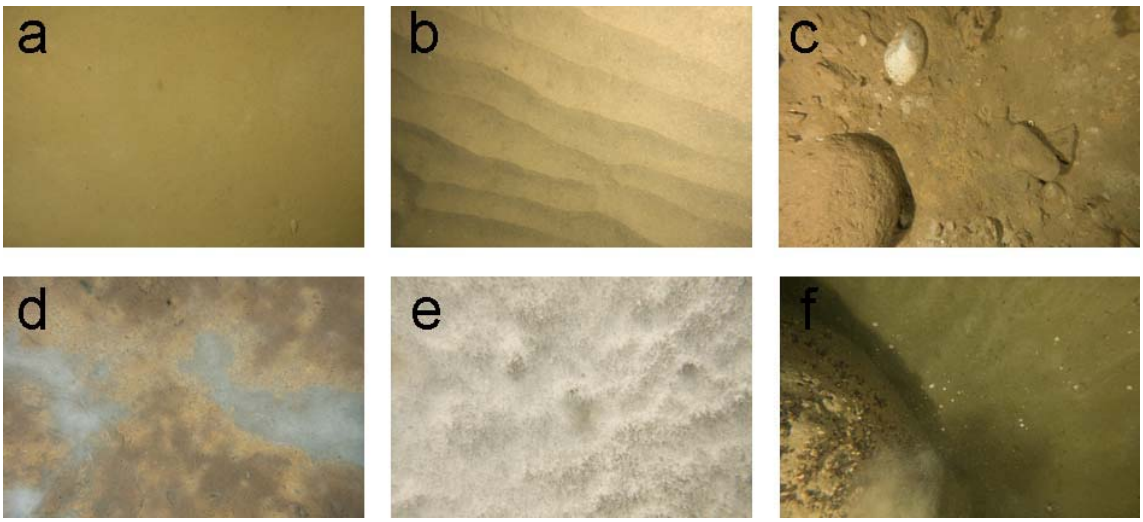

Figure 3. Sediment surface images (SSI) that show examples of different features registered a) sediment - silty sand + epifauna - Saduria entomon b) sediment - rippled sand + infauna structures - moderate c) boulders + infauna structures - rare d) 15% Beggiatoa e) 100% Beggiatoa f) Boulder + epifauna- Mytilus edulis.

Results

The SPI and SSI images from the Lithuanian waters in the Baltic Sea in 2009 indicated rippled sand at a majority of the coastal stations at depths (< 50 m, Figure 4) and poor ecological status at the deeper stations below 50 m (SP-42b, SP-43, SP-44 and SP-48 – Figure 5-8) and moderate conditions at station SP-48b (Figure 9).

Figure 4. Sediment Profile Image from station SP-5 at 14 m show rippled sandy bottom sediment.

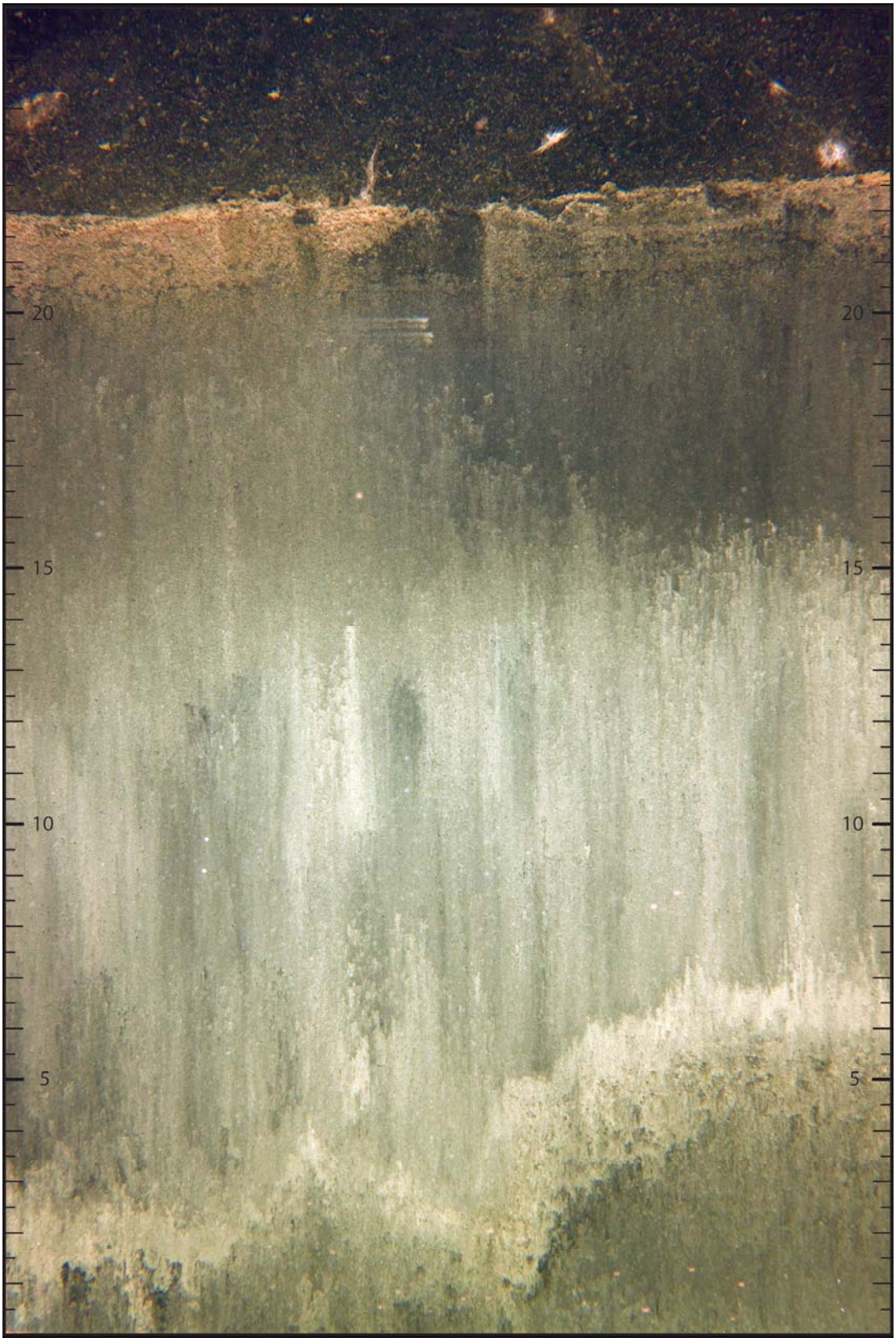

Figure 5. Sediment Profile Image from station SP-42b at 117m

Figure 6. Sediment Profile Image from station SP-43 at 95m.

Figure 7. Sediment Profile Image from station SP-44 at 81m.

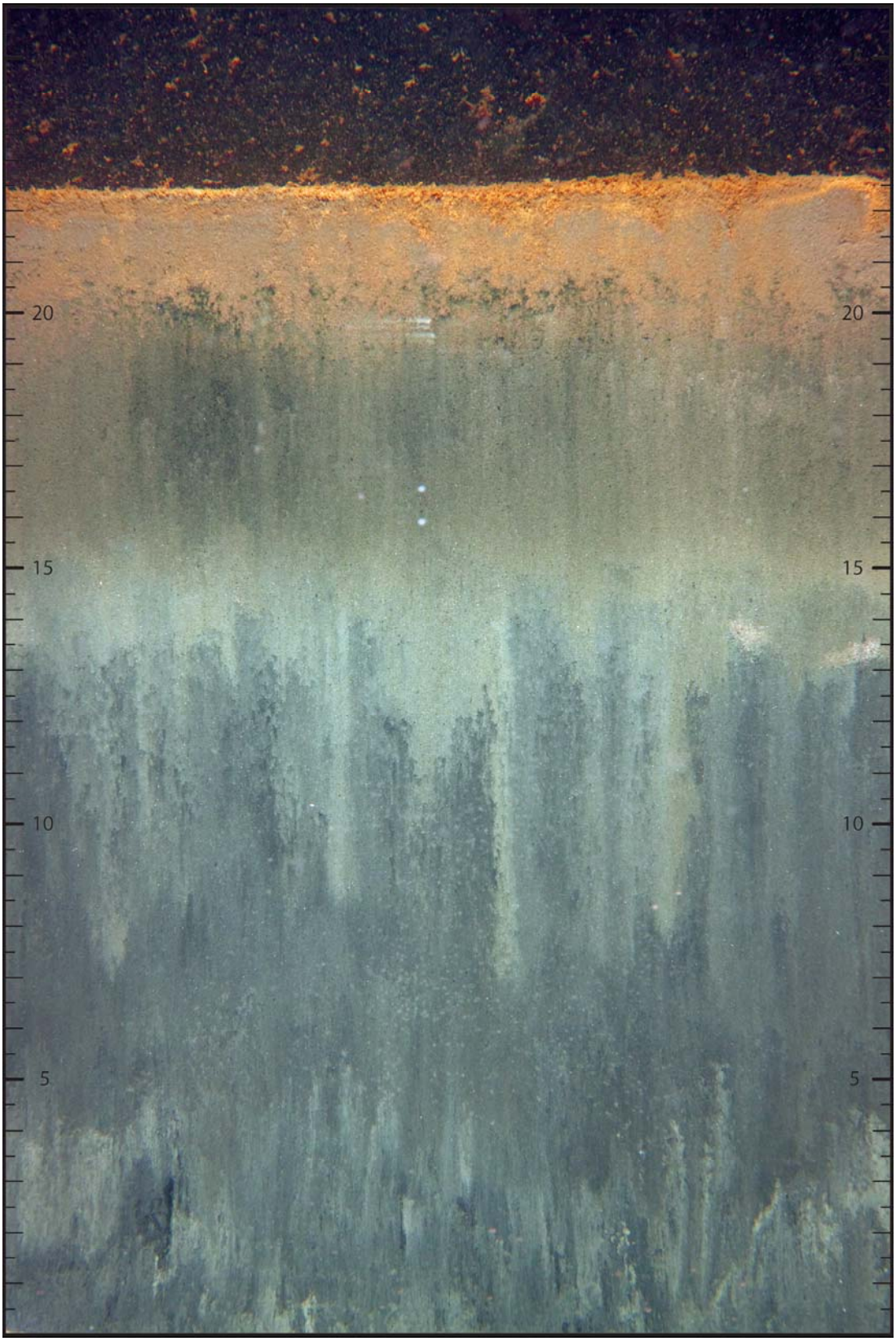

Figure 8. Sediment Profile Image from station SP-48 at 66m.

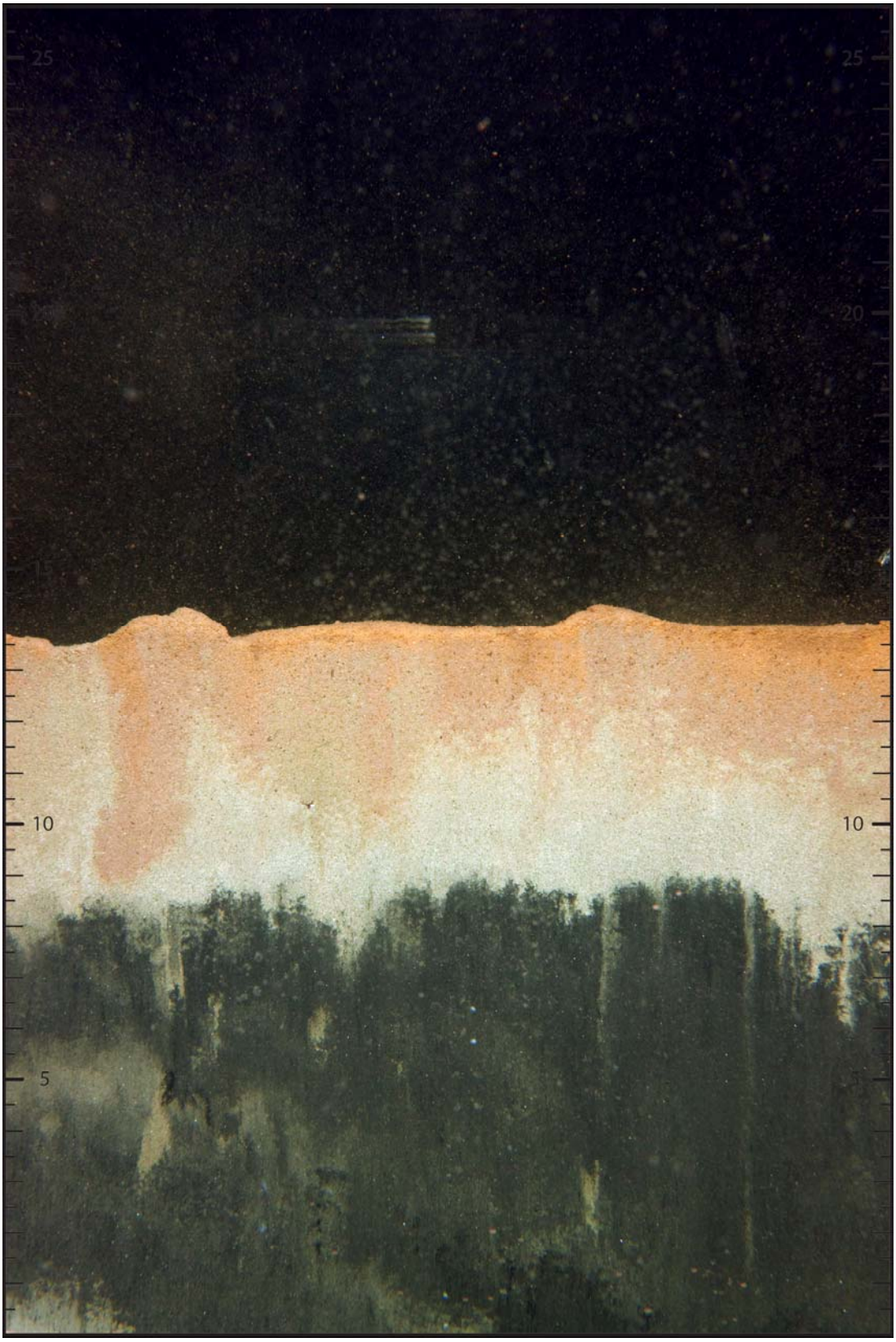

Figure 9. Sediment Profile Image from station SP-48b at 61m.

In the sediment from erosion and transport bottoms there were no distinct biogenic structures and the aRPD could not be detected (Figure 4, Appendix Table 1). The ecological status was bad at the deepest station 117m (SP-42b) with reduced sediment conditions and *Beggiatoa* (Figure 5). Intermediate stations at 95m (SP-43) and 66m (SP-48) showed poor ecological status respectively, with some occurrence of biogenic structures such as tubes and burrows and an oxidised surface layer (Figure 6 & 7). Station SP-48b at 61m showed moderate ecological status with occurrence of macrofauna, biogenic structures such as tubes, burrows and mounds and an oxidised surface layer with average aRPD of 1,7 cm. At 81m (SP-44) the ecological status was bad, but since only one image was good for analysis, BHQ should be interpreted with care because of the low penetrations depth (Figure 3 & 7).

Discussion

This study documented that the sedimentary environment varied from moderate to bad ecological status in different parts of Lithuanian coastal waters. The main aim was initially supposed to study plume area close to Curonian lagoon outlet, affected by human discharges of nutrients, organic matter and contaminants. This coastal area was, however, composed of transport bottoms with sandy sediments at depth <50m and no BHQ could be analyzed from SPI sampled in the area due to limited penetration (Figure 4, Appendix Table 1).

Deep water oxygen concentration have in several investigations been identified as the main stressor of the deeper part of the eastern Gotland basin (Laine et al 1997, Olenin, 1997 and review by Karlson et al 2002). Long term change with decrease in dissolved oxygen concentrations at 100m in the central Baltic was first described by Fonselius (1969). The present study confirm previous investigations with bad ecological status described from both SPI (BHQ=1) and SSI analysis at the deepest station 117m (SP-42b) due to impoverished sediment condition and total coverage of *Beggiatoa* at the sediment surface, probably caused by low oxygen concentrations. Intermediate stations show poor and moderate conditions and generally low density of macrofauna activities in and on sediments.

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Appendix

Table 1. Stations sampled, number of images and results from SPI and SSI. SPI with penetration less than 5 cm BHQ could not be analysed. SSI images were analysed for visible sediment structures, infauna structures (rare, moderate, common) and epifauna present.

Station							Sediment Profile Imagery (SPI)				Sediment Surface Imagery (SSI)			
Station	**Latitud**	**Longitud**	**Depth (m)**	**Date**	**Time**	**Note**	**SPI**	**#**	**Penetration**	**BHQ**	**#**	**Sediment**	**Infauna**	**Epifauna**
SP-16	55,72297	21,01971	25	16.06.2009	08:22:13		SPI 16,8 kg	(4)	1 cm	-	4	Sandy (ripples)	Moderate	
SP-15	55,68876	21,04024	23	16.06.2009	09:00:06		SPI 16,8 kg	(4)	1,3 cm	-	4	Sandy (ripples)	Common	
SP-2	55,68610	21,07027	17	16.06.2009	09:24:52		**SPI 26 kg**	(4)	1,6 cm	-	4	Sandy (ripples)	Rare	
SP-3	55,65244	21,07445	17	16.06.2009	10:09:25		**SPI 26 kg**	(4)	1,4 cm	-	5	Sandy (ripples)	Moderate	
SP-5	55,61975	21,08206	14	16.06.2009	10:40:14		SPI 16,8 kg	(4)	1,8 cm	-	4	Sandy (ripples)	Moderate	
SP-6	55,62418	21,05697	24	16.06.2009	11:11:44		SPI 16,8 kg	(4)	2,1 cm	-	5	Sandy (ripples)	Moderate	
SP-7	55,65983	21,01901	28	16.06.2009	11:52:43		SPI 16,8 kg	(3)	2,5 cm	-	4	Sandy (ripples)	Common	
SP-8	55,63595	20,97639	34	16.06.2009	12:28:07		SPI 16,8 kg	(4)	2,2 cm	-	5	Sandy (ripples)	Common	
SP-9	55,64246	20,93745	37	16.06.2009	13:22:21		SPI 5,6 kg	(4)	1,1 cm	-	-	-	-	
SP-33	55,68662	20,89059	41	16.06.2009	13:57:22		SPI 16,8 kg	(4)	0 cm	-	-	-	-	
SP-12	55,70193	20,97296	32	16.06.2009	14:37:28		SPI 16,8 kg	(4)	1,3 cm	-	4	Sandy (ripples)	Moderate	
SP-11	55,72725	20,97168	31	16.06.2009	15:04:38		SPI 16,8 kg	(4)	1,2 cm	-	4	Sandy (ripples)	Moderate	
Sp-31	55,75429	20,97202	29	16.06.2009	15:46:08		SPI 16,8 kg	(4)	1,5 cm	-	4	Sandy (ripples)	Moderate	
SP-34	55,74051	20,88652	39	16.06.2009	16:27:48		SPI 16,8 kg	(3)	0,5 cm	-	4	Sandy	Common	
SP-52	55,77148	20,84232	38	16.06.2009	17:13:34		SPI 16,8 kg	(4)	0,3 cm	-	5	Sandy	Moderate	
SP-37	55,80013	20,92664	-	16.06.2009	17:57:33	No depth	SPI 16,8 kg	(4)	1,0 cm	-	4	Sandy	Rare	
SP-27	55,83098	20,96924	24	16.06.2009	18:41:28		SPI 16,8 kg	(4)	1,4 cm	-	4	Sandy + Boulders	Rare	*Mytilus edulis*
SP-38	55,83521	20,88667	32	16.06.2009	19:29:25		SPI 16,8 kg	(4)	0,2 cm	-	3	Sandy	Moderate	
SP-51	55,78901	20,69244	42	16.06.2009	20:47:32		SPI 16,8 kg	(4)	0,5 cm	-	4	Sandy	Moderate	*Saduria entomon*
SP-50	55,80718	20,55915	46	16.06.2009	21:56:49		SPI 16,8 kg	(4)	0 cm	-	5	Sandy	Common	*Saduria entomon*
SP-49	55,83358	20,40228	49	16.06.2009	23:18:19	Dead bivalves	**SPI 26 kg**	(4)	2,0 cm	-	5	Sandy	Rare	*Saduria entomon*
SP-42b	56,00727	19,09351	117	17.06.2009	06:36:59		**SPI 0,0 kg**	3	21,8 cm	1	5	-	-	*Beggiatoa* 100%
SP-43	55,98869	19,22138	95	17.06.2009	07:40:55		**SPI 0,0 kg**	3	7,5 cm	2,7	4	Silty Sand	Rare	*Beggiatoa* 15%
Sp-44	55,97920	19,27228	81	17.06.2009	08:34:43		SPI 16,8 kg	1	4 cm	2	4	Sandy + Boulders	Rare	
SP-45	55,97460	19,34683	72	17.06.2009	09:41:24	Video, stone bottom with many boulders in size of a fotball								
SP-46	55,96706	19,42216	62	17.06.2009	10:40:49	Video, stone bottom with many smaller boulders in size of a golfballs								
SP-47	55,92550	19,67063	62	17.06.2009	12:06:47	Video, stone bottom with many boulders in size of a fotball and even larger								
SP-48	55,90468	19,93504	66	17.06.2009	14:06:02		SPI 16,8 kg	4	18,6 cm	2,3	4	Silty	Moderate	
SPI48b	55,86987	20,12177	61	17.06.2009	15:15:51		SPI 16,8 kg	4	10,9 cm	5,5	4	Silty Sand	Moderate	*Saduria entomon*